FLUID INCLUSION RESEARCH

Proceedings of COFFI

Edwin Roedder, *Editor*

Volume 6

1973

Fluid Inclusion Research

Volume 6

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

Important Subscription Information

All subscription correspondence, and checks in payment for Volume 6 ($6.00 per volume, postpaid) and subsequent volumes, should be made out to University of Michigan Press and addressed to:

Fluid Inclusion Research
University of Michigan Press
615 E. University
Ann Arbor, MI 48106, U.S.A.

All correspondence concerning editorial matters should be addressed to the editors. Reprints of volumes 1 (1968) through 5 (1972) are available (U.S. $3.00 per volume, postpaid); checks for these reprints should be made out to COFFI and addressed to the editor.

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

Andrzej Kozlowski, Associate Editor
Fluid Inclusion Research
Instytut Geochemii, Mineralogii, i Petrografii,
Uniwersytet Warszawski, 02-089 Warszawa
al. Zwirki i Wigury 93
POLAND

Volunteers Needed

The editors would appreciate any help that can be offered by the readers in issuing future volumes of Fluid Inclusion Research: Proceedings of COFFI. Help is particularly needed in covering various segments of the literature, preparing abstracts, indexing, and translation (particularly from the Russian). These jobs can be partitioned into as small units as desired; please contact either Edwin Roedder or Andrzej Kozlowski at the above addresses.

FLUID INCLUSION RESEARCH

Proceedings of COFFI

VOLUME 6

1973

Edited by Edwin Roedder

ANN ARBOR
THE UNIVERSITY OF MICHIGAN PRESS

ISBN 0-472-02006-4
Published in the United States of America by
The University of Michigan Press and simultaneously
in Rexdale, Canada, by John Wiley & Sons Canada, Limited
Manufactured in the United States of America

Preface

In 1968 the publication of Fluid Inclusion Research: Proceedings of COFFI was started as an offshoot of the Commission on Ore-Forming Fluids in Inclusions (COFFI) of the International Association on the Genesis of Ore Deposits (IAGOD). Although closely connected with COFFI and IAGOD, the publication of these volumes is independently arranged and separately financed, solely by subscriptions, on a nonprofit basis. It was started with a loan, now mostly repaid, from the International Union of Geological Sciences.

The purpose of the publication is to provide English abstracts or annotated bibliographic citations of all items from the world literature published during the volume year that either contain fluid inclusion data or are pertinent to some aspect of fluid inclusion work. This covers all types of inclusions (aqueous, organic, silicate melt, etc.), causes and mechanisms of trapping (including immiscibility), physical, chemical, and isotopic data, and data on experimental studies. These data are generally given without editorial value judgments except in the case of obviously contradictory or obscure statements. Coverage varies in part as an inverse function of the availability of the original text to the average Western reader, and as a direct function of the availability to the editor of an English translation. In addition to abstracts and citations, we publish English translations of inclusion papers from foreign languages, where available and not otherwise published in English, and notices of meetings and symposia.

The editor is particularly pleased to welcome Dr. Andrzej Kozlowski of the University of Warsaw as associate editor. Dr. Kozlowski has provided most of the translations from Russian sources in this volume. Included among these are many of the 144 translated abstracts (or citations) of papers presented at the Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, held September 24-30, 1973, in Rostov-on-Don, U.S.S.R. Since these are in addition to the normal world literature (332 items in the current volume), this volume is appreciably longer than previous volumes. The balance of the papers presented at Rostov will have to be placed in volume 7. Part of these abstracts were translated through the courtesy of Professor N.P. Ermakov, Dr. E.I. Dolomanova, and Dr. N.I. Andrusenko.

Although each abstract is duly credited, the editors wish to acknowledge, in particular, the help of Dr. M. Fleischer, of the U.S. Geological Survey, who provided two translations of full articles and helped with many citations. Chemical Abstracts, of Columbus, Ohio, has most graciously permitted the use of a limited number of their copyrighted abstracts, as indicated in the abstract citations. Many other individuals, too numerous to list, have helped by sending the editors books, reprints, references, and copies of abstracts. We are particularly indebted to Professor Ermakov for copies of Russian books. We would also like to acknowledge the help of J.W. Clarke and H.E. Belkin in many of the problems of publishing the first five volumes.

To authors of pertinent articles that have been omitted or are misquoted here through haste, or through language difficulties, we extend our apologies and our request to have these things called to our attention; to authors whose original abstracts have been drastically shortened, edited, or revised, we offer a reminder that the following "abstracts" are not intended to be abstracts of the whole paper, but only that part most pertinent to inclusion workers. The obvious inconsistencies in citation, transliteration, abstracting, and indexing are strictly a result of lack of editorial time. A vigorous effort is being made to make future volumes much more current than this one. 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 twenty-five cents per page.

Edwin Roedder, Editor
August 6, 1975 Andrzej Kozlowski, Associate Editor

Contents

Indices

Notices of Meetings and Symposia

The Fourth All-Union Conference on Thermobarometry met at Rostov-on-Don, September 24-30, 1973. The program (24 pages, 600 copies printed) lists, in addition to the 135 titles, the 5 sponsoring organizations, the membership of various committees, and the resolutions to be considered.

The 236 extended abstracts for this meeting were issued by the Rostov University Press in a separate 351-page volume; many of these abstracts will be found in this volume of Fluid Inclusion Research: Proceedings of COFFI (see Preface for details). The printed Proceedings volume or volumes for this conference may not be issued for several years.

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

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

Future Symposia

Professor N.P. Ermakov of Moscow University has announced that plans are underway for the Fifth All-Union Conference on Thermobarometry, to meet at Ufa (in the Urals), September 20-27, 1976. Abstracts of papers submitted are due by January. 1976.

The 25th International Geological Congress will be held in Sydney, Australia, August 16-25, 1976. Plans have been made to hold the Fifth International Symposium on Fluid Inclusion Research in conjunction with this Congress.

Anyone wishing to submit a paper for consideration for this symposium should contact the editors without delay, and should be aware of the following two published deadlines: September 30, 1975, for a title and a synopsis of the proposed paper; and February 29, 1976, for the submission of the abstract. Abstracts of such papers will be printed by the Congress, and in the next volume of Fluid Inclusion Research: Proceedings of COFFI. Please refer to the Second Circular of the Congress for detailed comments and specific limitations; several of these are not the same as in previous congresses.

Organization of COFFI

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

Africa: Dr. H.M. El Shatoury, Associate Professor
of Geology, Egyptian Atomic Energy Authority
(presently at Dept. of Mineral Development
Engineering, Univ. of Tokyo, 7-3-1 Hongo,
Bunkyo-Ku, Tokyo 113, Japan

Australia: Dr. Ronald W.T. Wilkins, CSIRO, Minerals
Research Labs, P.O. Box 136, North Ryde, NSW
2113, Australia

Belgium: Dr. Paul Bartholomé, Laboratoires de
Géologie Appliquée, Université de Liège,
45, Avenue des Tilleuls, Liège, Belgium

Brazil: Dr. J. Cassedanne, Chief Researcher, Conselmo
Nacional de Pesquisas, Avenida Marecmal
Câmara 6^{o} aud 350, Rio de Janeiro (G.B.) Brazil

Canada: Dr. S.D. Scott, Dept. of Geology, Univ. of
Toronto, Toronto 5, Canada

Czechoslovakia: Ing. Jána Ďurišová, Ústřední
ústav Geologický, Malostranski Nam 19,
Praha 1, ČSSR

Denmark: Dr. John Rose-Hansen, Universitetets
Mineralogisk-Geologiske Institut, Mineralogisk
Museum, Østervoldgade 5-7, København K.,
Denmark

E. Germany: Dr. Ludwig Baumann, Bergakademie
Freiberg, Sektion Geowissensch, 92 Freiberg,
Brennhausgasse 14, DDR

France: Dr. Bernard Poty, Centre de Recherches
Petrographiques et Geochimiques, Case Officielle
no. 1, 54 - Vandoeuvre, France

Great Britain: Dr. F.W. Smith, Weardale Lead Co., Ltd.,
Rookhope, Bishop, Auckland County, Durham, England
DL13 2BE

Holland: Dr. Hugo Swanenberg, State Univ. of
Utrecht, Dept. Petrology, Geol. Inst., Oude
Gracht 320, Utrecht, Holland

India: Dr. Ashoke K. Lahiry, Dept. of Geology,
Univ. of Rajasthan, Udaipur, 313001, India
Japan: Dr. H. Imai, 1-53, Haramachi, Shinjuku-Ku,
Tokyo, Japan 162
Malaysia: Dr. E.B. Yeap, Dept. of Geology, Univ.
of Malaya, Kuala Lumpur, Malaysia
Mongolia: Dr. J. Lkhamsuren, Box 46/433, Ulan
Bator, Mongolia
New Zealand: Dr. Brian W. Robinson, Inst. of
Nuclear Sciences, D.S.I.R., Private Bag,
Lower Hutt, New Zealand
Philippines: Dr. B.S. Austria, Professor of
Geochemistry, Dept. of Geology, Univ. of
Philippines, Manila, Republic of the
Philippines
Poland: Dr. A. Kozlowski, Wydzial Geologii,
Uniwersytet Warszawski, Instytut Geochemii
Mineralogii, i Petrografii, 02-089 Warszawa
Poland
Romania: Dr. Vasile V. Pomârleanu, Str. Cuza-
Vodă Nr. 7, Jassy, Română
Sweden: Dr. D.T. Rickard, Geologiska Institutionen,
Box 6801, 113 86 Stockholm, Sweden
Switzerland: Dr. H.A. Stalder, Naturhistorisches
Museum, CH - 3000, Bern, Switzerland
U.S.A.: Dr. Edwin Roedder, U.S. Geological Survey,
National Center, Stop 959, Reston, VA 22092,
U.S.A.
U.S.S.R.: Professor F.P. Mel'nikov, Dept. of Geology,
Moscow State Univ., Moscow, B234, U.S.S.R.

Abstracts, Translated Abstracts, or Annotated Citations to World Literature, 1973

Note — This section includes a few earlier items that were not available in time for inclusion in the previous volume. In part of these abstracts the following abbreviations are used: T or Temp = temperature; T_H = temperature of homogenization; T_D = temperature of decrepitation; F = degree of fill; G/L = gas-liquid; (...) = part of author's abstract omitted.

ABAKIROV, Sh.A., GROSHEV, A.K., and KIM, V.F., 1973, Mineralogical zoning and its connection with temperature conditions of formation of a rare-metal deposit: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 270 (in Russian; translation provided through the courtesy of A. Kozlowski). Authors at Inst. of Geol. of Acad. Sci. of Kirgiz, SSR.

Hydrothermal Be-rare-earth-Th mineralization, forming an ore deposit connected with Permian subalkaline granites, may be divided into 3 groups:

I. High-temp. Zr-Be (phenacite, beryl, bavenite, cyrtolite) - 420-350°C.

II. Moderate-temp. Th-rare earth (cerium), (ferrithorite, monazite, bastnaesite, parisite) - 350-250°C.

III. Moderate-low-temp. Th-rare earth (yttrium), (ferrithorite, xenotime) - 300-180°C.

Character of ore-bearing solutions changed from alkaline (potassium)-fluoride in the high-temp. stages to fluoride-carbonate at moderate and low-temp. stages.

Depending on specific conditions of ore formation (T and chemistry of solutions), rare metal mineralizations are specialized and individualized even in one ore field. Mineralization of various compositions concentrate in a zonal mode. From the top to the bottom Be mineralization is replaced by Th-yttrium and the latter by the Th-cerium one. (Authors' abstract)

ABE, Hiroshi, and AOKI, Morihiro, 1973, Artificial hydrothermal alteration of Miocene tuffs in sodium hydroxide solution at 200°C and 20 kg/cm^2, with special reference to analcimization (hydrothermal studies on the wall-rock alteration-2-): J. Japan. Assoc. Min., v.68, p. 161-169. First author at Miyagi University of Education, Sendai, Japan. (In English)

Natural rhyolitic tuff and green tuff (Miocene age) were subjected to alteration in sodium hydroxide solutions under 200°C and 20 kg/cm^2. When these were treated at 200°C for 50 hours, analcime ($NaAlSi_2O_6.H_2O$) was formed as an alteration product, whose X-ray reflections were gradually intensified with the duration of treatment. From the diffraction intensities, it was found that the alteration products of green tuff contained about 3 times more analcime than in the case of rhyolitic tuff. A comparison of chemical compositions between the original green tuff and its alteration products showed that SiO_2 was much dissoved out in the process of analcimization. On the basis of the present result, it is considered that the analcime zone surrounding Kuroko deposits is formed by the reaction between highly saline alkaline solution and tuffaceous sediments of middle Miocene age. The solution are considered to have been heated by submarine volcanism and/or exhalative activities, thus accelerated the alteration. (Authors' abstract)

ABE, Hiroshi, AOKI, Morihiro and KONNO, Hiroshi, 1973a, Synthesis of analcime from volcanic sediments in sodium silicate solution; experimental studies on the water-rock interaction: Contr. Mineral and Petrol., v. 42, p. 81-92. First author at Institute of Earth Science, Miyagi University of Education, Sendai, Japan.

Analcime has been synthesized from natural rhyolitic tuff and green tuff (Miocene age) at 200°C and 20 kg/cm^2 with solution of Na_2SiO_3 (12%) in 50- to 260-hr runs. From the diffraction intensities, it was found that the alteration products of green tuff contained more analcime than those of rhyolitic tuff. It has been concluded that the lithological character of starting materials and the chemical behavior of reaction products are important controlling factors in analcimization. (Authors' abstract)

ABE, Hiroshi, AOKI, Morihiro, and KONNO, Hiroshi, 1973b, Hydrothermal alteration of Miocene tuffs in NaOH-KOH solutions, with special reference to chemical behavior (hydrothermal studies on the wall-rock alteration-3-): Jap. Assoc. Min. Pet. Econ. Geol. Jour., v. 68, pp. 269-276. (In Japanese with English abstract).

Natural green tuff and rhyolitic tuff (Miocene age) were subjected to alteration in sodium hydroxide and potassium hydroxide solutions under 200°C and 20 kg/cm^2. Various chemical behaviors were shown under the influence of running times and chemical conditions. Al_2O_3 content in the alteration product shows an apparent increase. However, Al_2O_3 is absent from the present hydrothermal solutions. It is assumed that during hydrothermal alteration, fresh rock has decreased in weight so that Al_2O_3 has apparently increased. Column A in Table 5 shows the calculated weight in grams of each oxide remaining from the alteration of 100g of fresh rock, on the assumption of constant Al_2O_3. It may be concluded from the present experiments that the amount of analcime in the alteration product depends upon mineral association of starting material and contents of SiO_2 in alteration products. (Authors' abstract).

ABRAMOV, V.A., and VOLYNETS, O.N., 1973, On the study of glass inclusions in the phenocrysts of volcanic rocks: Akad. Nauk SSSR, SO, Geolog. i

Geofiz., 1973, no. 8, p. 126-131 (in Russian).

An attempt was made, using the microanalizer MS-46 (electron microprobe) to compare qualitatively the glass inclusions from plagioclase phenocrysts and those of the groundmass for two samples of Quaternary volcanic rocks of Kamchatka. The studies were carried out on transparent thin sections in preplanned profiles showing the Ca, Fe, and Mg contents. In the two cases there was a similarity in the compositions of the glass inclusions in plagioclase and that of the groundmass of the rock. (Authors' abstract)

ADDY, S.K., & YPMA, P.J.M., 1973, Metamorphism of sulfide deposits and the metamorphogenic circulation of pore water at Ducktown, Tennessee (abst): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 529-530. First author at Marine Biomedical Institute, Galveston, Texas 77550.

The rocks in the alteration zone around the massive sulfide ore bodies at Ducktown, Tennessee are depleted in O^{18} by approximately $2^{0}/00$ compared to the unaltered country rocks, Based on the average δO^{18} values the following depletions are observed: quartz from 11.0 to 8.9, muscovite from 7.5 to 5.5 garnet from 7.0 to 4.7, biotite from 5.0 to 3.4 and calcite from 8.7 to $7.7^{0}/00$ SMOW. The δC_{13} values of calcite in the ore zone range from -13.9 to -17.4 $^{0}/_{00}$ PDB and are similar to the values obtained in the country rocks, i.e. -15.2 to -20.2. The minerals in the alteration zone and in the country rock show identical δD values; -68 to -77 for biotite, -62 to -69 for chlorite and -49 to -54 $^{0}/_{00}$ SMOW for muscovite. This is suggestive of a situation in which the pore waters maintained isotopic equilibrium with the metasediments throughout metamorphism and have been recycled. However, in the ore zone part of the pore waters escaped through the shear zones during the regional metamorphism and effectuated the alteration. The isotopic composition of this water is as follows: δO^{18}=6.8 to $7.6^{0}/_{00}$ SMOW, δC_{13}-10 to $-16^{0}/_{00}$ PDB, and δD-28 to $-38^{0}/_{00}$ SMOW. Isotopic exchange with rocks at depth at higher temperatures and/or preferential loss of CO_2 from the solutions are suggested as the processes causing the oxygen shift in the water.

The results of this isotopic study along with the fabric studies indicate that the sulfides are partly pretectonic, probably syngenetic, and partly hydrothermal formed by the remobilization of trace sedimentary sulfides in the rocks during the period of regional metamorphism. The alterations around the ore bodies took place in the descending stage of metamorphism as the influx of the O^{18} depleted water continued. (Authors' abstract)

AGAFONOV, L.V., and ANDREYEVA, G.A., 1973, Gases in the alpine-type ultramafics of the Anadyr-Koryak fold system: Akad. Nauk SSSR Doklady, v. 210, p. 689-692 (in Russian; translated in Doklady Acad. Sci. USSR, v. 210, p. 232-234 (1974)). Authors at Institute of Geology and Geophysics, Siberian Department of the USSR Academy of Sciences, Novosibirsk.

Numerous analyses for H_2, CH_4, C_2H_6, C_3H_8, and (CO_2+SO_2), as well as bitumen content. (E.R.)

AHRENS, A.H., DUNCAN, A.R., and ERLANK, A.J., (Eds.), 1973, Internat. Conf. on Kimberlites, Extended Abstracts of Papers: Univ. of Capetown, Rondebosch, Cape, S. Africa. 332 pp.

These abstracts (approx. 90 papers) present information on a wide variety of subjects, particularly kimberlites and associated peridotites, carbonatites, and ultrabasic nodules from many areas of the globe. These include extensive mineralogical data, isotopic data (Rb, Sr, Pb, C, O), distribution of elements between coexisting phases, much evidence and discussion of kimberlite gas-solid intrusion phenomena, solid inclusions in diamonds, and a variety of synthetic experimental studies of systems including H_2O and CO_2; all are pertinent to any study of the fluid inclusions in such materials. Unfortunately there is no index; presumably the full Proceedings volume will have an index. A few of the most pertinent papers have been entered alphabetically by author. (ER)

AKIMTSEV, V.A. AND GORDEEVA, V.I., 1973, Temperature conditions of topaz crystallization in apogranites: Abstracts of papers from the Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 130-131 (in Russian; translation through the courtesy of A. Kozlowski). Authors at Inst. of Geology and Geochemistry, Siberian Branch of Academy of Sciences USSR-IGiG SO AN SSSR, Novosibirsk.

1. Inclusions in topaz from quartz-beryl-topaz veinlets of apogranies were investigated by the homogenization method.
2. In topaz three types of inclusions occur: primary, pseudosecondary and secondary.
3. Primary inclusions bear gas and liquid and sometimes (a?) solid phase. Phase ratios vary widely.
4. T_h interval of topaz = 400-260°C, in liquid. Presence of homogenous liquid CO_2 in pseudosecondary inclusions (2 liquids at 25-29°C) precludes reaching homogenization.
5. The data are comparable with data on inclusions in quartz and beryl of those veinlets. (Author's abstract)

ALEKSEENKO, V.A., GOLIKOV-ZAVOLZHENSKIY, I.V., KOLOMENSKIY, G.Yu., and ERMEKOV, O.M., 1973, Test of the application of vacuum-decrepitometric investigations during studies of some polymetallic and rare metal deposits of S and Central Kazakhstan: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973, Rostov, Rostov Univ. Press, p. 265-266 (in Russian; translation provided through the courtesy of A. Kozlowski). Authors at Karaganda Polytechnical Inst., Central Caucasian Geological Office, Karaganda, and Rostov Univ.

The following regularities were recognized:

1. For each group of deposits the T of origin was found to be similar to other deposits of the region. For stratiform deposits of Dzhungaria, occurring up to 200 km apart, it appears that the general T conditions of mobilization of primary dispersed ore substances was similar.
2. Based on the T of mineral origin, some stages of ore mineralization may be distinguished at the investigated deposits. Each stage is accompanied by a specific complex of elements, either as minerals, or as substituting elements in minerals. Such stages and elements at the Solnechnoe rare-metal deposit are: Pb, Cu, Zn - 340-270°C; Ge, F - 280-270°C; F, Be, Ag - 290-90°C; and Mo, Sn, W, Bi, Ag - 330-270°C. In the group of polymetallic deposits of Dzhungarian Alatau the groupings are: Sb, Cd, Bi - 110-130°C; Ge, Ag - 280-330°C.
3. For rare-metal deposits a distinct temperature zoning was detected. Vertical T gradients vary from 5-100°/100 m, horizontal, from 10-20°/100 m. Spatial agreement was found between these temperatures and the geochemical and ore zoning.
4. Clear distinction of rocks that have been impregnated during the process of ore-formation indicates the applicability of decrepito-

metric methods for prospecting for hidden polymetallic and fluorite-rare-metal ores in carbonate rocks. (Authors' abstract, abbreviated by A.K.)

AL-KHATIB, Ramzy, and TOURET, Jacques, 1973, Carbon dioxide fluids in granulite facies rocks from southern Norway. Semiquantitative utilization of the crushing stage: Soc. Géol. de France, Bull., v. 15, no. 3-4, p. 321-325 (in French with English abstract). First author at Laboratoire de sédimentologie, Université de Nancy I, C.O. no. 140, 54037 Nancy Cedex, France.

The crushing stage is a practical instrument to confirm the abundance and specificity of CO_2 in fluid inclusions from granulite facies quartzites of southern Norway. From the number and volume of bubbles released by crushing in anhydrous glycerine, it is estimated that 0.034 mm^3 CO_2 is released at 1 atm. for 1 mm^3 quartz. (Authors' abstract)

ALLEN, Leland, 1973, The rise and fall of polywater: New Scientist, v. 59, p. 376-380.

A review of the history of polywater (starting in 1961), the evidence for it, and the final disproof of it by its original proponent, B.V. Derjaguin as well as others (see Fluid Inclusion Research - Proceedings of COFFI, v. 3, p. 15-16, 1970),(E.R.)

ANDERSON, A.T., Jr., 1973a, An estimate of the before-eruption H_2O content of a high alumina basalt (abst.): Amer. Geophys. Union Trans. (EOS), v. 54, p. 493. Author at Dept. of the Geophys. Sciences, Univ. Chicago, Chicago, Ill. 60637.

Electron microprobe analyses of some glass inclusions in phenocrysts have considerably lower oxide sums than contemporaneous analyses of either the vesicular host glass or an anhydrous glass standard (from Kilauea, Hawaii). This difference is best explained as H_2O dissolved in the trapped glass inclusion but absent from the vesicular glasses. The analyses are performed such that Na is completely retained. Probably, H_2O is retained, too. Since sulfur is demonstrably 5 to 10 times higher in trapped glass inclusions than in host vesicular glass, it is reasonable to expect that H_2O also is kept at before-eruption concentrations in the included glass. With a two s.d. uncertainty of 1.4 percent the oxide sum differences (approx. H_2O) and K_2O contents of glasses included in olivine phenocrysts from a high-alumina basalt near Medicine Lake Highland, Calif. are (weight percent):

H_2O	0.8	0.6	1.7	3.7	2.5	3.6	4.3	2.4	0.9	1.0	1.4
K_2O	0.26	0.27	0.29	0.42	0.41	1.07	0.45	0.32	0.37	1.27	0.23

Thus, the before-eruption H_2O content was 2.1 ± 1.4%. Studies of other lavas from Medicine Lake to Mt. Shasta will be reported. (Author's abstract)

ANDERSON, A.T., 1973b, A volatile-rich picritic parent of andesites, Mt. Shasta, California (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5 no. 7, p. 532-533. Author at Univ. of Chicago, Chicago, Ill. 60637.

Glasses trapped in olivine megacrysts (Fo94-79) from Holocene and Pleistocene tephra erupted within 20 kilometers of Mt. Shasta summit range in composition from high-alumina basalt to andesite (anal. 1-4 below). The glass inclusions in the most magnesian olivines have about 8% of their volume occupied by vapor bubbles, and are surrounded by broad Fe-rich zones in the olivine host and by ghost outlines within the olinine host. These facts indicate that the melt which was initially trapped within the olivine contained 24% MgO (anal.5 below). Analogy with experimental data suggests an initial entrapment temperature of 1400°C. K_2O in glass inclusions increases regularly with Fe_2SiO_4 content of olivine host exactly as predicted by equilibrium crystallization whereby early magnesium-rich olivine reacts with successive liquid derivatives. H_2O,Cl and S decrease or remain approximately constant with increasing K_2O suggesting vapor-saturated differentiation at a depth of a few kilometers or less. These facts suggest that volative-rich parental picrite stagnates at a few kilometers beneath Mt. Shasta because of saturation with an H_2O-rich gas. The loss of gas promotes equilibrium crystallization which inhibits Fe-enrichment. Representative microprobe analyses of glasses follow (all Fe as FeO, H_2O estimated by difference $\pm$1.4% absolute error).

No.	Host	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	H_2O	Cl	S	Sum
1	Fo94	54.6	15.6	3.8	5.3	12.6	2.6	0.49	0.68	2.2	0.19	0.21	98.3
2	Fo89	58.9	16.1	5.4	4.1	7.9	2.7	1.05	0.66	0.8	0.11	0.05	97.9
3	Fo90	50.0	17.4	6.1	6.8	12.2	2.3	0.25	0.56	2.0	0.07	0.11	97.8
4	Fo85	56.4	15.1	7.2	4.2	7.1	4.0	0.93	1.20	1.4	0.06	0.01	97.6
5	Fo94	48.6	8.9	6.7	23.9	7.2	1.5	0.28	0.39	1.2	0.09	0.10	98.9

(Author's abstract)

ANDERSON, G. M., 1973a, The hydrothermal transport and deposition of galena and sphalerite near 100°C (abst.): Geol. Soc. Amer. Abstracts with Programs, no. 4, p. 293-294. Author at Department of Geology, University of Toronto, Toronto 181, Ontario, Canada.

Measurements of aqueous complex stability constants and sulfide solubilities near 100°C have allowed construction of a model which predicts galena and sphalerite solubilities in subsurface brines of various compositions. This in turn allows calculations of the amounts of galena and sphalerite which will be precipitated due to given changes of conditions in the solution, such as cooling, neutralization by limestone, dilution or sulfate reduction. Taking Roedder's estimate of an average fluid inclusion composition for Mississippi Valley type ores ($\sim$ 3m NaCl; .03m SO_4^{2-}), the model indicates that if ore precipitation is by any process that requires reduced sulfur and metals to be transported in the same solution (e.g. cooling, neutralization), then the solution is more acid than pH 5, will actively dissolve calcite and dolomite, and that chalcopyrite cannot be precipitated with galena and sphalerite. If precipitation is caused by sulfate reduction or mixing with an H_2S solution, then chalcopyrite, calcite and dolomite may or may not be stable during deposition, depending on pH, and mineral zonation should be much less distinct. Observations on paragenesis of ore and gangue minerals, particularly if combined with knowledge of the fluid inclusion compositions, may therefore enable depositional mechanisms to be deduced. (Author's abstract)

ANDERSON, G.M., 1973b, The hydrothermal transport and deposition of galena and sphalerite near 100°C: Economic Geology, v. 68, p. 480-492.

Using experimental data on the solubility of galena and calculated solubilities of sphalerite, some of the consequences of assuming that the ore-depositing fluid has the composition indicated by fluid inclusion evidence are examined. Assuming that at least 1 ppm Pb or Zn must be deposited as sulfide from the solution before an ore body can form, it is concluded that there is no difficulty in transporting and depositing sufficient metal and sulfur from a slightly acid, chloride-rich brine with a fairly low sulfate content. If the reason for sulfide precipitation is cooling, neutralization, or dilution, the ore-forming brine will actively dissolve calcite and dolomite and the sulfur fugacity is quite high. This means that, among other things, chalcopyrite is not stable during deposition of PbS and ZnS. If increase in reduced sulfur is the reason for sulfide precipitation, then calcite, dolomite, and chalcopyrite may or may not be stable during precipitation, but it is more difficult to account for zoning of galena and sphalerite. (Author's abstract)

ANDERSON, G.M., & HAMILTON, D.L., 1973, Sub-solidus phase relations in the sub-silicic part of the system Q-Ne-Ks-NaCl-KCl-H_2O and application to the York River, gneisses, (abst.): Geol. Soc. Amer. Abstracts with Programs v. 5, no. 7, p. 533. First author at Dept. of Geology, University of Toronto, Toronto, Ontario.

Phase relations involving albite and K-spar solid solutions (Ab,Or), analcite (Anl), leucite (Lc), nepheline and kalsilite solid solutions (Ne,Ns) have been determined by ion-exchange experiments at 2Kb, using 2m and 3m alkali chloride solutions and crystallized gels as starting materials. At 500°C, stable 3-solid-phase assemblages (with analytical K/(K+Na) ratio of the associated aqueous phase in brackets) are Ab+Or+Anl Anl+Or+Ne (0.44) and Or+Lc+Ne. At 600°C, they are Ab+Or+Ne (0.25) and Or+Lc+Ne (0.66). Two-solid-phase assemblages always have K/(K+Na) values consistent with those of the adjoining 3-solid-phase areas. The cross-reaction Ab+Ne=Anl+Or takes place near 600°C.

York River nepheline gneisses in the Bancroft area usually contain the assemblage Ab-Or-Ne, and analcite has never been observed. Phase compositions indicate temperatures of less than 500°C, but the above results indicate that this temperature the rocks should contain analcite if water was available. The observed assemblages and the metasomatic textures (chiefly nepheline replacing albite) are therefore thought to have originated at much higher temperatures. Since little or no melting of the gneiss has occurred, fairly narrow limits on the metamorphic conditions are imposed. (Author's abstract)

ANDRUSENKO, N.I., 1973, Siberian Platform pyroxene-sphene-zeolite altered traps connected with pegmatite-formation (according to results of experiments with inclusions): Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 216-217 (in Russian; translation through the courtesy of N.I. Andrusenko) Author at TSNIGRI, USSR, MG, Moscow.

1. Among the metasomatically altered intrusive traps of the Central Siberian Platform (Dmitriev, 1958; Kudrjashova, 1957; Yudina, 1963: Andrusenko, 1965) there are peculiar pyroxene-sphene-zeolite rocks enriched by sphene (30%) and zeolites (60%) from the natrolite and heulandite group. These rocks also contain analcime. The newly-formed diopside and sphene crystals are case- and enevlope-shaped and measure 1-2 cm. The sphene contains close to 0.33% lanthanides. The original dolerites have a pegmatoid structure. These rocks are frequently connected with valuable Iceland spar deposits.

2. Our studies of the inclusions have shed new light on the debatable problem of the genesis of such pegmatoid traps, transformed into pyroxene-sphene-zeolite rocks. Diopside and sphene contain glassy and crystallized inclusions with homogenization temperatures of 830-

750°C, crystal-gas inclusions (750-680°C) and gas-liquid inclusions (420-180°C). This warrants the assumption that the pegmatoid dolerites formed from residual melt of basic magma saturated with volatiles. The diopside and sphene completed their growth from gaseous and liquid solutions which had much titanium.

3. It has been found that zeolites may be used in thermometric studies which depend on the behaviour of water in these hydrated minerals. If the temperature of homogenization of the inclusions in the zeolites is below that of the endothermic effects on their thermograms, the heating will cause no leakage of their inclusions. (Author's abstract)

ANDRUSENKO, N.I., GODLEVSKY, M.N, AND YUDINA, V.V., 1973, Some data on the temperature conditions of mineral formation in connection with nickel-bearing intrusions of the Talnakh ore district: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 198-199 (in Russian; translation thourgh the courtesy of N.I. Andrusenko). Authors at TSNIGRI, USSR, MG, Moscow.

1. The temperatures of formation of successive mineral associations belonging to the magmatic and postmagmatic stages may be estmated because anhydrite is present in all the associations as a rock-forming and vein mineral.

2. Our numerous findings in the thermometry of inclusions show a wide range of anhydrite-forming temperatures (685-100°C), divided into several intervals a) 685-400°C - temperature of anhydrite formation from anhydrite marbles belonging to the quartz pyroxene facies of contact metamorphism; b) 570-340°C - anhydrite belonging to magnesium and calcium-skarn parageneses; c) 380-340°C - anhydrite belonging to veins containing datolite and apophylite; d) 260-230°C - anhydrite from hydrogarnet-serpentine postskarn rocks; 3) 140-100°C - temperatures of secondary solutions in sedimentary anhydrite.

3. The presence of the concomitant metasomatic copper-nickel ore in all the postmagmatic formations of the Oktyabrsky deposit makes it possible to indicate the approximate temperature limits of the ore associations: a) 570-340°C - early chalcopyrite-pentlandite-pyrrhotite which accompanies magnesium and partly calcium skarns; b) 260-230°C essentially chalcopyrite with bornite and valeriite.

4. According to the homogenization of inclusions in quartz occurring in the continuous deposit of injection-magmatic chalcopyrite-pentlandite-pyrrhotite ores the temperature of formation of the marginal part of the ore body is 520-300°C, while that of bornite-talnakhite ores is 240-180°C.

5. According to several aqueous extracts of anhydrite the mineral-forming solutions are composed of bicarbonate-chloride-sulfate with a predominace of fluorine over chlorine (ratio F/Cl from 3/1 to 8/1). Alkalies are absent in samples of solutions from sedimentary and metasomatic anhydrite and a sharp predominance of calcium over the sum of alkalies is found in the sample of anhydrite marble. According to individual analyses of the gaseous phase of inclusions both in the anhydrite and quartz, carbon dioxide predominates strongly. (Authors's abstract)

ANDRUSENKO, N.I., KOSOVETS, T.N., KONSTANTINOV, M.M., 1973, Thermodynamic conditions of formation of gold ore deposits in Transcaucasus: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 47-48 (in Russian; translation provided through the courtesy of N. I. Andrusenko). Authors at Central Scientific-Research Geological-Prospecting Institute of Geology Ministry, USSR, Moscow - TSNIGRI MG SSSR.

The thermodynamic condition of formation of Transcaucasian gold deposits was established on the basis of systematic studies of inclusions of seven deposits in the Sevan-Akerin and Miskhan-Zangezur structural zones. The deposits belong to different stages of mineralization: gold-copper-molybdenum and gold proper. The results place the deposits in the mesothermal group formed within the range 450 to 60°C.

The thermodynamic condition of formation of most of the deposits with an extended mineralization process is characterized by relatively wide temperature ranges for individual stages, with sharp interstage changes ($\leq$ 180°C) and less strongly pronouced intermineralization changes ($\leq$ 50-100°C).

The productive stages were formed at fairly high temperatures (360-200°C) that remained stable for a long period of time and covered several successive gold-bearing associations. The slow rate of cooling of the ore-forming solutions is due to the formation of these deposits at intermediate depths for the cooling intrusive body. The state of aggregation of early portions of the solutions was gaseous or near critical; the fluids condensed at temperatures ranging from 360-320°C and later in the deeper seated deposits.

The deposits of the gold-copper-molybdenum stage are characterized by a chloride composition and highly concentrated solutions, while chloride-carbonate solutions of moderate mineralization are typical of gold proper deposits, owing to the peculiarities of the structural and tectonic regime of their formation and the different magmatic sources feeding the solutions. (Authors' abstract)

ANTHONY, T.R., and CLINE, H.E., 1973, The stability of migrating droplets in solids: Acta Metallurgica, v. 21, p. 117-122. Authors at General Electric Research and Development Center, Schenectady, New York.

The stability of water droplets migrating in a thermal gradient in a single crystal of KCl was studied as a function of droplet size, droplet shape, droplet velocity and the applied thermal gradient in the solid. Droplet breakdown starts with the growth of protrusions from the rear corners of the droplet and is followed by the release of a thin trailing liquid veil from the rear peripheral edges of the droplet at a somewhat higher thermal gradient. Droplets with a velocity to applied thermal gradient ratio less than 9.4×10^{-8} cm^2/sec °C are stable while droplets with a greater ratio are unstable. This stability criterion is shown to be consistent with the idea that droplets disintegrate when the bulk droplet velocity exceeds the maximum theoretical velocity of droplet edges. The velocity difference arises from the difference between the thermal gradients in the center and the edges of a droplet. (Authors' abstract).

ANUFRIYEV, Yu.N., AND MOSKALYUK, A.A., 1973, Some comparative data on composition of solutions from inclusions in quartz of rock-crystal-bearing and gold-ore deposits of Ural: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 156-157 (in Russian; translation through the courtesy of A. Kozlowski). Author at All-Union Scientific-Research Institute for the Synthesis of Mineral Raw Materials, Aleksandrov, VSEGEI, Leningrad.

Over 150 water leachates of quartz from three hydrothermal gold deposits and three hydrothermal-metamorphic deposits of rock crystal from Ural were investigated, giving results as follows:

Quartz type	Cl^-	F^-	HCO_3^-	SO_4^{2-}	K^+	Na^+	NH_4^+	Ca^{2+}	Mg^+	Solution type
				Gold Ore Deposits						
1.Ore-bearing	18	3	62	15	5	23	3	64	5	1
2.Barren	39	3	45	12	6	39	1	50	8	2
3.Rock crystals	44	4	44	8	3	40	1	53	2	2
				Rock Crystal Deposits						
1.Rock-crystal bearing	62	2	28	9	3	62	not detmnd	37	3	3
2.Rock-crystal-free	40	3	47	11	5	42	"	51	3	2
3.Rock crystals	68	3	20	9	6	68	"	25	1	4

Note: Ion amounts in %-equivs. Solution types are as follows: 1 - chloride-calcium, 2 - bicarbonate-chloride-calcium-sodium, 3 - chloride-sodium-calcicum, 4 - chloride-sodium. (Authors' abstract)

ANUFRIYEV, Yu.N., STUPAKOV, G.P., and MOSKALYUK, A.A., 1973, Characteristics of quartz from the Kochkar gold ore deposit: Akad. Nauk SSSR, Izv., Ser. Geol., no. 3, p. 68-81 (in Russian).

Includes numerous decrepigrams and 12 analyses of water leachates for K, Na, Mg, Ca, Li, NH_4, Cl, F, SO_4, and HCO_3. (E.R.)

ARKHIPCHUK, R.Z., and VOVK, P.K., 1971, Crystallomorphology of fluorite from the Kharasunskoe deposit (Western Transbaikal region): Mineral. Mineral. Kristallogr., Tr. Soveshch. 1969 (Pub. 1971), p. 70-71: Edited by Vertushkov, G.N., Sverdlovsk. Gorn. Inst.: Sverdlovsk, USSR (In Russian) Chem. Abst., v. 79, (12), 138468 w, 1973.

Phys. properties of various forms of fluorite crystals and their aggregates in quartz-fluorite veins of the Kharasunskoe deposit such as habit, color, size, and mosaic structure were described in detail. A study of internal zonality of the crystals and also relation among their different habit forms proved that the octahedral crystals appeared first during the mineral formation. From the octahedral forms, the fluorite crystals of rhombododecahedral, cubic, and more complex habits were gradually developed. The evolution of crystallog. forms resulted from changes in both supersatn. and chem. compn. of the crystg. medium during a successive decrease in the crystn. temp. The data on homogenization of gas-liq. inclusions indicated that the fluorite crystals were probably formed from homogeneous hydrothermal solns. at 190-75°.

ASHLEY, R.P., and KEITH, W.J., 1973, Occurrences of alunite in hydrothermally altered rocks and ores at Goldfield, Nevada: Geol. Soc. Amer. Abstracts with Programs, v.5, no. 1, p. 6. Authors at U.S. Geol. Survey, Menlo Park, Calif. 94025.

The Goldfield mining district is a classic locality for alunite-bearing altered rocks associated with epithermal precious metal ores. Alunite at Goldfield appears in at least five different settings: (1) Alunite replaces constituents of silicified volcanic and plutonic rocks in many silicified zones throughout the 15-square-mile altered area at Goldfield. Silicified wallrocks and wallrock breccia fragments associated with the ore bodies carry this replacement alunite. (2) Alunite is intergrown with quartz near the margins of quartz veins or breccia fillings which bear sulfide ore minerals. (3) Alunite forms veins in unoxidized ore-bearing veins or breccia fillings. (4) It forms platy crystals as much as 1 cm wide, intergrown with jarosite crystals. These alunite-jarosite aggregates fill fractures and brecciated areas in some silicified zones. (5) Fine-grained alunite forms veins that crosscut both argillized and silicified zones. All these veins contain quartz, and some have kaolinite and minor K-mica as well.

Petrographic and field relations, as well as mineral assemblages, suggest that alunite in the first three settings is hypogene. Sulfur isotopic data also support a hypogene origin. Petrographic relations and minor element data suggest that the coarse-grained alunite-jarosite aggregates are also hypogene. Field relations and sulfur isotopic data suggest that the fine-grained vein alunite is supergene or possibly late hypogene, developed during hot-spring activity at the end of the hydrothermal episode at Goldfield. (Authors' abstract).

AUGUSTITHIS, S.S., 1973, Atlas of the textural patterns of granites, gneisses and associated rock types: Elsevier, Amsterdam, 378 pp.

An atlas of 687 photographs, mainly photomicrographs, plus 96 pages of text and an extensive bibliography, on the title subject. Of interest to inclusion workers in the many details of solid inclusions, mineral growth, replacement, shearing and recrystallization illustrated that may well be involved in any attempt to understand the fluid inclusions in such rocks. Although the photomicrographs are excellent, this reviewer disagrees with many of the interpretations made. Fluid inclusions are not listed in the index, but are mentioned briefly in the text (e.g., p. 54). Many photomicrographs which look to this reviewer to be laden with fluid inclusions are otherwise interpreted by the author. Thus, Fig. 126, which looks like healed secondary planes of inclusions cutting across quartz grain boundaries, is described as a "Linear distribution of fine pigments (representing an initial gel-structure)..."; what appear to be planes of vermiform secondary melt inclusions in augite from a basalt (Fig. 210) are interpreted as a myrmekitic-like intergrowth of undertermined infiltration process (p. 32); and solid inclusions of tourmaline outlining growth stages in a quartz crystal (Fig. 632) are interpreted as formed by a later infiltration along "interleptonic spaces" (p. 70). (ER).

AVDONIN, V.V. AND KEL'KH, V.Ye, 1973, Temperature conditions of formation of the Tishinskoe deposit as indicated by results of inclusion homogenization and decrepitation: Abstracts of papers at Fourth Regional

Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30, Sept., 1973: Rostov, Rostov Univ. Press, p. 87-88 (in Russian; translation through the courtesy of A. Kozlowski). Authors at Moscow University.

1. The Tishinskoe polymetallic deposit occurs in Middle Devonian volcanic-sedimentary rocks (in Ore Altai Mts. - Rudnyi Altai).Decrepitation data of pyrites, as well as T_d and T_h in quartz from quartz-carbonate veins are based on about 350 samples.

2. Temp. of beginning of decr. of pyrites ranges from 210-310°C, and the temp. decrease (210-270°C) toward the ore body or ore channel way faults. Maximum temp. were found in late (post-ore) feldspathic metasomatites.

3. Quartz veins may be divided into two groups; early with extensively developed deformation, practically does not decrepitate; late, post-ore gives T_d 320-350°C. The above data are supported by T_h of primary inclusions (at 370-260°C). Inclusions in blocks of quartz lying between large boudinages of quartzites and massive deformed ores homogenize at 365-375°C. (Authors' abstract)

BAKUMENKO, I.T., CHEPUROV, A.I., and CHUPIN, V.P., 1973, Diagnostics and investigations of the properties of melt inclusions: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Spet., 1973: Rostov, Rostov Univ. Press, pp. 21-23 (in Russian; translation provided through the courtesy of A. Kozlowski). Authors at Inst. of Geology and Geophysics, Siberian Branch, Academy of Sciences USSR, Novosibirsk.

The essential question during investigation of magmatic processes by the methods of physical geochemistry is the correct genetic and phase diagnostics of primary and pseudosecondary glass, crystallized, transformed and combined inclusions of parent melts. There exist the distinct properties distinguishing them from secondary glass inclusions formed during the local crushing of minerals in the case of meteoritic or other impacts, from pseudo-melt inclusions formed in the experiment or under natural conditions as the result of migration and contamination of gas-liquid inclusion matter with silicate phases. Silicate gas-crystal inclusions or salt-rich inclusions of brine with a composition not corresponding to the composition of parent magmas, when minute, may be incorrectly identified as melt inclusions.

All these kinds of inclusions may be identified during morphologic and optical investigations combined with scientific photography, visual observations of inclusions during heating and cooling, gas phase analysis and electron microprobe analysis (EMA) of individual inclusions. For example, it was shown by the EMA method that the compositions of melt inclusions in magmatic minerals of acid, alkaline and ultrabasic rocks actually are the same as the composition of appropriate magmas, i.e. those inclusions are not the products of dispersion of host minerals in other strange phases. On the other hand, strongly impacted samples contain inclusions with the composition of the host minerals (lechatelierite or other glasses without analogous natural magmas).

The important aspect is to achieve comparable data from a series of hermetic inclusions, investigated at equilibrium at the temperature of phase changes. Diagrams of homogenization (heterogenization) temperature (T_H) versus time of experiment (t or better log t) are useful to determine the time for reaching equlibrium and the viscosity of melt. The heating rate most suitable is 10-30°C/min. before the beginning of melting and 1-2°C/min. with periodic breaks in temperature increase at the time of melting. The time period for inclusion homogenization in basic rocks is 1/2 to 1/4 of that for acid rocks and at least 3-5 hours to 6-12 hours in the latter (acid) rocks (1-2 hours for ultrabasic rocks). Large and crystallized inclusions require longer exposure time than the small ones. In previously stablilized melt inclusions in minerals of ultrabasic rocks, alkaline basaltoides, and granitoids, the time for achievement of equilibrium at temperatures close to T_H are 2-5 min., 20-30 min. and 1-2 hours respectively. (Authors' abstract).

BANNIKOVA. L.A. AND SUSHCHEVSKAYA, T.M., 1973, Chemical regime of formation of cinnabar deposits of Krasnodar district: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept. 1973: Rostov, Rostov Univ. Press, p. 154-155 (in Russian; translation through the courtesy of A. Kozlowski). Authors at GEOKHI, Acad. Sci. of USSR, Moscow.

1. (...) At the investigated deposits (Pereval'noe, Sakhalinskoe) two mineralogical zones were distinguished. The interal zone consists of strongly silicified clays partly replaced by quartz, with irregular aggregates and veinlets of sulfides. The external zone is made of calcite veinlets cutting the silicified clays. Silicification was the first stage of deposition. Calcite and sulfides precipitated at the same time but at various places.

2. Using water leachates from quartz, calcite, cinnabar, antimonite and pyrite, the following features of the mineral-forming solutions were determined: low salinity, $Ca>Mg>K>Na\geq Li$, $SO_4>HCO_3>F>Cl$ (but in calcite: $Ca>Mg>Na>K$, $HCO_3>Cl>F\geq SO_4$). Li was found in inclusions in calcite. Sulphate ion occurs in very small amounts in calcite but in solutions from quartz it is the prevailing anion. Na/K, Mg/K, Cl/F and Cl/B differ strongly (by 1-2 orders) in solutions from quartz and from calcite. (Authors' abstract, abbreviated by A.K.)

BANSHCHIKOVA, I.V., KRAVCHENKO, S.M. AND MANUCHARYANTS, B.O., 1973, Conditions of crystallization of extrusive andesites of Mendeleev Volcano (melt inclusion data): Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 209 (in Russian; translation through the courtesy of A. Kozlowski). Authors at Inst. of Mineralogy and Geochemistry of Rare Elements, Moscow.

Melt inclusions were investigated in phenocrysts of plagioclase, quartz, and olivine from andesites and dacites of the central post-caldera Holocene dome of Mendeleev Volcano at Kunashir Island (the Southern Kurils).

Phenocrysts of plagioclase and quartz commonly bear melt inclusions: glass plus gas, rarely glass plus cyrstals plus gas, distributed in all the phenocrysts in the same mode and strictly regularly. The central part of plagioclase phenocrysts(with melted edges) does not bear primary inclusions, but often contains numerous pseudosecondary melt inclusions corresponding to primary ones from the outer part of the crystal.

The outer part of the plagioclase phenocrysts bears major amounts of primary inclusions, localized along growth zones. The most numerous inclusions in a zone adjacent to the partly melted inner part have T_H 1380°C. In the outer part of pheocrysts, in addition to the above, some groups of primary inclusions are distinctly isolated in growth zones, with T_H regularly decreasing from 1370 to 1290°C, toward the outside of the pheoncrysts. In some cases certain groups of inclusions mark small local zones of slight melting.

Phenocrysts of quartz bear primary and pseudosecondary melt inclusions with T_H 1150-980°C. (Authors' abstract)

BARKER, Colin, and SOMMER, M.A., 1973, Mass spectrometric analysis of the volatiles released by heating or crushing rocks, in Analytical Methods Developed for Application to Lunar Samples Analyses, ASTM STP 539, American Society for Testing and Materials, p. 56-70. Authors at University of Tulsa, Tulsa, Oklahoma 74104.

The volatiles trapped in rocks can be released either by heating or by crushing. Unfortunately crushing generates new, clean surfaces which adsorb chemically active gases and thus change both the amount and composition of the evolved gases. For quantitative analysis the volatiles were released by heating 0.1-g samples in fused silica tubes at temperatures up to 1200°C. The evolved volatiles were separated into two fractions by fractional freezing. Volatiles which were not condensed in a liquid nitrogen-cooled trap (hydrogen, carbon monoxide, methane, nitrogen, helium, etc.) were mixed with a known amount of argon internal standard and leaked into a calibrated E.A.I. QUAD 1110 mass spectrometer for analysis. The condensable volatiles (water, carbon dioxide, higher hydrocarbons) were subsequently evaporated and analyzed in the same way. The analog output from the mass spectrometer was fed to a digital integrator which printed the areas of the peaks on a teletype and simultaneously punched a paper tape. The tape was later transmitted over a telephone line to a time-shared computer for data processing. (Authors' abstract)

BARLIER, J., TOURAY, J.-C., and GUILHAUMOU, N., 1973, Evidence of the genesis of liquid and gaseous hydrocarbons in the inclusions in quartz of the Autapie Nappe, Provence Alps, France: Acad. Sci., (Paris) C.R., Ser. D, v. 277, no. 21, p. 2297-2300 (in French). First author at Lab. de Géochim. des Roches Séd., Univ. Paris Sud, Centre d'Orsay, Bat. 504, 91405, Orsay, France.

A series of inclusions were examined over a wide range of temperature (-180 to +220°C) and tabular data presented on the thermal behavior of aqueous and hydrocarbon (mainly CH_4) inclusions. Good photomicrographs. (ER.)

BARNES, H.L., 1973, Review of Composition of Fluid Inclusions, by E. Roedder: Econ. Geol., v. 68, p. 415 (see Fluid Inclusion Research - Proceedings of COFFI, v. 5, 1972, p. 89).

A generally favorable review by an otherwise negative exponent of fluid inclusions. (E.R.)

BARNES, Ivan, and HEM, J.D., 1973, Chemistry of subsurface waters: Annual Review of Earth and Planetary Sciences, v. 1, 1973, Fred A. Donath, Editor: Palo Alto, California 94306, Annual Reviews Inc., p. 157-181. Authors at U.S. Geological Survey, Menlo Park, California.

A review of water types and localities in terms of special (or non-special) compositions or temperatures, with explanations of their origins and 178-item bibliography (E.R.).

BARRON, L.M., 1973, Nonideal thermodynamic properties of H_2O-CO_2 mixtures for 0.4-2kb and 400-700°C: Contr. Mineral. and Petrol., v. 39, p. 184. Author at Geological Survey of New South Wales, Australia.
A brief discussion of data in Ryzhenko and Malinin, 1971. (ER)

BARSUKOV, V.L., and SUSHCHEVSKAYA, T.M., 1973, Evolution of composition of hydrothermal solutions in the formation of tin-ore deposits: Geokhimiya 1973, no. 4, p. 491-503 (in Russian; translation in Geochem. Internat., v. 10, no. 2, 1974, p. 363-375). Authors at Vernadskiy Institute of Geochemistry and Analytical Chemistry, Academy of Sciences of the USSR, Moscow.

Results are presented on decrepitation, homogenization, and analysis of aqueous extracts (particularly for Na/K and HCO_3/Cl) from inclusions in the minerals of ore bodies and mineralized zones around sulfide-cassiterite and quartz-cassiterite deposits. It is found that the hydrothermal solutions that gave quartz-cassiterite deposits contained mainly sodium, whereas those that gave sulfide-cassiterite ones contain mainly potassium.(Authors' abstract)

BARSUKOV, V.L., and SUSHCHEVSKAYA, T.M., 1973, On the composition evolution of hydrothermal solutions in the process of the formation of tin ore deposits: Geokhimiya, 1973, no. 4, p. 491-503 (in Russian; translated in Geochemistry Internat., v. 10, no. 2, 1974, p. 363-375). Authors at V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry, USSR Academy of Sciences, Moscow.

Data on decrepitation (100°-380°C), homogenization (190°-514°C) and analysis of water extracts from inclusions in minerals of ore bodies and mineralized zones of sulfide-cassiterite and quartz-cassiterite deposits are presented. Some of the decrepitation temps. are as much as 130° lower than homogenization temperatures, due to high CO_2 concentrations. It is shown that during the formation of quartz-cassiterite deposits hydrothermal solutions are mainly sodic, and during the formation of sulfide-cassiterite deposits they are mainly potassic. F ranged from 1 to 4 gm/l. (Authors' abstract, extended by ER.)

BARTON, P.B., BETHKE, P.M., and RYE, R.O., 1973, Hypothetical process for formation of O^{18} and deuterium-rich ore-forming waters at Creede, Colorado: Geological Survey Research 1973, U.S. Geol. Sur. Prof. Paper 850, p. 5.

The oxygen and hydrogen isotopic compositions for sericite, chlorite, quartz, carbonates, and fluid inclusions show that the water of the ore-forming system differs dramatically from both normal magmatic water and modern ground water. The data suggest either a drastically different climatic regime in the San Juan area in the late Oligocene, or a hypothetical process (such as the evaporation of lake) that could enrich the meteoric water in both O^{18} and deuterium, or prolonged reaction of magmatic water with volcanic rocks at low temperature to produce an oxygen shift of heretofore unrecognized magnitude. (Authors' abstract)

BARTON, P.B., Jr., and HAAS, J.L., Jr., 1973, Role of nitrogen in hydrothermal ore formation: Geol. Survey Research 1973, U.S. Geol. Sur. Prof. Paper 850, p. 138.

Considerations of thermodynamic data and natural occurrences of nitrogen-bearing compounds show that atmospheric nitrogen could have an oxidizing influence under some conditions of sulfide ore formation. The nitrogen is reduced to ammonia or ammonium ion, giving an oxidizing effect about three times as great as that of dissolved atmospheric oxygen. This effect is favored by low pH and fixation of ammonium in solid phases. It is suggested that these processes would lead to significant isotopic fractionation of nitrogen and that such fractionation could prove useful in the interpretation of conditions of ore formation. (Authors' abstract)

BASKOV, Ye.A., VETSHTEYN, V.Ye., SURIKOV, S.N., TOLSTIKHIN, I.N., MALYUK, G.A., and MISHINA, T.A., 1973, Isotope composition of H, O, C, Ar, and He in hot springs and gases in the Kuril-Kamchatka volcanic region as indicators of formation conditions: Geokhimiya, 1973, no. 2, p. 180-189 (in Russian; translated in Geochemistry Internat., v. 10, no. 1, 1974, p. 130-138). First author at All-Union Geological Research Institute, Leningrad.

Isotopic compositions are given for H, O, C, Ar, and He in thermal springs and gases in the Kuril-Kamchatka volcanic region; the isotopes of H, O, and Ar indicate that most of the hot springs contain water of atmospheric and sedimentation (marine) origins. Volcanoes in the solfataric stage, the most deep seated, are fumaroles, (sic) as of sulfate composition, to judge from the $\delta^{18}O$, whereas those of the halogen stage are fumaroles of chloride composition. The source of the methane rich in ^{12}C($\delta^{13}C$ to -3.2) may be organic matter in sediments. Some of the gases (CO_2, He) have a probable deep (mantle) origin. The clearest criterion for a deep origin of hydrothermal solutions is the very high level of ^{3}He ($\delta^{3}He$ usually 500-700% relative to atmospheric helium). Authors' abstract)

BASS, M.N., MOBERLY, R., RHODES, J.M., SHIH, C., and CHURCH, S.E., 1973, Volcanic rocks cored in the Central Pacific, leg 17, Deep Sea Drilling Project, sect. 14 <u>in</u> Initial Reports of Deep Sea Drilling Project, v. 17, ed. by P.H. Roth and J.R. Herring: Washington, U.S. Govt. Printing Office, p. 429-503. First author at Hawaii Inst. Geophysics, Honolulu, Hawaii.

A thorough study of the petrology and alteration of the various igneous and volcanic rocks cored. Zeolite facies metamorphism has been extensive. Some textures suggested as stemming from immiscible carbonatite magmas (Plate 1, figs. 7 & 8). (E.R.)

BAZAROV, L. Sh., 1973, Evolution of mineral-forming medium during pegmatitic and apogranitic processes: Abstracts of papers from Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 191-192 (in Russian; translation through the courtesy of A. Koslowski). Author at Inst. of Geology and Geophysics, Siberian Branch, Acad. Sci. of USSR, Novosibirsk.

Process of formation of pegmatites and apogranites (depending on local conditions) includes three stages following one another:

a) Magmatic: phase state - melt; solution-melt. T interval 1080± 400°C; P 1500 ± 250 atm, water concentration 40 - 2 wt %. Melts consist of rock-forming minerals (quartz, feldspars, spodumene, etc.) and alkaline chlorides (KCl, NaCl), CO_2 not analytically recognizable H_2S, SO_2, HF, HCl + NH_3, besides N_2+ rare gases and other components.

b) Pneumatolytic: phase state-gaseous, T, 780 - 370°C (and lower under condition of low density of solutions) P, 1400 - 150 atm, (and lower) density (calculated on the basis of water, dissolved salts omitted) up to 0.3 g per cm^3 when homogenous. Gases, in addition to H_2O bear CO_2, the group (H_2S + SO_2 + HF + HCl + NH_3), H_2, O_2, and N_2 + rare gases.

c) Hydrothermal: phase state-liquid, T, 520 to 60- 100°C (depending on density), P, 670 - 30 atm, density (calculated as above, in b) up to 0.95 g per cm^3, salt concentrations from 2 - 3 wt % to 50 and more. Composition: Ca, Mg, Si, Fe, Al, Mn, Na, K, Cl, SO_4^{2-}, F, CO_2, O_2, H_2, CO, N_2 + rare-gases and other components. (Author's abstract)

BAZAROV, L.Sh., AND BAULIN, K.M., 1973, Inclusions in minerals of non-granitic pegmatites: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30, Sept. 1973: Rostov, Rostov Univ. Press, p. 239-240 (in Russian; translation through the courtesy of A. Kozlowski). Authors at Inst. of Geol. and Geophysics, Siberian Branch Acad., Sci. of USSR, Novosibirsk.

1. (...)

2. Inclusions in veins of olivinite pegmatoids of Bor-Urlyakh intrusion: The intrusion is composed nearly completely of olivinites, cut by thin veins of alkaline syenites and carbonatites. The essential part of the pegmatoid veins of olivinite with phlogopite and titaniferous magnetite ores occurs in central and NE part of intrusion.

3. (...) T_H of crystallized inclusions in olivine from pegmatoid veins = 980-1100°C, in clinopyroxene such inclusions gave T_H = 900-1000°C,

4. Phase composition of the inclusions (in %): gas (5) + olivine (55) plus pyroxene (30) plus ore mineral (10). (Authors' abstract, with abbreviations by A.K.)

BAZAROV, L. Sh., GORDEYEVA, V.I., SENINA, V.A., and MOTORINA, I.V., 1973, Physicochemical conditions of crystallization of spodumene in rare-metal pegmatite: Akad. Nauk SSSR, Doklady, v. 213, no. 4, p. 922-925 (in Russian; translated in Doklady Acad. Sci. USSR, v. 213, p. 137-139, 1975; abstract in Int. Geol. Rev., v. 16, no. 2, p. 241-242, 1974.) Authors at Institute of Geology and Geophysics, Siberian Division, USSR Academy of Sciences, Novosibirsk.

Mineralo-thermo-barometric investigation of thousands of primary, pseudosecondary, and secondary inclusions in spodumenes, from several pegmatite provinces in USSR, lead to the following generalizations: a) in rare metal pegmatites, spodumene crystallizes from the melt (solution) at 520-220°C and around 1500 atm pressure; b) density of the spodumene-yielding solution is up to 1.8 g/cm^3 of which, in gm/cm^3, 0.3 is water and CO_2, 0.3 dissolved salts, and the remainder - dissolved solid phases of minerals; c) the aqueous phase of the inclusions contains Na, K, Li, Mg, HCO_3, Cl, SO_4; the gas phase contains CO_2, H_2S, SO_2, HCl, HF, NH_3, N_2, rare gases; d) concentration of Li in the solutions, 1.92 to 0.15% by weight, decreases progressively at decreasing temperature of the crystallization; Mg is missing at >350°C; K seems unrelated to the temperature; Na increases from 400 to 300°C and then decreases to its minimum at 200°C. (Authors' abstract)

BAZAROV, L.Sh., and MIKHAYLOV, M.Y ., 1973, New method for determining carbon dioxide and water in inclusions in minerals: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. press, p. 300 (in Russian; translation provided through the courtesy of A. Kozlowski). Authors at Inst. of Geol. and Geophysics of Siberian Branch of Acad. Sci. of USSR, Novosibirsk.

In IGG SB AS USSR the authors have constructed an apparatus for determination of the amount of water and carbon dioxide in inclusions. Two methods are used for opening inclusions: crushing in vacuum and opening by heating.

Exact determination of the amount of CO_2 and H_2O is achieved by recording the solid-gas phase inversion during temp. decrease in a system of constant volume. When the system reaches the two-phase curve, a sharp decrease in pressure occurs. Calculations were made using the Mendeleev-Clapeyron equation, taking into account the temperature dependence of the phase inversion on the pressure of saturated water vapor and CO_2. The method permits determination of the amount of H_2O and CO_2, practically separately, for each temperature generation of G-L inclusions. The accuracy of the determination of the amount of H_2O ± 2.5%, and the sensitivity is 0.00001g. (Authors' abstract)

BAZAROVA, T.Yu., CANILHO, E.M., SOBOLEV, V.S., and SHUGUROVA, N.A., 1973, Temperatures and conditions of crystallization of alkaline effusives from the Majo Isle (Cap Vert): Lithos, v. 6, p. 403-411. First author at Institute of Geology and Geophysics, USSR Academy of Sciences, Novosibirsk, USSR.

Inclusions of glass, crystals, and gases in minerals from the rocks basanite, etindite and melilite-ankaratrite, Majo Island, Cap Vert, indicate that crystallization took place at temperatures between 1180 and 1110°C and that CO_2 was the most important gas, making up 97.5 vol. % of the gas phase. The partial pressure of CO_2 during crystallization of melilite-ankaratrite was 4.5 kbars. (Authors' abstract)

BELAVIN, E.A., and KARZHAVIN, V.K., 1973, Calculating homogeneous gas reactions in geochemistry. Algorithm for calculating equilibrium constants: Probl. Izuch. Osvoeniya Prir. Resur. Sev., 1973, p. 207-215 (in Russian). Edited by Ivanova, T.N., Akad. Nauk SSSR, Kol'sk, Filial: Apatity, USSR. Chem. Abstracts, v. 80, 136005q, 1974.

Starting with the law of mass action an algorithm was developed for the computer-assisted calcn. of equil. consts. (K) in the closed gas-liq. systems, found as inclusions in rocks and minerals. The theor. K detd. for several temp. and pressure conditions can be compared with K detd. for the actual gas-liq. inclusions. The comparison provides the ranges of temp. and pressure for the inclusion formation. (Authors' abstract)

BERGER, V.I., BELOZEROV, V.N., GOLUBCHINA, M.N., KUZ'MIN, V.G., LEVITSKIY, Yu.F., AND MOSKALYUK, A.A., 1973, Formation conditions of the W. Palyanskoe mercury deposit: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press,

p. 96-97 (in Russian; translation provided through the courtesy of A. Kozlowski) Authors at VSEGEI, Lenigrad.

The deposit occurs in the N part of Okhotsk-Chukotka volcanic range and it is connected with a Lower Cretaceous volcanic structure. Two stages of mineralization were found: A. early hydrothermal - veins of quartz, and B. postvolcanic ore stage, subdivided into two parts: early - cinnabar-sulfide with very fine-grain collomorphic ores, and late, cinnabar-dickite-siderite with coarse-grained aggregates of cinnabar, free of other sulfides.

Stage A is characterized by a low temperature of origin: 150-130°C, and by alkaline sulfate-bicarbonate solutions.

Early ore mineralization (stage B) formed at temperatures 230-160°C, from solutions of sulfate-NH_4^+-Mg-Ca type, that were acid and high in salt concentrations; late ores (stage B) precipitated at 190-129°C from dilute bicarbonate-halide-Mg-Ca-alkaline solutions bearing low amounts of NH_4^+. (Authors' abstract, shortened by A.K.)

BESKROVNYI, N.S., 1973, Specific peculiarities of petroleum in endogenic processes: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 158 (in Russian; translation through the courtesy of A. Kozlowski). Author at All-Union Scientific-Research Geological-Prospecting Institute, (locality not given, A.K.)

Two groups of specific peculiarities of petroleum in endogenetic processes were distinguished on the basis of data obtained from investigations of recent hydrotherms of Uzon volcano (Kamchatka), Yellowstone caldera (Wyoming), inclusions in a doleritic dike (Dipvik)* (Norway), inclusions in quartz from vein of a crystalline massif (S. Africa; probably that investigated by Kvenvolden & Roedder, A.K.), inclusions in fluorite from Koh-i-Maran (Pakistan, cf. Beskrovnyi, et.al., 1971, Doklady AN SSSR vol. 201, no 1, pp. 187-190, A.K.) and others.

The first group of features testifies to a "hot" origin of petroleum, with the action of hydrogenization processes, synthesis from simple gases and, perhaps, decomposition of complex organic compounds.

1. Presence in petroleum of compounds that are unstable under atmospheric conditions, probably with aldehyde group C=O and with S with isotopic composition close to meteoritic standard. 2. Petroleums of various composition occurring very sparsely and lacking fractions in the range 200-250°C. 3. Domination of molecules with an even number of carbon atoms between n-alkanes. 4. Strong domination among n-alkanes of molecules with n - C_{18} etc.

The second group of features indicating an anomalous "hot" occurrence of petroleum: hydrocarbons and structural elements, which after some reconstruction can be related to components of living substance.

1. Porphyrins. 2. Tetracyclic naphthene hydrocarbons (C_nH_{2n}). 3. Isoprenoids 4. Optical activity. (Author's abstract)

---

* Russian transcription, original name is not available (A.K.).

BESKROVNYI, N.S., and KAMENSKIY, I.L., 1973, Gaseous homologs of methane in some hydrothermal systems of Kamchatka: Akad. Nauk SSSR, Doklady, v. 208, no. 1, p. 211-213 (in Russian; trans. in Doklady Acad. Sci. USSR, Earth Sci. Sects., v. 208, p. 200-202). Authors at All-Union Petroleum Exploration Research Inst., Leningrad.

Gases from 16 samples from hot springs were concentrated and analyzed by gas chromatography using molecular sieves for H_2O, O_2, CH_4,

C_2H_6, C_3H_8, H_2, N_2, (Ar, Kr, Xe), (He, Ne) and heavy hydrocarbons. (ER)

BETHKE, P.M., RYE, R.O., & BARTON, P.B., Jr., 1973, Hydrogen, oxygen and sulfur isotopic compositions of ore fluids in the Creede District, Mineral County, Colorado (abst.): Geol. Soc. Amer. Abstracts with Programs; v. 5, no. 7, p. 549. First author at U.S. Geological Survey, Reston, Va. 22092

Measured isotopic ranges from the Ag-Pb-Zn-Cu Creede District are:

PHASE(samples)	$\delta^{18}O$‰ SMOW	δD‰ SMOW	PHASE(samples)	$\delta^{34}S$‰ CD
Surface water (3)	-15.2 to -14.9	-112 to -109	Sphalerite (49)	-3.3 to +1.7
Fluid incl. (2)	- 5.9 to - 5.4	- 62 to - 54	Galena (2)	-4.1 to -0.9
Sericite (8)	+ 1.8 to + 4.9	-101 to - 88	Pyrite (5)	-3.5 to +0.7
Chlorite (11)	-2.1 to + 0.9	-111 to -102	Barite (4)	+19.8 to+31.3
Vein quartz (13)	+4.4 to + 9.3			

Studies of fluid inclusions and calculations on the mineral assemblages show that the depositional parameters were: T = 190-265°C (median 250°C); depth = 1500±500 feet; salinity=4-12 wt.%; Na/K $_{(atomic)}$ ∿10; pH = 5.5-6; $\Sigma S = 10^{-1\pm0.8}$. f_{O_2/S_2} was buffered by reactions between chlorite, hematite, pyrite, and quartz to a band between $\log f_{O_2}/\log f_{S_2} = -33/-10$ to $-38/-13.5$ (250°C), and most, but not all, sulfide deposition appears to have taken place from a Σsulfate>Σsulfide fluid. $\delta^{18}O$ of water from fluid inclusions in sphalerite, and calculated from the solid phases, ranges from -6 to 0‰ and δD is -58±‰. The $\delta^{18}O$ is far too low to be of deep-seated origin, whereas the δD differs drastically from present surface water. The ore fluids apparently were dominantly meteoric waters whose isotopic character was established in the late Oligocene under a different climate and then enriched in ^{18}O by reaction with the volcanic country rocks. The interpretation of the sulfur isotope data remains ambiguous, but the narrow range in $\delta^{34}S$ of sulfides formed over a wide range of chemical conditions suggests isotopic and/or chemical disequilibrium in redox reactions involving sulfur. (Authors' abstract)

BETTETINI, Etienne, 1973, De l'utilisation de la macro et microcinématographie appliquée a l'étude des inclusions dans les cristaux et les gemmes, en particulier aux inclusions fluides: PhD dissertation, Univ. Nice, 79 pp. (in French)

A review of the study of inclusions (20 references), both solid and liquid, in a variety of minerals and gems, and a discussion of the mechanical and optical procedures used by the author in making a motion picture of several facets of their behavior, as on heating. Includes 17 large photoplates and description of 72 slides used in a talk on "The interior of crystals and gems" as well as the script accompanying the 16-mm film (title as shown at top). (ER).

BOBOLOVICH, G.N., 1972, Application of inclusion decrepitation methods for investigation of minerals with excellent cleavage; Institute of Geology of Komi Division, Academy of Sciences of USSR, Yearbook for 1971: Syktyvkar 1972, pp. 183-189. (In Russian; abstract through the courtesy of A. Kozlowski). Author at Inst. of Geology of Komi Division of Acad. Sci. of USSR, Syktyvkar.

In the literature one may find various opinions on application of the decrepitation method to minerals with excellent cleavage (e.g. calcite, dolomite, barite, and fluorite). The author, after reinvestigation of the problem by use of thermoacoustic, visual, thermogravimetric and thermobaric decrepitation methods and the homogenization method, concludes as follows:

1. Thermometric determinations by the decrepitation method in minerals with excellent cleavage can be made to reach reproducible results that are independent of the crystallization temp. Data on minerals with various types of cleavage are not comparable.

2. During interpretation of acoustic decrepigraphs it is necessary to take into account not only presence or absence of inclusions in minerals, but also the relative amount of inclusions. The beginning of decrepitation ought to be determined especially carefully, and usually is used to estimate T_H. The temperatures of maximum decrepitation are believed to be more comparable, and best results are obtained by examination of all decrepigraphs.

3. Values of T_D obtained by all the methods tried are similar, proving that calcite, fluorite and sphalerite of the investigated deposits crystallized at similar intervals of temperature.

4. Anomalous decrepitation is not caused only by mineral cleavage, but also by the presence of (solid? Ed.) inclusions, and the cleavage intensifies the decrepitation effect.

T_D obtained by use of various decrepitation techniques'

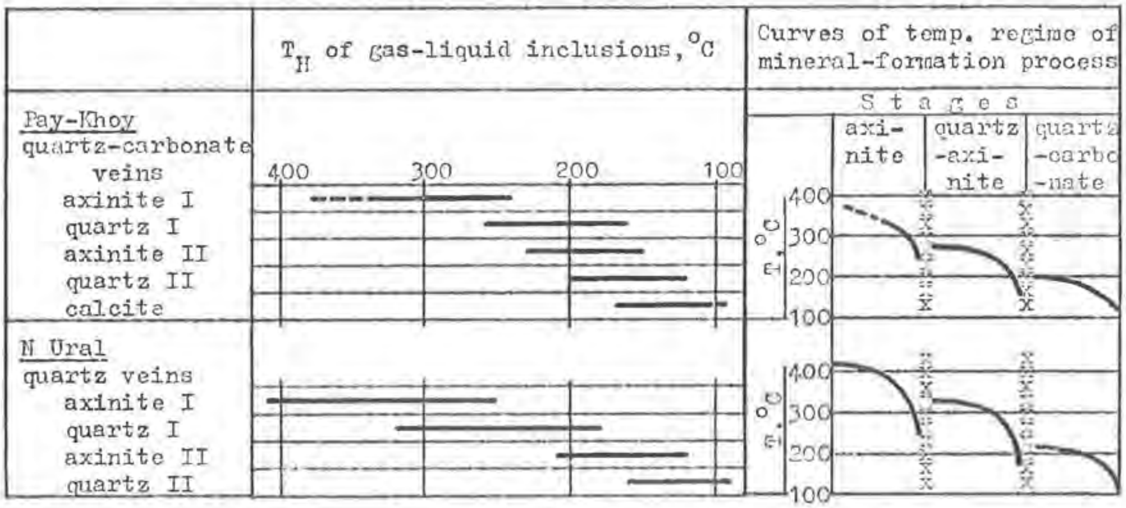
Locality	Acoustic			Visual		Gravimetric			Baric
	fluorite	calcite	sphalerite	fluorite	calcite	fluorite	calcite	sphalerite	fluorite
Andermin fluorite deposit, quartz-fluorite-sphalerite ore	260-280(2)	-	-	-	-	400(1)	-	-	-
	260-280(1)	-	-	320-340(1)	-	-	-	-	-
	300(2)	-	-	320-370(2)	-	370-450(8)	380-410(4)	-	350-390(2)
	300(1)	-	-	-	-	395(1)	-	-	-
NE part of anticlinorium sphalerite-sulvanite ore	-	280(1)	240-300(2)	-	320-340(1)	-	-	-	-
Severnyi Field, Morey Mt. Cu ore	-	260-280(2)	-	-	350(1)	-	-	-	-
Yushar Region chalcopyrite-sphalerite ore	-	-	260-300(1)	-	-	-	-	380(1)	-
Central Pay-Khoy quartz-calcite veins in diabases	-	300-320(1)	-	-	-	-	390-395(2)	-	-

BOBOLOVICH, G.N.,1973, Temperature regime of axinite-bearing vein formation at Pay-Khoy and N. Ural: Institute of Geology of Komi Division, Academy of Sciences of USSR, Yearbook for 1972: Syktyvkar, 1973, pp. 149-154 (In Russian; abstract through the courtesy of A. Kozlowski). Author at Inst. of Geol., Komi Division, Acad. Sci. USSR, Syktyvkar.

Axinite-bearing quartz-calcite veins at Pay-Khoy are connected genetically with sills of Middle Paleozoic diabases and occur in diabase or in hornfels. External zones of the veins consist of opaque and semitransparent axinite (1), mainly fine grained; zone 2 - coarser grained axinite and semitransparent quartz; zone 3 - the main part, filled by milky quartz; zone 4 - central, platy calcite. Axinite of (1) bears minute two- and one-phase inclusions; primary ones have degree of filling F = 70-80 vol. %, T_H 245-342°C. The earliest axinite (unsuitable for investigations because of very low transparency) was probably formed at higher temperatures. Axinite of (2) bears very numerous inclusions (solid) of tremolite asbestos, and fluid inclusions with F 85 - 90 vol. %, T_H 230-150°C. Milky quartz of (3) gives T_H 200-120°C, and calcite of (4) - 175-105°C.

Early axinite from N. Ural gives T_H of primary inclusions 405-250°C, late axinite - 205-125°C. The temperature and tectonic regime is given in the figure.

Figure. Temperature and tectonic regime of axinite-bearing veins



xxxxxxxxx - tectonic gaps

BOBOLOVICH, G.N. and PETROVSKY, V.A., 1973, Mechanism of formation of anomalous syngenetic inclusions in crystals: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press p.313-315 (in Russ.; translation provided through the courtesy of N.P. Ermakov). Authors at the Institute of Geology of the Komi Branch of the USSR Academy of Sciences, Syktyvkar, USSR.

A directional stream of gas bubbles was formed by adding some acid to the solution and several Zn granules were placed under one of the two seed-crystals. A large number of hydrogen bubbles formed from the reaction of Zn with HCl.

Thus two types of crystal growth conditions were produced in the crystallizer: a) growth in the directional stream of gas bubbles; b) growth in comparatively quiet conditions, with chaotic motion of small gas bubbles. A series of six experiments were made, varying the degree of supersaturation, with the following results:

1. The first type of growth conditions did not result in bubble capture even at considerable supersaturation except through formation of separate inclusions on faces having the greatest growth speed. On the other hand, a considerable number of anomalous inclusions were trapped in the crystal growing free of the directional flow of gas bubbles.

2. If large gas bubbles (0.5 - 1.0 mm) stuck to a normal growth face, its surface is broken because of the nonhomogeneous stream of nourishing solution. Streaming-over-bubble-figures were marked by convectional stream, which is fixed by series of small transformator inclusions (0.01 - 0.3 mm) (sic). Radial inhomogeneities were observed on the phase boundary gas bubble - crystal face, because of bubble vibration, which formed a halo of small inclusions. This case is much like

the one described by G.G. Lemmlein for overheated inclusions.

3. Capture and non-capture of the bubble and its form were determined by its size and growth speed of the face under consideration.

4. In all cases liquid phase was captured together with the gas phase and their ratio is independent of the size of bubbles. (Authors' abstract).

BOETTCHER, A.L., MYSEN, Bjorn O., and MODRESKI, P.J., 1973, Phase relationships in natural and synthetic peridotite-H_2O and peridotite-H_2O-CO_2 systems at high pressures (extended abst.): in Internat. Conf. on Kimberlites, Extended Abstracts of Papers, L.H. Ahrens, et al., eds.: Univ. of Cape Town, Rondebosch, Cape Town, South Africa, p. 35-38. Authors at Dept. of Geosciences, Pa. State Univ., University Park, Pa. 16802.

BOGOLEPOV, V.G., 1972, Essential directions of investigations in determination of the practical value of hydrothermally altered rocks; criteria of ore productivity of metasomatites, in Papers of All-Union Symposium, Alma-Ata, 1972, Kazakh Scientific-Research Institute of Mineral Raw Materials, and Inst. of Geological Sciences, Academy of Sciences of Kazakh SSR, part 1, Alma-Ata 1972, pp. 9-35 (in Russian; abstract through the courtesy of A. Kozlowski).

On the basis of fluid inclusion study the similarity of ore-forming fluids with subsuperficial waters (from near surface to 5 km) in terms of hydrochemical zonality, was ascertained. Argon composition from fluid inclusions of quartz from pegmatites, greisens and skarns of relatively shallow deposits (same range of depths), indicates its atmospheric origin (similar to Ar isotope composition in subsuperficial waters). Juvenile waters were revealed only in inclusions in pegmatitic minerals of very old and deep formations (Karelia, Volhyn). Mixed Ar isotope compositions are known also, and in higher temperature inclusions the participation of atmospheric Ar is sometimes less than in low temperature inclusion generations (pp. 19-20).

The presence of F in chloride type greisenising solutions complicates the greisen composition and the ore mineralization has a complex character. When F is practically absent, metasomatites become simpler and bear essentially only Mo ore mineralization.

The amounts of Cl and CO_2 in greisens of Kazakhstan are the same in all parts of the greisen bodies, being trapped in gaseous-liquid inclusions (in some bodies calcite was found in their top parts). The amount of F and S in the solutions migrating in the metasomatites increases, reaching a maximum in apical parts of the bodies, forming quartz-topaz greisens with continuous presence of disseminated pyrite (p. 34).

BOGOLEPOV, V.G., DAVIDENKO, I.V. AND POLYVYANNYI, E.Ya., 1973, Application of argon from gaseous-liquid inclusions of quartz from pegmatites to the solution of genetic and practical problems: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 162-163 (in Russian; translation through the courtesy of A. Kozlowski). Authors at Kazakh Inst. of Mineral Raw Materials, Geological Inst. of Kola Division of Acad. of Sci. USSR.

One may ascertain, as shown by a number of pegmatites from various regions of the USSR, that the content of atmospheric and radiogenic argon in low- and high-temperature inclusions in quartz is not accidentally connected with the dimensions of commercial mineralization of pegmatitic bodies. As the unit to be compared, the percent concentration of atmospheric Ar in low- and high-temperature inclusions was accepted. Commercial muscovite pegmatites have a ratio lower than 1, deposits with minor amounts of poor muscovite have a ratio 1 - 2.5, and quartz from non-commercial pegmatities have a ratio higher than 2.5 (see Table).

Characteristics of gaseous component of gas-liquid inclusions of quartzes from pegmatitic deposits

No.	Atmospheric Ar, %		I/II	Commercial value of pegmatitic body			
	I	II		A	B	C	D
			Mica-bearing pegmatites				
1	26.60	3.27	8.15				x
2	0.63	0.16	3.94			x	x
3	36.82	12.0	3.06				x
4	14.49	5.68	2.55			x	x
5	10.70	4.28	2.50			x	
6	2.49	1.78	1.40			x	x
7	73.30	53.33	1.38			x	
8	92.46	79.49	1.17		x	x	
9	44.80	41.66	1.07		x	x	
10	2.66	2.84	0.93	x			
11	9.89	11.69	0.85	x			
12	1.77	3.53	0.50	x			
13	15.33	33.37	0.46	x			
14	13.48	42.88	0.314	x			
15	1.94	10.60	0.11	x			
			"Ceramic" pegmatites				
16	1.02	0.35	2.92			x	
17	3.56	1.96	1.82	x			
18	4.94	3.12	1.59			x	
			Silexites				
19	66.67	31.83	2.10	x			
20	90.0	83.4	1.08	x			

Note: I - percent of atmospheric Ar in low-temp. inclusions, II - as above, in high-temp. inclusions, A - large pegmatitic body, B - medium, C - small, D - non-commercial; 1-6, 11-13 and 15-18 - pegmatites of Kola Peninsula, 7-9, 19 and 20 - pegmatites & silexites of Kazakhstan, 10 & 14 - pegmatites of Mama River Region. (Authors' abstract)

BOGOYAVLENSKAYA, I.V., 1973, Investigations of inclusions of mineral-forming fluids abroad (1968-1972): Abstracts of Papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 26-27 (in Russian; translation provided through the courtesy of A. Kozlowski). Author at Moscow University. (Ed's. note: In the Program this was listed with L.M. Valyashko as co-author).

A review.

BOGOYAVLENSKAYA, I.V., DOLOMANOVA, E.I., LOSEVA, T.I. and BOYARSKAYA, R.V., 1973, Fluid-inclusion evidence on the physico-chemical aspects of the environment of formation of the Ehrenfriedersdorf tin deposit (DDR): Abstracts of papers at Fourth Regional Meeting on Thermobarogeochemistry of Mineral-Forming Processes at Rostov-on-Don, 24-30 Sept., 1973: Rostov,

Rostov Univ. Press, p. 76-77. (In Russian; translation provided by Dr. E.I. Dolomanova of IGEM, Moscow) Authors at Moscow State University and IGEM, USSR Academy of Sciences, Moscow

1. Inclusions of hydrothermal solutions in cassiterite, topaz, and quartz were studied. The gas-to-liquid ratio for vacuoles in the above minerals is different in greisen (after granite) and quartz veins occurring in the outer-contact zone. In the former, the gaseous phase predominates in primary inclusions (up to 60%); in the latter the liquid phase (up to 50-60%). In pseudosecondary inclusions, gas occupies 25 percent or less of a vacuole.

2. X-ray microspectrographic analysis was made of the composition of deposits on the walls of the vacuoles in cassiterite. The principal elements of the solids in the vacuoles in cassiterite from greisen are Nb, Ta, Fe, Mn, Ti, Al, Ca, K, and Si; the minor elements are W and Mo. The common elements in the vacuoles in cassiterite from quartz veins are Si, Ca, Al, Ti, Fe, K, and Cl, with lesser S and Na. The above elements in some cases enter into the composition of certain mineral species: NaCl, KCl, $AlCl_3$, $FeCl_3$, $CaCl_2$, potassium feldspar (?), fluorite or calcite (?), hauyne, columbite-tantalite, ilmenite, and rutile, and in others they form mixtures of powder-like mineral aggregates which are difficult to identify.

3. The homogenization temperature for cassiterite from greisen was 470-490°, according to type II (i.e., in the gas phase; Ed.), and 390-420°, according to type I (i.e., in the liquid phase; Ed.). The homogenization of the liquid-gaseous inclusions in cassiterite from quartz veins took place at 390-430°, and that of the gaseous-liquid inclusions at 360-370°, in both cases according to type I. The secondary inclusions were homogenized at 200-220°, according to type I.

The homogenization temperature for the liquid-gaseous fluid inclusions in topaz from greisen ranged from 430-490°, according to type II, and for gaseous-liquid ones from 290-370°, according to type I. In topaz from quartz veins, the liquid-gaseous inclusions homogenized at 390-430° and gaseous-liquid ones at 280-360°, according to type I.

The homogenization temperatures for inclusions of hydrothermal solutions in quartz are similar to those recorded for topaz. The homogenization usually proceeds according to type I, rarely to type II.

4. Decrepitation temperature of the inclusions was determined with the help of a thermobarometric unit. Most inclusions in cassiterite from greisen blow up at 450°, and those in cassiterite from quartz veins between 350° and 525°. Violent decrepitation of the inclusions took place in topaz at 320-470° and in quartz at 250-400°. In all the minerals very few inclusions blew up at higher or lower temperatures. Decrepitation temperature produces evidence of statistical character; it involves inclusions differing in size, shape, and gas-to-liquid ratio. Heating rate was 3-5° per minute.

5. The evidence obtained suggests that the deposit was formed from pneumatolytic-hydrothermal, high-concentration, multicomponent solutions at temperatures between 500° and 200°, disregarding the P correction. (Authors' abstract).

BOGOYAVLENSKAYA, I.V., and NAUMOV, V.B., (compilers), 1973, Bibliography of Soviet literature for 1972 on inclusions of solutions and melts in minerals: Moscow, Vernadski Inst., Akad. Nauk SSSR, 32 pp. (in Russian; N.P. Ermakov, Editor).

This little volume, issued in only 300 copies, lists 164 references (plus author index). Many references are to sources such as theses that are otherwise impossible to locate. It represents the continuation of the previous issue (Fluid Inclusion Research - Proceedings of COFFI, v. 5, 1972, p. 20-21). (ER)

BORCOS, Mircea, 1973, Observations on the significance of magmatic relics of mineral inclusions in volcanic rocks: Buchar., Univ., An., Geol., v. 22, p. 23-30 (in Romanian with Engl., Fr., Russ. sum.).

BORISOV, O.G., and BORISOVA, V.N., 1973, Gases of eruptive rocks and possibility of their use for geological interpretation: in Geosynclinal magmatic formations and their ore production, V.M. Necheukhin and V.A. Marks, eds.: Sverdlovsk, Inst. Geol. and Geochem., Ural Scientific Center, Acad. Sci. USSR, Transactions, v. 102, p. 168-179 (in Russian; translation provided through the courtesy of A. Kozlowski).

On the basis of statistical methods of investigation, the possibility is examined of the application of gas phase data (separated from rocks under vacuum conditions at temp. 1200°C) as petrochemical indicators of conditions of origin of those rocks. The method of calculation, the precision, and the application of data on gases of rocks, from various geological materials are given. (...) The amount of gas emanations and composition depends on the magma source. (Authors' abstract)

BOYARSKAYA, R.V., 1973, Advantages of electron microscopy in studying fluid inclusions in minerals: Abstracts of papers of Fourth Regional Meeting on Thermobarogeochemistry of Mineral-Forming Processes at Rostov-on-Don, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p320-321 (in Russian; translation provided by Dr. E.I. Dolomanova of I.G.E.M., Moscow). Author at IGEM, USSR Academy of Sciences, Moscow.

The morphology of fluid inclusions in cassiterite and sphalerite is studied by methods of transmission and scanning electron microscopy with microdiffraction and electron probe analysis. Together with E.I. Dolomanova and M.G. Kobrovol'skaya, several entrapped minerals and the composition of the liquid phase of vacuoles are identified.

The shape, size, and distribution pattern of the fluid inclusions in sphalerite and cassiterite from different deposits were established. It was also found that crystallization of the liquid phase takes place when it is ejected onto the adjacent areas of the fracture at the moment of vacuole opening. During its crystallization dendritic segregations were shown to form, as were incompletely crystallized drops, crystals with strans, (sic.) etc.

The parameters of the grid of some entrapped minerals and the minerals from the crystallized liquid were determined by microdiffraction in combination with the method of replicas with extraction. As a result, sylvite has been identified in the vacuoles in sphalerite and cassiterite and hauyne among the minerals from the crystallized liquid in cassiterite from the Ehrenfriedersdorf deposit. (Authors' abstract).

BOZHKO, M.T., POLYKOVSKIY, V.S., and KHATUNTSEV, G.V., 1973, Improved model of decrepitation apparatus "Luch-2" and of apparatus for its calibration: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 308-309 (in Russian; translation provided through the courtesy of A. Kozlowski). Authors at MINGEO, Uzbek SSR.

Decrepitometers in which electromechanic counters were applied for registration of microfracturing are characterized by limited speed of counting, <100 impulses per sec. At higher counting speeds and larger numbers of breaks, such decrepitometers yield erroneous results.

To remove this liability, industrial counting apparatus PP-16, having decatrons as indicators, was applied in "Luch-2", an improved model of decrepitometer. This apparatus can count 10^5 impulses per sec.

Decrepitometer "Luch-2" consists of a heating stage with initial amplifier, counting apparatus PP-16, a 3-millivoltmeter M-64, and a system of semi-automatic regulation of speed of heating of the furnace.

Under industrial conditions during simultaneous use of two or more decrepitometers the most important question is the calibration of sensitivity of the decrepitometers. A C-generator with 4 frequencies: 5, 20, 200 and 1000 Hz was constructed for calibration.
(Authors' abstract, with abbreviations by A.K.)

BRAITHWAITE, R.S.W., FLOWERS, W.T., HASZELDINE, R.N., and RUSSELL, M., 1973, The cause of the colour of Blue John and other purple fluorites: Mineralog. Mag., v. 39, p. 401-411. Authors at Dept. of Chemistry, Univ. of Manchester Institute of Science and Technology, England.

'Blue John' and other purple fluorites have been studied by a wide range of techniques. Hydrocarbons are not the cause of the colour of these fluorites. No significant difference in the concentrations of 73 elements between the purple and colourless zones of Blue John has been detected. The spectroscopic and thermal bleaching behavior of the purple zones is consistent with the presence of 'colloidal' calcium as colouring agent, and coloration of fluorites with calcium vapour gives material showing similar properties. The distribution of colour suggests trapping of the calcium in lattice defects along {III} (cleavage) planes through {00I} (growth) zones. The 'colloids' could be produced by aggregation of calcium atoms liberated by irradiation from sources found in the geological environment of Blue John. The banding could arise from variations in the concentration of lattice defects caused by variations in growth rates of the fluorite. (Authors' abstract) (Editor's note - see also Holgate, this volume)

BRICE, J.C., 1973, The growth of crystals from liquids: Amsterdam, North-Holland Pub. Co. 379 pp.

A general discussion of growth processes, kinetics, transport processes, and techniques. (ER).

BROWNE, P.R.L., and LOVERING, J.F., 1973, Composition of sphalerites from the Broadlands geothermal field and their significance to sphalerite geothermometry and geobarometry: Economic Geology, v. 68, p. 381-387.

Sphalerites from the Broadlands, New Zealand, geothermal field have been analyzed by electron microprobe and shown to have variable FeS and MnS contents. Samples analyzed come from drillcores at depths between 302 m and 1,841 m, where measured temperatures range from 140°C to 294°C and water pressures vary from 58.6 bars to 158.8 bars. The variable FeS contents of sphalerites coexisting with pyrite but not pyrrhotite are attributed to sulfur fugacity fluctuations. One core from drillhole Br 16 at 787 m depth (219°C) contains vugs in which pyrite, pyrrhotite and sphalerite (7.1 ± 0.6 mole % FeS) have crystallized together in equilibrium.

The composition of the Broadlands sphalerites indicates that the slope of the sphalerite + pyrite + pyrrhotite phase boundary shifts sharply below 300°C toward the low FeS field, and means that Boorman's (1967) and Scott and Barnes' (1971) constant sphalerite composition value of 20.7 ± 0.6 mole % FeS between 300°C and 550°C cannot be extrapolated to lower temperatures. Similarly, the proposed sphalerite geobarometer (Scott and Barnes, 1971) cannot be applied to deposits in which sphalerite, pyrite and pyrrhotite crystallized together at temperatures below about 300°C. (Authors' abstract)

BULGAKOVA, Ye.N., and KONENKO, V.F., 1973, Determination of pressure in inclusions of melt: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 311-312 (in Russian; translation provided through the courtesy of A. Kozlowski). Authors at Inst. of Geol. and Geophysics of Siberian Branch of Acad. Sci. of USSR, Novosibirsk.

(...) Pressure of gas in inclusion was measured at room temp. on basis of enlargement of gas bubble after opening of inclusion, as well as T of beginning of melting of solid phases. Gas composition was determined by method of quantitative analysis of individual inclusions. Gas bubble remains unchanged up to a T 100-150°C lower than T_H; changes of P versus T are isochoric. Equation of state of real gases at constant volume permits calculation of the pressure of gas mixture at T near to T_H of inclusion of melt.

Pressures determined by this method for rocks of Norilsk trap intrusives were ca. 10-200 atm, and may be accepted as minimum P of origin (for T about 100-150°C lower than T_H).
(Authors' abstract, with abbreviation by A.K.)

BURYKHINA, Z. Ye. and BURYKHIN, I.V., 1973, Temperatures of formation of mineral associations of polymetallic and low-temperature mercury ore mineralization of Moldo-too and Akchatash chains: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 95-96 (in Russian, translation provided through the courtesy of A. Kozlowski). Authors at Geological Inst. of Kirgiz SSR Academy of Sciences.

Ore areas of Moldo-too and Akchatash chains, Middle Tyan'-Shan', have mecury and polymetallic ores of low T origin, simple mineral associations, and monometallic character.

Temperature interval, indicated by fluid inclusions, is 30-200°C. T_d of galena 40-120°C, T_h of inclusions in sphalerite - 50-150°C; Th of inclusions in calcite, fluorite, and barite - 30-100°C, with most inclusions in the interval 30-70°C.

In mercury ore fields Th of inclusions in cinnabar, tetrahedrites (?), barite, and calcite range from 40 to 120°C.

Polymetallic and mercury deposits formed in practically isothermal conditions with the main part of the crystallization at 50-120°C.
(Authors' abstract)

CALAS, G., and MAURY, R., 1973, The color centers of fluorite; principles of a geologic thermometer (abstr.): Reun. Annu. Sci. Terre., (Programme Resumes), p. 115 (in French).

An attempt to combine data on T_H and laboratory bleaching of color centers to yield time-temperature data on natural fluorite. (E.R.)

CHEPUROV, A.I., 1973, Thermometric study of inclusions of melt in pseudoleucitite minerals of the central Aldan district: Akad. Nauk SSSR, Doklady, v. 213, no. 2, p. 437-440 (in Russian; translated in Doklady Acad. Sci. USSR, v. 213, p. 165-168 (1975); abstract in Int. Geol. Rev., v. 16, no. 2, p. 236, 1974). Author at Institute of Geology and Geophysics, Siberian Division USSR Academy of Sciences, Novosibirsk.

Solid inclusions in olivine, pyroxene, apatite from the "ultra-potassium" alkalies in the Yllymakh and the Tommot massifs (fig. 1) homogenize at 1140-1220°C, on the whole (fig. 2), i.e. at somewhat lower temperatures than their analogs in the "pseudoleucitite" minerals elsewhere. (Author's abstract)

CHETYRBOTSKAYA, I.I., 1971, On one classification feature of wolframite deposits, pp. 164-172, <u>in</u> Mineralogy and geochemistry of tungsten deposits (Materials of 2nd All-Union Symposium on Mineralogy, Geochemistry and Genesis of Tungsten Deposits of USSR): Leningrad, Leningrad Univ. Publishing House, 344 pp. (In Russian; abstract through the courtesy of A. Kozlowski). Author at Central Scientific-Research Geological-Prospecting Institute.

Concentrations and interrelations of Ta, Nb and Sc in wolframite changes regularly, depending upon the genetic type of deposit, and on geological-structural and physico-chemical conditions of origin, as follows:

Genetic type of deposit	Formation groups	Ore formation	T° decr. of wolframite	Deposit	Element Content, %		
					Ta_2O_5	Nb_2O_5	Sc_2O_3
Greisen	Quartz greisen	Wolframite -molybdenite	280 - - 300	Akchatau	0.004	0.23	0.036
		Wolframite	270	Antonova Mt.	0.042	0.44	0.019
		Wolframite -cassiterite	260	Dedova Mt	0.23	0.50	N. F.
			240	Zun-Undur	0.162	0.63	0.002
			200	Karaoba	0.012	0.50	0.014
Hydrothermal	Quartz low-sulfide	Wolframite -cassiterite	200	Aldakachan	0.029	0.46	0.0005
	Quartz-sulfide	Wolframite -sulfide	220	Belukha	0.003	0.058	0.0006
			200	Dzhida	0.003	0.044	-
			150 - -200	Bukuka	0.004	0.09	0.0004

CHETYRBOTSKAYA, I.I., 1972, Wolframite as indicator and new source of tantalum raw material: Moscow, Nedra Press (in Russian).

T_D of wolframites decreases with increasing distance of the mineralization from the parent granites, but the intensity of decrepitation increases: the difference of intensity is especially great between wolframites from metasomatites and from veins filling open fractures, the latter being the highest. Similar changes of T_D are typical for cassiterites. T_D of columbite-tantalite from apogranites of E Siberia is 220°C. Other data given are the same as in Chetyrbotskaya, 1971 (see previous item). (Abstract by AK)

CHIKAYAMA, Akira, 1973, Gem identification by the inclusions: Gemmological Assoc. of All Japan, (Color Edition), 246 pp. (in Japanese with some English section captions).

This volume includes 588 color photomicrographs, mostly photomicrographs of solid, liquid, or gas inclusions in gem material. (ER).

CHIKHIRKIN, V.K., PROKOPOV, N.C. AND KLINKOV, S.V., 1973, Mechanism of trapping and coalescence of gaseous-liquid inclusions (experimental data): Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov, Univ. Press, p. 286-287 (in Russian; translation through the courtesy of A. Kozlowski). Authors at Rostov University.

To explain the trapping and coalescence of fluid inclusions experiments were made on the synthesis of crystals from concentrated aqueous solutions in stainless steel autoclaves under conditions of sharp changes of P & T. In experiments of T = 350°C and P = 300-350 atm, skeletal crystals of NaCl were obtained (3 mm long), bearing a large amount of G-L and L-G inclusions. Formation of inclusions filled to various degree is explained by local microheterogenization of the solutions during quick pressure change and great speed of trapping of particles of the parent medium by the growing crystal faces.

Fluid inclusions are localized in growth zones of the crystals, they are characterized by elongated-tubular or hypidiomorphic shape and their dimensions increase greatly from the tops of growth pyramids to the base. This fact proves the correlation of speed of growth of crystal and speed of enlargement of heterogeneous defect areas in the parent solution structures.

Along with closed inclusions, numerous channels were found in crystals of NaCl; the channels are filled by gas that is soluble in silicone, and olive oils, gasoline, and other organic solvents but very slightly soluble in water and aqueous solutions of halide salts.

T_H of G-L inclusions varies from 175 to 200°C (i.e., one half of the initial T of experiment). This T decrease may be explained by the adiabatic character of the process during sharp P drop.

During thermodynamic activation of synthetic and natural halite crystals, the phenomenon of coalescence was observed in inclusions systems, taking place with measurable speed. The individual phases migrated with various speeds under the action of thermodynamic gradients resulting in diffusion of fluid, the regulation of the habit of the inclusions, and fractionation of their filling to separate gaseous and liquid phases. (Authors' abstract).

CLEMENT, C.R., 1973, The emplacement of some diatreme-facies kimberlites (extended abstract): in Internat. Conf. on Kimberlites, Extended Abstracts of Papers, L.H. Ahrens, et al., eds.: Univ. of Cape Town, Rondebosch, Cape Town, South Africa, p. 67-69. Author at Geology Dept., De Beers Consolidated Mines Ltd., Kimberley, South Africa.

Presents textural evidence (p. 68) for emulsion-like mixtures of late-stage, low temperature, immiscible K-rich silicate and carbonatitic liquids. (ER)

COOPE, J.A., 1973, Geochemical prospecting for porphyry copper-type mineralization - a review: Journal of Geochemical Exploration, v. 2, p. 81-102. Author at Newmont Mining Corporation of Canada, Toronto, Ont. (Canada).

Various prospecting techniques are discussed, including fluid inclusions. Unfortunately, the use of fluid inclusions is discussed essentially in connection with analyses of whole-rock water-extractable chloride (see Kesler et al., 1973). Although this procedure has some merit, the most obvious possible application of inclusions to prospecting is ignored. This is the qualitative identification, under the microscope, of inclusions characteristic of porphyry copper deposits, both the high salinity inclusions (from recognition of NaCl daughter crystals) and inclusions from boiling (large vapor phase). It is the presence of such inclusions and not their abundance (and hence total chloride) that is perhaps most significant, and they should be preserved in quartz residues in gossan, soil and stream sediments from a porphyry copper terrain, long after most soluble chloride is leached and gone.(Ed.)

COVENEY, R. M., Jr., 1973, Fluid inclusion studies at the Oriental Gold Mine, (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 4, p. 309. Author at Department of Geology-Geography, University of Missouri, Kansas City, Mo. 64110.

Filling temperatures of primary fliud inclusions indicate that the gold-quartz veins of the Oriental mine were emplaced at temperatures exceeding 220°C. The inclusions are enriched in CO_2 which is present as a separate immiscible liquid phase at room temperatures. Estimates of the relative volumes of the various included phases combined with thermometric data permit estimation of the total CO_2 contents (about 24 wt. percent) and the minimum pressures of entrapment (near 800 bars). These results coupled with those from sulfide geothermometers suggest maximum P-T conditions of entrapment in the vicinity of 500°C at 2000 bars.

Dawsonite ($NaAlCO_3(OH)_2$) occurs as a daughter salt in nearly all primary fluid inclusions examined. Calcite, ankerite and oligoclase are less common as daughter salts. Thus the fluids are generally saturated at room temperature in Na^+, Al^{+3}, OH^- and CO_3^{-2} and commonly have high concentrations of Ca^{+2}, Mg^{+2}, and silica.

Serpentinite and amphibolite wall rocks have been hydrothermally altered to mixtures of various carbonate species including ankerite and magnesite, though not dawsonite. Granitic rocks have been altered to a material consisting predominately of oligoclase. The characteristics of the mineralizing fluids as inferred from fluid inclusion studies are viewed as being fully consistent with the bulk mineralogies of the quartz veins and the adjacent altered rocks. (Author's abstract)

CRAMPON, Norbert, 1973, Hydrothermal low grade metamorphism within saline and penesaline facies with reference to the "saliferous complex" in Northern Tunisia: Contr. Mineral. and Petrol., v. 39, p. 117-140 (in French with English abstract). Author at Laboratoire de Pétrologie, U.E.R. Sciences de la Terre, Métallurgie, Chimie Minérale, Université de Nancy I, 54037-Nancy Cedex, France.

The sedimentary rocks of "saliferous formations" in the Tunisian far North have gone through frequent recrystallization or a notable dolomitization to which idiomorphic minerals, mainly quartz and feldspar, are frequently added. Studies carried out on fluid inclusions from these crystals lead thermometric figures clearly exceeding the range of values met with in diagenesis. These new parageneses are best related to low grade metamorphism in hypersaline brines bearing relation with thermal anomalies likely connected to volcanism. (Author's abstract)

CUNNINGHAM, C.G., Jr., 1973, Multiple intrusion and venting of the Italian Mountain intrusive complex, Gunnison County, Colorado (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 6, p. 474. Author at Central Mineral Resources, U.S. Geological Survey, Denver Fed. Center, Denver, Colo.

Fluid inclusion studies of hydrothermal quartz veins suggest that moderately saline fluids in the core boiled at 385° ± 15°C. Pressure limitations based on a hydrostatic model suggest a depth of approximately 2500 meters for this last event. (Author's abstract, greatly abbreviated by ER)

DAVIS, J.D., 1973, Geothermometry, geochemistry, and alteration at the San Manuel porphyry copper ore body, San Manuel, Ariz.: Ph.D. Dissertation, Univ. of Ariz., 250 pp.

The San Manuel-Kalamazoo ore deposit in southeastern Arizona, a type example of porphyry copper deposits, has been investigated using a multisided approach involving fluid inclusion study, alteration petrography, and geochemistry in cooperation with the Magma Copper Company and the U.S. Geological Survey. Investigation of a large number of closely spaced samples in two arrays across the ore-alteration zones has produced new information on the nature of the ore-forming system in three-dimensional space and provided information to test the various genetic hypotheses proposed for this ore type.

The fluid inclusion data suggests a single period of hydrothermal activity characterized by the gradual evolution of highly saline fluids at temperatures approaching 600°C and associated with barren quartz veinlets through an ore-depositing stage at 450°C to 275°C characterized by boiling of the hydrothermal fluids, to dilute, non-boiling fluids associated with quartz-calcite veinlets below 275°C. Fluid inclusion barometry suggests the top of the ore-forming system was emplaced at depths of less than one mile.

The lack of salinity and thermal gradients proposed by White and others (1971) or a thermal-salinity discontinuity at the interface of the potassic and phyllic zones (Sheppard and others, 1971) along with the temporal and spatial relationships of alteration minerals to fluid-inclusion-bearing quartz suggests a magmatic source for the hydrothermal fluids. There is little evidence for an outward migration of higher temperature-salinity conditions with time. There is, however, evidence for a post-mineralization retrograde encroachment of low temperature-salinity conditions as reflected by late secondary inclusions imposed upon early barren veinlets and sulfide-bearing veinlets. Fluid inclusion study at San Manuel-Kalamazoo supports the orthomagmatic genetic model for porphyry copper deposit formation, although some post-ore mineralization introduction of meteoric water is indicated. (Author's abstract)

DeGROODT, J.H., Jr., 1973, Determination of temperatures of fluorite formation by fluid inclusion thermometry, central Tennessee, (abst.): Geol. Soc. America Abstracts with Programs, v. 5, no. 5, p. 394. Author at The University of Tennessee, Knoxville, Tennessee, 37916.

Samples were collected in the northeastern part of the Central Basin of Tennessee from seven surface veins and from the Elmwood Mine of the New Jersey Zinc Company. Approximately 700 inclusion filling temperatures were determined on individual vacuoles within 50 specimens. Inclusions examined are considered to be dominately primary as indicated by negative crystal shape, regularity of outline, uniformity of vapor bubble size, and disposition in zones parallel to primary crystal growth features such as color banding and crystal faces.

For the surface veins, temperatures recorded from 64° to 151°C. Within this range approximately 75% of the temperatures are between 90° and 119°C. A temperature gradient is indicated for the formational temperatures of the fluorite from the surface veins, the mean and average temperatures decreasing from southeast to northwest across the study area.

At the New Jersey Zinc Company's Elmwood Mine, temperatures recorded range from 99°C to 126°C. Within this range, approximately 70% of the temperatures are between 110°C and 120°C. (Author's abstract)

DEICHA, Georges, 1973a, Scanning electron microscopy of cavities in gangue and rock minerals (abstr.): Soc. Fr. Mineral. Cristallogr., Bull., v. 96, no. 4-5, p. XIX (in French).

DEICHA, Georges, 1973b, Microfractures of granitic quartz and geochemical circulation of fluids of plutonic origin: Les Roches Plutoniques dans leurs Rapports avec les Gites Mineraux; Relations Spatio-Temporelles entre Granites et Gites Mineraux; Methodes d'Etudes, p. 229-230: Paris, Masson & Cie (in French, with English sum.).

DEINES, P., and GOLD, D.P., 1973a, The carbon isotopic composition of carbonatites, kimberlites, and diamonds (extended abst.): in Internat. Conf. on Kimberlites, Extended Abstracts of Papers, L.H. Ahrens, et al., eds.: Univ. of Cape Town, Rondebosch, Cape Town, South Africa, p. 85-88. Authors at Dept. of Geosciences, Pa. State Univ., University Park, Pa. 16802.

DEINES, P., and GOLD, D.P., 1973b, The isotopic composition of carbonatite and kimberlite carbonates and their bearing on the isotopic composition of deep-seated carbon: Geochimica et Cosmochimica Acta, v. 37, p. 1709-1733. Authors at Department of Geosciences, The Pennsylvania State University, University Park, Pennsylvania 16802.

New carbon and oxygen isotopic compositions of carbonates from 14 carbonatite and 11 kimberlite occurrences are reported. A review of the available data on the carbon isotopic composition ranges of carbonatite and kimberlite carbonates shows that they are similar and overlap that of diamonds. The mean carbon isotopic composition of carbonates from 22 selected carbonatite complexes (-5.1 o/oo, s = ±1.4 o/oo vs PDB) is indistinguishable from that of 13 kimberlite pipes (-4.7 o/oo, s = ±1.2 o/oo) as well as that of 60 individual diamond analyses (-5.8 o/oo, s = 1.8 o/oo). The oxygen isotopic compositions of kimberlite carbonates, however, are enriched in O^{18} by several permil with respect to those of carbonates from the subvolcanic type of carbonatite.

The data suggest that not all carbonatite, kimberlite and diamond occurrences have the same average carbon isotopic composition and that significant differences exist between them. Carbon isotopic composition measurements available for the East African Rift system suggest geographic and/or tectonic groupings e.g. carbonate lavas, tuffs and intrusive carbonatites associated with the Eastern Rift yield a range of δC^{13} values from -5.8 to -7.4 o/oo, similar to that of the carbonate rocks associated with the Western Rift volcanism (-5.8 to -7.9 o/oo). In contrast the interrift area encompassing Lakes Victoria, Malawi (Nyasa) and Chilwa, apparently are characterized by carbonatitic carbonates of higher C^{13} content (-2.4 to -4.4 o/oo).

If carbonatite and kimberlite carbonates as well as diamonds represent deep seated carbon, the mean isotopic composition of this carbon is estimated as -5.2 o/oo and the range is -2 to -8 o/oo. The selection of any particular value within this range to be used as a criterion of deep-seated origin is at the moment not warranted. Indeed, the choice of any specific composition for such carbon may be meaningless, as the source of kimberlite, carbonatite and diamond carbon may not be isotopically uniform. (Authors' abstract)

DERJAGUIN, B.V., 1973, [Soviet study shows polywater doesn't exist]: Chem. Eng. News, v. 51, 1973, p. 13-14.

DESMARAIS, D.J., HAYES, J.M., and MEINSCHEIN, W.G., 1973, Techniques for the analysis of gases sequentially released from lunar samples, in Analytical Methods Developed for Application to Lunar Samples Analyses, ASTM STP 539, American Society for Testing and Materials, p. 71-79. Authors at Indiana University, Bloomington, Indiana 47401.

This paper describes two methods for the analysis of light gases that are sequentially evolved from 2 to 10 mg of lunar sample. A hydrofluoric acid hydrolysis of lunar material is achieved by repeated exposure of the sample to hydrogen fluoride. In the second technique, gases are evolved from lunar samples by the stepwise heating of these samples to 1400°C. The gases evolved by either hydrolysis or pyrolysis are analyzed in a gas chromatographic system using a helium ionization detector. The sensitivities of this detector for the gases, as analyzed, range from 2×10^{-11} g/s for hydrogen to 2×10^{-13} g/s for carbon dioxide. (Authors' abstract)

DOBROVOL'SKAYA, M.G., BOYARSKAYA, R.V., and VASIL'EVA, G.L., 1973, On the fluid inclusions in highly ferrugenous sphalerite from the Savinskoe no. 5 deposit, East Transbaikal: Abstracts of papers at Fourth Regional Meeting on Thermobarogeochemistry of Mineral-Forming Processes at Rostov-on-Don, 24-30 Sept., 1973: Rostov, Rostov Univ. Press* (In Russian; translation provided by Dr. E.I. Dolomanova of I.G.E.M., Moscow). Authors at IGEM, USSR Academy of Sciences, Moscow. * p. 176-177

Vacuoles up to 1.5 mm in diameter have been found in a fragment of a large sphalerite studied in detail. On mechanical opening, salt particles crystallized on the smooth cleavage surface of the crystal. This rare natural phenomenon was studied by various methods: under the microscope in reflected light, by spectral analysis, and under the electron microscope, to obtain new data on the composition of fluid inclusions and their patterns of distribution in the studied sphalerite.

As a result of the microscopic study of the sphalerite, rare inclusions of accessory minerals were found: pyrrhotite, cubanite, and mackinawite. The above inclusions are occasionally two-phase or three-phase. In rare cases the polished surface of the sphalerite exhibits vacuoles partly filled with pyrrhotite.

The microspectral laser analysis conducted at IGEM and at Korovel Laboratory (GOI, Leningrad) has shown that the surficial film adjacent to a fluid inclusion contains much calcium, silicon, manganese, magnesium, iron, carbon, and aluminium, and some titanium, and very little zinc, magnesium (sic.), sulphur, and chlorine. It also suggests that carbonate solutions participated in sphalerite crystallization. The presence of calcium, magnesium, silicon, and aluminium in the sphalerite is apparently due to the fluid inclusions, rather than to mechanical admixture of mineral inclusions containing the above elements.

The replicas of the fractured surfaces of the sphalerite, ion-etched areas, and the crystalline particles on the surface of the sphalerite were studied under the electron microscope to obtain data on the distribution of the particles crystallized following vacuole decrepitation. The morphology of the crystals precipitated from solution has been determined. The inclusions are generally grouped, their aggregates having variable shape: droplike, crystalline, dendritic, starlike, etc. Each aggregate contains, as a rule, individual crystals of clearly cubic or rectangular shape, 0.2 to 2 μm in size. Microdiffraction studies of the crystallized liquid phase shows the presence of sylvite in the inclusions. (Authors' abstract).

DOE, B.R., 1973, Lead isotopes, ore genesis, and ore prospect evaluation: a review (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 599-600. Author at U.S. Geological Survey, Denver, Colorado 80225.

Lead isotope data are now available not only for ores but also for cryptic leads in most principal rock types. The data are finding great application to problems of ore genesis and show great promise for us in ore prospect evaluation. In ore genesis, the major applications are in defining the source material for ore lead and in determining an estimate of the age of mineralization. As examples, (1) lead in the Phanerozoic galena ores of southeast Missouri is found to have been derived mainly from a Cambrian sandstone aquifer unit with perhaps subordinate amounts from Paleozoic carbonate host rocks and Precambrian basement rocks (in agreement with a lateral secretion hypothesis), and (2) the age of the bulk of the Coeur d'Alene ores in Idaho now is established as Precambrian, whereas some geologists previously thought the deposits were Cenozoic. In mineral prospect evaluation, most major base metal ore deposits of the world have lead isotopic compositions that evolved under conditions approximating *single-stage* conditions wherein there are no changes in the value of U/Pb and Th/Pb in the source since the earth formed other than those resulting from the radioactive decay of uranium and thorium. Many minor deposits appear to have leads not evolved under these conditions. A tool therefore exists for ore prospect evaluation anywhere in the world. The "igneous-type" leads in high-temperature copper ores of Utah and the "country rock-type" leads in low-temperature, lead-zinc-silver ores at Creede, Colorado, suggest that the lead isotopic composition might parallel the zoning of the ore metals in a district and be of use in exploration. (Author's abstract)

DOLGOV, Yu. A., 1973a, Investigations of inclusions in cosmogenic material: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, P. 9-11 (in Russian; translation provided through the courtesy of A. Kozlowski). Author at Inst. of Geophysics and Geology, Academy of Science USSR, Siberian Branch, Novosibirsk.

1. Varieties of tektites were investigated with special attention to the composition of gases in inclusions. On melting tektites the gases evolved can be essentially divided into 3 groups:

a) pure carbon dioxide with a small admixture of S-bearing gases,

b) 50 to 70% CO_2, 20 to 40% H_2, up to 6% N_2, and up to 5% S-bearing gases,

c) air plus 20 to 40% CO_2.

2. The first group of gases is similar to those from terrestial volcanic glasses, e.g., from the Transcaucasus and Transcarpathians area. The second group is believed to be mixed gases formed during the explosion of comets in the Earth's atmosphere (moldavites, Libyan glass). The third group can form during the melting of glasses in the Earth atmosphere (Darwin glass, artificial glasses).

3. Melted globules from the layered sediments from 1908 at the area of the Tungusskiy phenomenon contain gases of the second group. This indicates the phenomenon to be a comet explosion in the Earth's atmosphere.

4. Cosmic dust from deep parts of the Pacific Ocean, similar to various tektites, was melted in the atmospheres of Moon, Mars, Venus and unknown atmospheres of other planets (sic.).

5. Investigations of the glass globules from the lunar soil shows the prevalance of hydrogen in the gas mixture in the inclusions.

6. Pressures in inclusions of the all cosmogenic samples are significantly lower than 1 atm. Some tektite inclusions had pressures as low as 0.0002 atm.

7. In meteorites there occur inclusions consisting of coexisting glass, crystal and gas phases, like those described by Roedder in lunar rocks. (Author's abstract).

DOLGOV, Yu. A., 1973b, Condensed gases at the ocean bottom: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 24-26 (in Russian; translation provided through the courtesy of A. Kozlowski). Author at Inst. Geol. and Geophys., Acad. Sci. USSR, Siberian Branch, Novosibirsk.

1. Investigation of inclusions in authigenic minerals such as barite, and phillipsite, as well as the droplets of deep water in the shells of forams, radiolarians and in microconcretions of palagonite proves that the deep waters are the mineral-forming solutions for those same minerals. Deep waters from inclusions of authigenic minerals contain a large amount of dissolved gases (CO_2, N_2, O_2). Inclusions in transparent minerals were one-phase, liquid, and the amount of dissolved gas after opening was tens times larger than the volume of the inclusion.

2. The solubility of gases in the depths of the oceans depends on the total pressure, but not on the partial one (as some scientists thought). Partial pressure of CO_2 has a significant influence on

solubility only at low pressure, in agreement with the numerous determinations in the surface layer of the ocean. Sampling and investigation of waters from ocean depths with consideration of their pressures have not been done previously. High pressures influence the solubility of gases by Henry's coefficient in the thermodynamic expression of Henry's law.

3. Under pressures of 1000 atm in ocean deeps, submarine volcanic extrusions loss their explosive nature, and exhalations occur as secretions of liquified, (condensed) gases. Under high pressure the gases dissolve in sea water to reach saturation. The continuous secretion of liquified gases from submarine volcanoes makes it possible to form a separate (liquified gas) phase with a phase boundary. These liquified gases may exist for indefinitely long periods of time. Isolated liquified gases at 1000 atm are heavier than sea water and they concentrate in "valleys" in the sea bottom.

4. Similar to subaeral volcanoes, the most common gases of exhalations determine their minimum depth ranges for possible preservation of phase boundaries on the sea bottom. At 3000-3500 m, the densities of CO_2 and of water are equal. At lesser depths small amounts of liquid CO_2 are possible, but the density of CO_2 is lower than the density of water and the CO_2 will rise up with increasing speed. Above 600 m depth exhalations of CO_2 from submarine volcanoes are possible only in the gas phase. This depth (600m) is the probably boundary of origin of gas-hydrates.

Investigations of inclusions in authigenic minerals open the way to recognition of hitherto unknown processes in the ocean depths. (Author's abstract.)

DOLGOV, Yu.A., 1973c, Inclusions in minerals of metamorphic rocks: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 222-223 (in Russian; translation through the courtesy of A. Kozlowski). Author at Inst. Geol. and Geophysics, Siberian Branch, Acad. Sci. of USSR, Novosibirsk.

Investigations of inclusions in quartz and kyanite from metamorphic rocks of the Mama River mica deposit proved as follows:

1. Normal two-phase inclusions were revealed as not gas-liquid but as bearing two dense liquids without gas bubble. Homogenization of such inclusions gave T of full homogenization of CO_2 with aqueous-salt solution in the range 260-329°C. Phase ratio varied widely, but had little influence on T_H. On $CO_2 - H_2O$ diagram for the same T, two values of concentration of CO_2 occur.

2. Inclusions bearing 100% of CO_2 were found. The density of CO_2 was determined by cryometric homogenization and heterogenization of CO_2.

3. On the intersection of the isochor and the isotherm, known from physico-chemical experiments as the parameters for the formation of kyanite, P was obtained (at T of growth). These P values agree well with theoretical. This means that density is the characteristic parameter.

4. In metamorphic rocks from the Chuysk area inclusions in kyanite, andalusite and quartz were studied. Measurements, as described above, gave the highest P-values for kyanite, and the lowest for andalusite. Besides inclusions with CO_2 and mixed ones, vacuoles with liquid N_2 were found (sic).

5. The distribtion of minerals proves that the pressure changes

from higher values in the center of fan-like folds (kyanite) to the lower ones in the periphery (andalusite) with an abrupt, stepwise transition to green schist facies of metamorphism. This testifies to the presence of horizontal pressures and the vertical zonal occurrence of metamorphic series. (Author's abstract)

DOLGOV, Yu. A., VISHNEVSKIY, S.A. AND SHUGUROVA, N.A., 1973, Preliminary investigation of gaseous-liquid inclusons in glassy and melted rocks of the Popigayskaya Crater: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p.197-198 (In Russian; translation through the courtesy of A. Kozlowski). Authors at Inst. of Geol. and Geophysics, Siberian Branch of Acad. Sci. of USSR.

Gas-liquid inclusions were investigated in separated parts of lechâtelierite, maskelinite, and other glasses, as well as inclusions in essentially glassy rocks of the Popigayskaya Crater.

1. In glasses of vitroclastites gas inclusions of various density are found.

2. In glasses of tagamites various inclusions are found: gaseous, gas-liquid with various ratios G:L (up to the domination of one of phases), and G-L with a solid phase. All kinds of indusions may occur in one schlieren simultaneously.

3. In glasses of partly melted wall-rocks, similarly tagamites, various inclusions also occur.

4. T_H ranges from 150 to 400°C, and the type of homogenization varies.

5. During freezing of inclusions down to - 42 to - 57°C, a solid phase in the gas bubble appears; during heating at T = -19 to -28°C the original phase ratios return. In the solutions no observable changes occur during cooling to -167°C.

6. The composition of the gaseous component of the inclusions (determined by the method of quantitative individual micoranalysis) is characterized by the absence of O_2 and CO, the presence of H_2 (0-20 vol. %, usually 8-12 vol. %), CO_2 (47-75 vol. %) and a group of undifferentiated gases ($H_2S + SO_2 + HCL + NH_3$) (8-23 vol. %). In some inclusions hydrocarbons occur (8-22 % by vol.), and gas phase of the inclusion consisted of 98 vol. % of hydrocarbons + 2 vol. % of H_2.

7. The variety of gas-liquid inclusions and the essential variations of their characteristics in one sample together with inhomogeneity of the glasses prove that the rocks of the Popigayskaya Crater were internally unequilibriated and the processes of their formation were of short duration. (Authors' abstract) (Translator's note--see also Dolgov, 1973a).

DOLIDZE, I.D., 1973a, Stages of mineral-formation of copper-polymetallic deposits of Merissa ore district (Adzharian Autonomous SSR): Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 179-181 (in Russian; translation through the courtesy of A. Kozlowski). Author at Geological Inst. of Acad. Sci. of Georgian SSR, Tbilisi.

The Merissa group of Adzharian Cu-polymetallic deposits occurring in a volcanic complex of Middle Eocene age are characterized by continuous substantial composition of ores. (. . .) On the basis of chemical analyses of triple water leachates, and homogenization studies in quartz, barite, carbonate,+sphalerite, one may ascertain that formation of minerals at all deposits took place during three stages (barren, sulfide, and sulfide-barite).

In the early (barren) stage during formation of fine-grained quartz with sericite, chlorite and pyrite, the mineral-forming solution had a relatively high temp. (above 260°C) and contained mainly chlorides and bicarbonates of alkali and alkaline-earth metals.

In the sulfide stage T decreased to 260-155°C and solutions became chloride-sulfate-bicarbonate with alkaline-earths prevailing over alkalies.

Mineral-forming solutions of the sulfide-barite stage are characterized by further drop of temperature to 230-60°C and equilibrium between alkali and alkaline-earth ion, or domination of the latter. Sulfate-ion strongly prevails over bicarbonate and chloride ions, yielding barite (only at this stage).

During temp. decreases of mineral-forming solutions (there is a) regular drop of concentration of Cl and alkalies and increase of concentration of SO_4^{2-} and alkaline-earth ions.

First and third stage are characterized by a simple solution composition; solutions of the second stage are most complex. Formation of ores took place mainly at the second stage. (. . .) (Author's abstract, abbreviated by A.K.)

DOLIDZE, I.D., 1973b, Thermobaric conditions for the formation of the Lukhuni deposit: Soobshch. Adad. Nauk Gruz. SSR, 1973, 70(3), p. 649-652 (in Russian). Author at Geol. Inst., Tbilisi, USSR. Chem. Abst., v. 79, no. 13, 148058b, 1973.

The Lukhuni As deposit is associated with preore quartz-carbonate veins. Results of homogenization of gas-liquid inclusions in quartz and calcite of the veins indicate that ore mineralization proceeded in a wide (265-125°) temp. interval and at 350-850 atm. The crystn. temp. of quartz, of the ore mineralization stage, increased in proportion to an increase in depth. Realgar-orpiment mineralization occurred during the metasomatic replacement of limestones by hydrothermal solns.

DOLOMANOVA, E.I., GASOYAN, M.S., RUDNITSKAYA, Ye.S., TYUTHNEVA, G.K., and USPENSKAYA, A.B., 1972 Determination of the composition of mixtures and temperature of origin of vein and other quartzes by use of infrared spectra: Acad. Sci. of USSR, Fersman Mineralogical Museum, Trudy, v. 21, p. 35-49 (in Russian; translation provided through the courtesy of A. Kozlowski).

The authors propose an infrared method of distinguishing of paramorphs of low- after high-quartz, believing that the IR method is better than other methods, e.g. fluid inclusion studies.

DOLOMANOVA, E.I., LOSEVA, T.I., and TSEPIN, A.I., 1973, X-ray micro-spectral evidence on the chemical composition of the solids from fluid inclusions in cassiterite, tourmaline, and quartz from the tin deposits of Transbaikal: Abstracts of papers at Fourth Regional Meeting on Thermobarogeochemistry of Mineral-Forming Processes at Rostov-on-Don, 24-30 Sept., 1973: Rostov, Rostov Univ. Press*(In Russian; translation provided by Dr. E.I. Dolomanova of I.G.E.M., Moscow). Authors at IGEM, USSR Academy of Sciences, Moscow. * p. 181-182

1. X-ray microspectral analysis has been used to study the elementary composition of the solids from the vacuoles found in cassiterite, tourmaline, and quartz from the tin deposits of Transbaikal and Central Africa. (Presumably solids found on the surface of the host after opening an inclusion - see Dobrovol'skaya et al., and Tsepin and Dolomanova, this volume. Ed.).

2. The vacuoles in cassiterite exhibited chlorides of K, Na, Fe, Ca, and Al, ZnS, $ZnAl_2O_4$ (?), Na_2S, $FeTiO_3$, and $(Fe,Mn)(Nb,Ta,Ti)_2O_6$ with an admixture of W. Many vacuoles contain solids consisting of K, Al, Si, and Ca, Al, Si (they probably belong to feldspar), and Al (corundum), Ti (rutile), Ca, Ti ($CaTiO_3$?), Si (quartz), and Mn.

3. K, Na, and Ca chlorides were found in the vacuoles in tourmaline. In many vacuoles they form a mixture with the sulphides of the same metals plus Ag_2S, ZnS, PbS, and Bi_2S_3, and with SnO_2, Al_2O_3, and TiO_2. More complex solids were recorded as follows: Ca and Ti as $CaTiO_3$?; Fe, Mn, and Ti as $(Fe,Mn)TiO_3$; Ca, Ti, and Si as $CaTiSiO_5$?; and K, Na, and Mg phosphates.

4. In the solids from less studied vacuoles in quartz, the following were found: Zn, Fe, Cr, Ni, Mn, Cu, Pb, Co, Ti, Ca, Na, Al, F, N, S, and Cl. Among compounds that are apparently present are $FeTiO_3$, $Fe(Al,Cr)_2O_4$, $Al(NO_3)$, NaCl, TiO_2, CrS, phosphates, nitrates, and sulphides. Owing to the coating with carbon, it was not determined. (Authors' abstract).

DONALDSON, C., REID, A.M., RIDLEY, W.I., BROWN, R.W., and DAWSON, J.B., 1973, The Igwisi Hills extrusive "kimberlites" (extended abst.): in Internat. Conf. on Kimberlites, Extended Abstracts of Papers, L.H. Ahrens, et al., eds.: Univ. of Cape Town, Rondebosch, Cape Town, South Africa, p. 93. First author at Lunar Science Institute, Houston, Texas 77058.

DOROGOVIN, B.A., and MENCHINSKAYA, T.I., 1973, Liquid inclusions in turquoise and their homogenization temperature: Zap. Vses. Mineral. Obshchest., 1973, v. 102, no. 6, p. 712-713 (in Russian), Chem. Abstracts, v. 80, 72716n, 1974.

Turquoise in the Biryuzkan and Kalmakyr deposits is localized in secondary quartzites and granodiorite-porphyries. The 2-phase gas-liq. inclusions occur in the center of turquoise grains. The homogenization temp. of the gas-liq. inclusions is 90-195°. Data indicate that turquoise was formed from hydrothermal solns. at moderate depths. (Authors' abstract).

DYMKIN, A.M., SHEPEL', A.B., and FEDOSEYEVA, M.M., 1973, Crystallization temperature of pegmatite in magnetite deposits of the Tashelgin ore no. 4, p. 957-959 (in Russian; translation in Doklady Acad. Sci. USSR v. 211, 1974, p. 175-176; abstract in Int. Geol. Rev., v. 15, no. 10, p. 1236,1973). Authors at Institute of Geology and Geophysics, Siberian Division, USSR Academy of Sciences, Novosibirsk.

Homogenization temperatures of gas-liquid inclusions in microcline fall definitely in one of the following groups (°C): 800-690; 600-450; 400-200. Curiously, there are none in the 690-600 range, i.e. the temperatures are either "high" or "low" and the "medium" microcline T is missing. In quartz, the homogenization temperatures are: 750-600;

500-350; 300-150. The gap (100°C) here is between the "high" and the "medium" T. The fact that the "high" T range is found in both microcline and quartz is evidence of a magmatic origin of the pegmatites. (Authors' abstract).

DYMOND, J., and HOGAN, L., 1973, Noble gas abundance patterns in deep-sea basalts - primordial gases from the mantle: Earth Plan. Sci. Letters, v. 20, no. 1, p. 131-139.

DZHUMAILO, V.I., VASILENKO, V.N., AND RYLOV, V.G., 1973, Forms of redeposition and conditions of formation of gold in Cu-sulfide ores of the Urup group of deposits, (N. Caucasus): Abstracts of papers from the Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 115-116 (in Russian; translation through the courtesy of A. Kozlowski). Authors at Rostov Univ.

Three stages of ore formation were revealed: quartz-pyrite, bornite-sphalerite-chalcopyrite, and quartz-calcite. The first stage was the exhalation-sedimentary process, at low temp. and pressure in the presence of increased amounts of Zu, An and noble metals. The second one ranged from 400 to 190°C and the noble metals crystallized at 190-250°C. Chemical-analytical and physicochemical investigations of water leachates revealed that hydrothermal Au-transporting solutions were alkaline , with low redox potentials (pH 10, Eh 0.6 V). Such parameters permit the existence in solution of sulfides of various metals, including the noble ones. Gold probably was transported as sulfide (AuS). Sulfide ores and wall rocks of the deposit were metamorphosed under greenstone facies conditions (T 300-500°C) and the productive mineral association was also formed under such conditions. (Authors' abstract)

EGGLER, D.H., 1973a, CO_2 as a volatile component of the mantle (extended abstract): in Internat. Conf. on Kimberlites, Extended Abstracts of Papers, L.H. Ahrens, et al., eds.: Univ. of Cape Town, Rondebosch, Cape Town, South Africa, p. 95-98. Author at Geophysical Laboratory, 2801 Upton St., N.W., Washington, D.C. 20008.

Petrologic studies of kimberlite and related rocks have indicated that a CO_2-H_2O vapor phase was involved in their origin. This phase equilibria study indicates at least three reasons why such vapor associated with kimberlite and alkaline rocks should be CO_2-rich: (1) The model system Fo-En-H_2O-CO_2 indicates that in the presence of CO_2 or CO_2-H_2O mixtures peridotite comprising the upper mantle melts at higher temperature. Although the presence of CO_2 has little effect on the silica-saturated or undersaturated nature of liquid produced by partial melting at any particular temperature, liquids produced at higher temperatures are less silica-saturated because of the "enstatite effect". Higher melting temperatures also produce a smaller degree of melting, at any point along the geotherm, yielding more alkalic melts. The effect of CO_2 is therefore the production of less silica-saturated, more alkalic melts. There may be primordial areas of the mantle rich in CO_2, or CO_2-rich vapor may rise to certain localities. Mantle regions with vapor richer in H_2O would melt more completely to yield silicic magmas. (2) Silicate melts dissolve rather large amounts of H_2O at high pressures.

The presence of a free vapor is unlikely. Melts dissolve much less CO_2, so that the miscibility gap between melt and CO_2-rich vapor is wider, and the presence of a free vapor is more likely. (3) Vapor rich in CO_2 does not dissolve excess silica, unlike H_2O-rich vapor and may well dissolve excess alkalies. Such vapors would produce many alteration effects observed in kimberlite. (Author's conclusions)

EGGLER, D.H., 1973b, Phase relations in the system $CaMgSi_2O_6$-CO_2-H_2O at 20 kilobars (abst.): Amer. Geophys. Union, Trans. (EOS), v. 54, no. 4, p. 479.

EGGLER, D.H., 1973c, CO_2 in the mantle: Mg_2SiO_4-SiO_2-CO_2 at 20 Kbars (abstr): Geol. Soc. Amer. Abstracts with Programs, v. 4, no. 7, p. 608. Author at Geophysical Laboratory, 2801 Upton St., N.W., Washington, D.C. 20008.

Compositions of liquid (L) produced by partial melting of the model peridotite assemblage forsterite (Fo)-silica-CO_2-H_2O have been determined. Hydrous melting relations are dominated by the melting of enstatite (En) to En+L (H_2O-undersaturated) at temperatures above 1400°C at 20 kbar and to Fo+En+L at temperatures below 1400°C. When CO_2 is added (up to 3.7 percent dissolves in melt), temperature of the change in enstatite melting behavior is nearly the same, both in the vapor-absent region and in the presence of H_2O-CO_2 fluid. The results indicate negligible effect of CO_2 on melt structure.

CO_2 has a large effect on composition of initial melts, however. In the presence of CO_2-rich vapor, "peridotite" (Fo-En) melts at much higher temperature than with H_2O. Because of the melting behavior of enstatite, initial melts produced at the same depth in the mantle may range from silica-oversaturated (temperature low, vapor H_2O-rich) to silica-undersaturated (temperature high, vapor CO_2-rich). For Fo-En, the change from silica-undersaturated to silica-oversaturated liquid occurs at 1400°C at 20 kbar when $CO_2/(CO_2 + H_2O)$(mole) equals 0.42. The results indicate a natural affinity between silica-undersaturated melts and CO_2-rich fluids. (Author's abstract)

EHMAN, M. F. AND HANNA, J. E., 1973, Gas chromatographic analysis of gases in crystal inclusions: Journal of Crystal Growth, v. 18, pp. 309-311. Authors at North American Rockwell Electronics Group, Anaheim, California 92803.

A technique is presented for analyzing gases trapped in inclusions in crystals. The qualitative and quantitative analysis of gases trapped in BeO crystals grown by the flux-method is presented. A screw-driven pin is used to puncture the inclusions in a vacuum chamber, and a triangular array of stopcocks permits entry of the sample gas into the gas stream to the gas chromatograph. (Authors' abstract, extended by ER)

ELDERS, W.A., & BIRD, Dennis, 1973, Active low-temperature alteration of arenaceous sands in a near-surface geothermal environment in the Imperial Valley of California (abst): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 610. Authors at Institute of Geophysics and Planetary Physics, University of California, Riverside, California 92502.

Extensive alteration of sandstones by geothermal brines at shallow depths occurs near the Algodones Dunes at the southeastern margin of the Salton Trough where a positive gravity anomaly is accompanied by very high temperature gradients near the surface (112°C at 114 meters). A 612-meter deep test hole encountered a temperature maximum of 105°C at 290 m, with a negative thermal gradient below this depth.

The rocks recovered are terrigenous detritus of the Colorado River Delta, primarily medium to fine arenaceous sands and silty sands, with pebble, granule, and clay size fractions together comprising about 15% of the section. Four distinct sedimentary facies are present, deltaic sand, channel-fill, beach-dune and lacustrine facies. Below 240 m the sediments are typically detaic whereas at shallower depths they have been modified by beach and eolian processes.

Post-depositional alteration from unaltered, porous, red sandstone to dense, vitreous appearing gray quartzite is evident in three intervals: 110 to 115 m, 148 to 154 m, and 240 to 300 m. In the incipient stages, this alteration is characterized by syntaxial growth of minute, pyramidal quartz crystals and the reduction of hematite to pyrite. In more advanced stages this is accompanied by expitaxial growth of quartz and by euhedral overgrowths of albite on detrital microcline. The porosity and permeability of these sandstones is reduced almost to zero and the density and seismic velocities are greatly increased. It appears that when hot geothermal brines migrating laterally through the aquifers encounter colder rock, the consequent percipitation of silica renders the rock impermeable. Thus, in porous sandstones, this geothermal system is essentially self-sealing. (Authors' abstract)

ELINSON, M.M., and ALIDODOV, B.A., 1973, Composition of gases of inclusions in minerals and some physico-chemical conditions of mineral formation in the Chorukh-Dairon ore field: Izvest. Akad. Nauk S.S.S.R., Ser. Geol., 1973, no. 7, p. 103-111. (In Russian). See Translations Section.

EPPLER, W.F., 1973, An unusual three-phase inclusion in kunzite: Deutsche Gemmol. Ges., Z., v. 22, no. 3, p. 93,(in German).

A kunzite from California contains a large three-phase inclusion: liquid, vapor, and an unidentified solid phase. (E.R.)

ERHAN, V., and ONICEANU, M., 1973, The geothermometry of quartz in the crystalline rocks of the Ineu-Bretila anticline zone, East Carpathians: Iasi, Univ., An. Stiint., Sect. 2, B (Ser. Noua), v. 19, part 2, p. 23-27 (in Romanian with German sum.).

ERMAKOV, N.P., 1973a, Homogenization and decrepitation temperatures of inclusions in knowledge of dynamics of processes of deep mineral formation: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 5-7 (in Russian; translation provided through the courtesy of N.P. Ermakov). Author at Moscow University.

Temperature is one of the important intensive thermodynamic parameters regulating the course of crystallization of minerals in deep and surface earth conditions and in synthetic systems of mineral-forming solution and melts. This parameter fixes the degree of heating of substances of different states of aggregation on a conditionally accepted scale. The choice of the latter is subjective. The notion of temperature is (based on) its measurement. The measurement of energetic levels of endogenous processes of mineral formation is revealed with the help of retrospective thermodynamic tests of geochemical systems of inclusions.

The determination of relative homogenization and decrepitation temperatures is the main problem. These temperatures (Th and Td) have the independent sense for the deep processes and do not depend on the accepted temperature's scale for the Earth's surface (sic). The exposure of only relative temperature in a system T-P-X-F is insufficient for the general direction of the development of thermobarogeochemistry. (There have been many attempts to determine) the homogenization and decrepitation temperatures in terms of the Centigrade thermometer.

It is not necessary to correct homogenization temperatures for revealing the temperature intervals and dynamics of formation of ore bodies and deposits. There is full coincidence of Th with T synthesis for inclusions in synthetic quartz, formed under pressures of 100 atmospheres.

For pressures up to 300 atm, T_h is low only by 10-20°C. In synthetic calcites, formed at 227 and 270°C, and under pressure below 100 atm at a salt concentration of 9%, the homogenization temperatures of gas-liquid inclusions were 224-227° and 266-273°C.

The difference between the synthesis temperature (T_s) and homogenization temperature (Th) was insignificant at salt concentration of 12%; T_s-280°; T_h-275-280°C; T_s-224°; T_h-224-230°C.

In view of the permeability of rocks, in our opinion, a pressure of 500 atm is very high for hydrothermal system in fractures, in which veins are formed. On account of high density of magmatic matter filling the vacuoles, the pressures effects on the T_h of melt inclusions (is very small). Hence the temperatures of the Moon's tholeiite basalt lavas are determined sufficiently exactly (1050-1220°C).

For the determination of the decrepitation temperature quartz is most often used, because of detailed study of its strength. The temperature of the start of mass decrepitation (T_d) and the interval for the first peak must (be determined).

This temperature (T_d°C) corresponds to the T_h°C in accordance with the last of our experiments, and those of Dr. Dorogovin, carried out on synthetic quartz.

The results are represented in the following table:

	Synthesis conditions		Temperature °C		T_s	T_d	T_d
	P	T	T_h	T_d	$-T_h$	$-T_s$	$-T_h$
1.	100	306	308	370	-1*	+64*	+65*
2.	300	318	300	360	+18	+42	+60
3.	500	334	300	360	+34	+26	+60
4.	700	338	288	350	+50	+12	+62

*sic.

From these data (we deduce that) the results of decrepitation are given by the homogenization temperature plus 60-65°C, because of mechanical solidity of quartz. From this table it can be seen that T_h coordinates with T_s.

The time is not ripe for the breit (sic) use of decrepitation for the determination of mineral formation temperatures because of the unknown strength of different minerals. Relative values of T_d may be useful for genetic interpretation, especially in combination with the results of homogenization, of inclusions in the same mineral, formed in different generations and physico-chemical conditions.

Thus, the most important quantity in mineralogical thermometry of deep and ancient processes is the homogenization temperature of geochemical systems of melt and gas-liquid inclusions, permitting clarification of the character of changes of other interrelated general parameters of past mineral formation. (Author's abstract.)(Editor's note — This abstract is not identical to that printed in the Russian original).

ERMAKOV, N.P., 1973b, Use of gas-liquid inclusions in geologic prospecting: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, R ostov Univ. Press, p. 20-21 (in Russian; translation provided through the courtesy of N.P. Ermakov). Author at Moscow University.

At the present time the application of decrepitation of gas-liquid inclusions in rocks, minerals and ores must develop in two directions: 1) The search of simple and overlapped pneumatolytic-hydrothermal bodies with the help of decrepitophonic and shlichodecrepitatic (sic.) methods and 2) perspective estimation of parcel productivity of quartz veins and zones of hydrothermal solution-saturation (quartzolites, albitites, etc.). It is necessary to give additional attention to the useful study of cation composition of inclusions and exposure of CO_2 composition, distillated aside from the mineralizing canals (sic.).

Its composition is always less in the inclusions of the hydrothermal solution-saturation aureoles in rocks, formed around the ore bodies. Aqueous and aqueous-carbonic paleohydrotherms, preserved in secondary inclusions in host-rock minerals, are so abundant that we can use the dehydrotationic (sic.) method of detailed study with the help of the microthermal or torsion balance. The value of weight loss by such heating is definitely related to distance to the ore body.

Decrepito-logging of drill core based on the theory of formation of hydrothermal solution-saturation aureoles must be in the arsenal of detailed geological methods, combined with geophysical and geochemical methods of prospecting for ore bodies. The paper presents concrete examples of use of gas-liquid inclusions in practice of geologic prospecting. (Author's abstract).

ERMAKOV, N.P., KHETCHIKOV, L.N., NAUMOV, V.B., and BAZAROV, L.Sh., 1973, Method of homogenization and its application in mineralogical thermometry: Program of the Fourth Regional Meeting on Thermobarogeochemistry of Mineral-Forming Processes, at Rostov-on-Don, 24-30 Sept., 1973: Rostov-on-Don, USSR (in Russian). (Part of an inclusion training session ; no abstract in Abstracts volume).

ERMAKOV, N.P., and KUYKIN, S.S., 1973, An attempt at comparing the decreptophonic and geochemical methods on the example of the vein polymetallic deposits of the Sadonian group: Bulgarian Acad. Sci., Bull. Geol. Inst., Metallic and Nonmetallic deposit series, v. 22, p. 155-167 (in Russian, with English abstract).

The studies carried out show the applicability of the decreptophonic method of prospecting for endogenic mineral deposits and of the portable decreptograph, developed for this purpose at Moscow State University.

Intensive haloes of hydrothermal solution-saturation of the enclosing rocks, as a rule well-comparable with the primary geochemical haloes, are established to stretch for up to several dozens of meters in proximity to quartz-sulphide veins and up to hundreds of meters in the case of closely disposed veins. The number of the decrepitations increases on approaching the mineral veins, except an occasional decrease in zones of leaching or post-ore tectonic movements.

The different displacements of the maximums of the decreptophonic and geochemical anomalies observed in certain places, as well as the separate manifestations of either of the anomalies, above all reflect the unequal representation of the products from the different stages of a common mineralization process or the superposition of diverse mineralization processes or the superposition of diverse mineralogical geochemical types of mineralizations of different ages.

The haloes of hydrothermal solution-saturation, reflecting the manifestations of the pneumatolytic-hydrothermal mineralization in general are an indirect indication for ore deposit prospecting, whereas the geochemical haloes are a direct indicator for the presence of a given type of mineralization in the region prospected.

The comparison of the number of impulses of the high temperature (500-700°C) and the low-temperature (up to 500°C) intervals of heating helps in determining the characteristic temperature and aggregate type of the mineralizing solutions. In the case of prospecting for medium and low-temperature hydrothermal deposits, a decreptometric study of the samples at temperatures of up to 500°C is more efficient than one up to 700°C (useful for prospecting for pneumatolytic-hydrothermal deposits). (Authors' abstract, edited by ER)

ERMAKOV, N.P., and LAPSHIN, V.A., 1973, Application of decrepitation method for detailed prospecting for rock-crystal-bearing veins in quartzites: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 259-260 (in Russian; translation provided through the courtesy of A. Kozlowski). Authors at Moscow Univ.

1. Studies were made at one of the deposits in the Upper Aldan rock-crystal-bearing region, in quartzites of an Archean sedimentary-metamorphic complex.

2. Decrepitation of quartzites in an experimental section near a known rock-crystal-bearing vein occurs in the interval 120-600°C. On a statistical basis two characteristic decrepigraph peaks were found: 120-300 and 300-400°C.

3. On the basis of relative intensity of decrepitation of quartzites at these temps., one may determine the occurrence and distance from vein. On approaching the vein an increase of intensity of the peak at 120-300°C is observed, with a stable background intensity at $T = 300-480°C$. When the distance from the vein is 25-30 m, a sudden decrease of intensity of decrepitation at 120-300°C is observed and a similar increase of the maximum at 300-480°C; in the immediate proximity of the vein this latter may reach values 20 times higher than background.

4. Thermometry of samples taken at various distances from the vein zone is as follows: the maximum at 120-300°C is connected with two-phase GL inclusions (volume of gas 5-10% of vacuole) and with inclusions bearing gas, liquid CO_2, and aqueous solution; the maximum at 300-480°C is caused by decrepitation of GL inclusions bearing gas in following ranges (vol. %): 15-20; 25-30 and 40.

5. These data were used as the main criteria for detailed prospecting for vein zones.

At the eluvium/deluvium level of the deposits an area 300x350 m was sampled in a 20x20m net; the area has a number of geophysical anomalies from fracture tectonics. On the basis of decrepitometric studies of 600 samples a large anomaly, of 300 m length was found, with high decrepitation activity in the interval 300-480°C, proving the vein mineralization of the fractures. (Authors' abstract)

ERMAKOV, N.P. and PIZNYUR, A.V., 1973, Theoretical modelling of thermobarogeochemical conditions of postmagmatic mineral-forming solutions: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes 24-30 Sept., 1973: Rostov, Rostov Univ. Press p. 29-30 (In Russian; translation provided through the courtesy of N.P. Ermakov). Authors at Moscow University.

Natural deep mineral forming ionic-molecular solutions usually consist of water containing gases and salts; the main compounds are CO_2 and NaCl. In such geochemical fluid media there are some quantity of easily soluble combination of useful components, which formed ore-bodies and mineral deposits in definite P-T-X- conditions (sic). This was established with experiments on synthetic systems and was confirmed with observations of geochemical systems of gas-liquid inclusions. The latter points directly at predominance of one or the other of the three mentioned chemical compounds in solutions, forming corresponding mineral associations.

Thus H_2O, CO_2 and NaCl are the "base" of mineral-forming solutions, their properties in synthetic combinations and separately have been comparatively well studied and presented as PT-diagrams.

The level of heating and pressure determine the density of these fluids. Consideration of their interrelations has shown that the mixing of H_2O and CO_2, CO_2 and 30% solution of NaCl (sic) may be unlimited at specific temperatures and pressures. Their solutions are homogeneous in conditions of equal specific volume. On the compiled diagram this is expressed as two "tops", between which there is limited mixing of these components. There are concrete temperature and pressure data on the diagram, by which it is possible to define conditions of mineral-forming solutions in a given section of the "tops", in a static system.

This thesis is confirmed by experiments with synthetic systems (Takenouchi and Kennedy, 1965) and numerous experiments with natural microautoclaves - inclusions of mineral-forming solutions.

We can not submit for consideration the proposed model in this abstract, but it will provide important background for the thermobarogeochemistry of magmatic, metamorphic and postmagmatic mineral-forming processes, with the help of modeling of dynamic systems. The solution of the problem will be aided by data received with the help of synthetic mineral-forming systems, natural mineral-formation on the basis of diagrams, and many varieties of tests of gas-liquid and melt inclusions in minerals. The data presented can reconcile many contradictory views and directions about endogenous postmagmatic ore-forming processes. (Authors' abstract.)

ERMAKOV, N.P., et al., 1973, Homogenization of inclusions and electrical properties of dielectric minerals: Akad. Nauk SSSR, Doklady, v. 208, no. 6, p. 1439-1442 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 208, p. 165-168; abstract translated in Int. Geol. Rev., v. 15, no. 5, p. 614, 1973).

Flattening in the resistivity-temperature curves at increasing T, as found in synthetic and natural quartz, beryl, and calcite, is found to represent homogenization of inclusions in the minerals, thus changing the dielectric permeability. The authors suggest that this technique for determining T_H has promise. Diamonds from the Mir kimberlite pipe show a similar flat suggesting low-temperature inclusions (426-500°C).

Lingulate secondary liquid-gas inclusions homogenizing at ∿430°C were found in these diamonds (Editor's note - this is apparently the first known occurrence of liquid inclusions in diamond.) (ER)

ESSENE, Eric, WALL, Victor, and SHETTEL, Donald, 1973, Equilibria in $CaO-MgO-SiO_2-H_2O$ (abst): Amer. Geophys. Union, Trans. (EOS), v. 54, no. 4, p. 480.

FAIZIEV, A.R., 1973, Morphology of fluorite crystals from the Ak-Dzhilginsk deposit in the eastern Pamirs: Vses. Mineral. Obshchest., Zap., v. 102, no. 6, p. 685 (in Russian).

Very similar to Fayziyev, 1972 (see Fluid Inclusion Research - Proceedings of COFFI, v. 5, 1972, p. 36), but with somewhat different T_H values. (ER)

FAYZIYEV, A.R. AND MOROZOV, S.A., 1973, Thermodynamic conditions of fluorite origin from deposits and ore mineralizations of Tadzhikistan: Abstracts of papers from the Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 125-126 (in Russian; translation through the courtesy of A. Kozlowski). Authors at University of Tadzhikistan, Geology Institute of Academy of Sciences of Tadzh. SSR.

Fluorite in deposits of S. Hissar and Karategin has crystallized in a wide range of temp. (350-50°C) and pressure (450-80 atm). Commercial generations of fluorite have formed at 250-130°C and 350-200 atm. At analogous deposits of Pamir the T and P conditions are 180-70°C and 250-90 atm. At the deposits of the Zervashan Chain optical fluorite crystallized at 185-70°C and 330-120 atm.

Fluorite formation at telethermal Hg-Sb deposits of N slope of the Hissar Chain took place at 110-45°C and 200-60 atm. At some pegmatitic deposits of Central Tadzhikistan fluorite crystallized at temp. 250-80°C and pressures 350-150 atm. For gold deposits T=380-220°C and P=560-275 atm are characteristic and for rare-metal deposits - T=340-290°C and P=500-410 atm.

At tin deposits of Pamir, fluorite cyrstallization occurred at T=305-85°C and P=500-160 atm, and at contact-metasomatic mineralizations, T=230-130°C and P=350-200 atm. (Authors' abstract)

FENN, P.M., & LUTH, W.C., 1973, Hazards in the interpretation of primary fluid inclusions in magmatic minerals (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 617. Authors at Dept. of Geology, Stanford Univ., Stanford, California, 94305.

Primary fluid inclusions have been produced during the growth of synthetic alkali feldspars from melts in the system $NaAlSi_3O_8-KAlSi_3O_8-H_2O$. Fluid filled bubbles and tubules are commonly observed in crystals grown from H_2O-undersaturated melts. An interface enrichment mechanism is proposed as the source of these inclusions and as such the presence and/or composition of these inclusions is not indicative of the state of the bulk system. These results suggest the need for a reanalysis of the significance and interpretation of primary fluid inclusions in magmatic minerals. (Authors' abstract)

FESQ, H.W., BIBBY, D.M., ERASMUS, C.S., KABLE, E.J.D., and SELLSCHOP, J.P.F., 1973, A comparative trace element study of diamonds from Premier, Finsch and Jagersfontein Mines, South Africa (extended abstract): in Internat. Conf. on Kimberlites, Extended Abstracts of Papers, L.H. Ahrens, et al., eds.: Univ. of Cape Town, Rondebosch, Cape Town, South Africa, p. 111-114. Authors at NIM-WITS A.A.R.G., N.P.R.U., Univ. of the Witwatersrand, Johannesburg.

Gives some evidence (p. 113) for the presence of trapped liquid (silicate) inclusions in diamond, possibly with CO_2 and H_2O. (ER)

FIELD, C.W., 1973, Sulfur isotope abundances in hydrothermal sulfate-sulfide assemblages of the American Cordillera (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 619. Author at Department of Geology, Oregon State University, Corvallis, Oregon 97331.

Hypogene sulfides from hydrothermal deposits of the American Cordillera are isotopically similar to meteoritic sulfur (0 $\delta 34$ $^{o}/oo$) regardless of deposit-type, geologic age, and tectonic location. The majority of values occupy a narrow range (-3 to +3 $^{o}/oo$) and sulfide mineral pairs and triplets exhibit small temperature dependent fractionation effects with progressive S^{34} depletion in the order molybdenite, pyrite sphalerite, chalcopyrite, bornite, and chalcocite-galena. Sulfides from several contact metasomatic (Craigmont, Peacock, Christmas, and others) and porphyry-type (Galore Creek, Yerington, Ajo, Esperanza-Sierrita, El Salvador, and others) deposits are anomalously depleted in S^{34} (-1 to -14 $^{o}/oo$). They are of local to widespread distribution; associated with hypogene iron oxides (magnetite or hematite), hypogene sulfates (anhydrite or gypsum), or both; and presumably confirm the Eh-pH control of sulfur isotope fractionation proposed by Sakai (1968) and Ohmoto (1970; 1972). In contrast, associated hypogene sulfates are expectably enriched in S^{34} (+7 to +15 $^{o}/oo$) and isotopic temperature estimates (300 to 600°C) from sulfate-sulfide pairs broadly agree with published fluid inclusion filling temperatures. Models based upon the sulfate-sulfide data, mixing, and isotopic equilibration suggest that total sulfur in these hydrothermal systems was compositionally (0 ± $3^{o}/oo$) similar to meteoritic sulfur and may have been derived from a deep-seated source. The data do not indicate appreciable contributions of heavy sulfur (+20 $^{o}/oo$) from ocean water-metalliferous sediments or evaporite sources as might be incorporated in convergent plate or craton-shelf tectonic regimes.(Author's abstract)

FOMICHEV, V.I., and KUZNETSOVA, Ye.I., 1972, Metasomatites of Sayakskiy region and criteria of their ore productivity, in Papers of All-Union Symposium, Alma-Ata, 1972, Kazakh Scientific-Research Institute of Mineral Raw Materials, and Inst. of Geological Sciences, Academy of Sciences of Kazakh SSR, part 1, Alma-Ata 1972, pp. 185-192. (In Russian; abstract through the courtesy of A. Kozlowski). Authors at Inst. of Geological Sciences, Acad. of Sci., Kazakh SSR, Alma-Ata.

The ores have a reverse temperature gradation in relation to granitoid massives; on the other hand the metasomatites have the normal, simple temperature zonation. The earliest and highest-temperature (over 250°C) association: gold 1 - gersdorffite - arsenopyrite - cobaltite agrees with the external zone of relatively late and low-temperature metasomatites of quartz-calcite-chlorite composition. The association gold 2 - bismuth - chalcopyrite 1 - pyrrhotite (250°C) occurs in moderate-temperature epidote-actinolite zone. The association gold 3 - wittichenite (Cu_3BiS_3) - molybdenite - bornite - chalcopyrite 2 (225°C) was ascertained in the internal high-temperature zone of skarns. The authors ascertained that the above distribution of ore and parent rock, temperatures is in good agreement with phenomena accompanied by the thermohygroscopic diffusion effect (Lykov, 1950).

FOURNIER, R. O., and TRUESDELL, A. H., 1973, An empirical Na-K-Ca geothermometer for natural waters: Geochemica et Cosmochimica Acta, v. 37, pp. 1255-1275. Authors at U. S. Geological Survey, Menlo Park, California 94025.

An empirical method of estimating the last temperature of water-rock interaction has been devised. It is based upon molar Na, K, and Ca concentrations in natural waters from temperature environments ranging from 4 to 340°C. The data for most geothermal waters cluster near a straight line when plotted as the function $\log (Na/K) + \beta \log [\sqrt{(Ca)}/Na]$ vs reciprocal of absolute temperature, where β is either 1/3 or 4/3 depending upon whether the water equilibrated above or below 100°C. For most waters tested, the method gives better results than the Na/K methods suggested by other workers. The ratio Na/K should not be used to estimate temperature if $\sqrt{(M_{Ca})}/M_{Na}$ is greater than 1. The Na/K values of such waters generally yield calculated temperatures much higher than the actual temperature at which water interacted with the rock.

A comparison of the composition of boiling hot-spring water with that obtained from a nearby well (170°C) in Yellowstone Park shows that continued water-rock reactions may occur during ascent of water even though that ascent is so rapid that little or no heat is lost to the country rock, i.e., the water cools adiabatically. As a result of such continued reaction, waters which dissolve additional Ca as they ascend from the aquifer to the surface will yield estimated aquifer temperatures that are too low. On the other hand, waters initially having enough Ca to deposit calcium carbonate during ascent may yield estimated aquifer temperatures that are too high if aqueous Na and K are prevented from further reaction with country rock owing to armoring by calcite or silica minerals.

The Na-K-Ca geothermometer is of particular interest to those prospecting for geothermal energy. The method also may of use in interpreting compositions of fluid inclusions. (Authors' abstract)

FRAZIER, W.J., 1973, Origin of celestite-bearing vugs in the Pennington Formation of central Tennessee (abst.): Geol. Soc. America Abstracts with Programs, v. 5, no. 5, p. 397. Author at Dept. of Geology, Madison College, Harrisonburg, Virginia 22801.

Celestite-bearing vugs occur in the lowermost dolomite beds of the Pennington Formation (Upper Mississippian) along the northern Highland Rim of central Tennessee. Vugs are elliptical, up to 15cm in length, and may coalesce. Many have brecciated sides and floors. Celestite occurs in two forms: 1) small (0.4-3.6mm), euhedral crystals with anhydrite inclusion-rich centers and 2) larger (1-5mm), subhedral to anhedral, inclusion-free crystals. Intimately associated with the celestite are large euhedral dolomite crystals with curved edges and undulose extinction. Other minerals found in some vugs include: quartzine (usually as small spherulites), calcite, sphalerite and fluorite.

Based on an analogy with recent gypsum nodules and on petrographic data, I interpret the Pennington vugs as having been formed as gypsum nodules beneath the surface of an evaporitic, sabkha-like environment, later undergoing dehydration to form anhydrite. Eogenetic silicification and partial celestite replacement resulted in quartzine spherulites and inclusion-rich celestite. At a later time anhydrite dissolved (due to increased porewater acidity or decreased temperature) allowing celestite to attain a euhedral form. The source of Sr was seawater and concentration was affected by evaporation. Celestite formed by replacement of anhydrite or by direct precipitation from porewaters. (Author's abstract)

GALABURDA, Yu.A., 1973, Hydrothermal mineral formation in the Krivoi Rog Basin: Akad. Nauk Ukr. RSR, Dopov., Ser. B, no. 5, p. 392-395 (in Russian with English sum.).

Some physicochemical parameters of the environment of hydrothermal mineral formation are determined on the basis of investigations of inclusions in quartz from veins in the Krivoy Rog metamorphic rocks. Temperatures of solutions were different for different regions and changed from 220 to 385°C. Only a lower limit of 800-900 atm pressure was determined. Solutions were often enriched with liquid CO_2. (Author's abstract)

GALIY, S.A., KUZNETSOV, Yu.A. AND KULIK, Zh.V., 1973, Conditions of sphalerite formation at Ukrainian deposits: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 85-87 (in Russian; translation through the courtesy of A. Kozlowski). Authors at IGFM AN UkrSSR, Kiev.

1. Sphalerites of 15 deposits were investigated, mainly from Zakarpat'e and Donbass. (...).

2. Over 500 measurments of T_h and T_d were made (...). The data were gathered with those obtained by Kullerud's method.

3. Sphalerite from Zakarpat'e formed at similar temp.: (°C)

a.	Beregovskoe	255-220	200-145
b.	Byegan'skoe	245-235	210-150
c.	Vyshkovskoe	230-170	

4. Polymetallic deposits in the Nagol'nyi district have sphalerite crystallized in two stages of hydrothermal process: 306-270 and 230-150°C. During the first generation precipitation pressure was higher than 700 atm, and during the second - 600-700 and less.

5. The temperature interval of sphalerite formation at Sushchano-Perzhanskaya tectonic zone of Ukrainian Shield was 305-290°C, and 280-250°C, from Krivoy Rog basin - 226-220°C; NW range of Donbass - 250-195°C; N range of Donbass - 152-145°C.

6. Decrepitometric data agree very well with T_h values.

7. Water leachates of fluid inclusions were analyzed (data not given in abstract). Analysis of the gas composition of individual inclusions gave the following results: CO_2 12.5-22.5%, O_2 15.7-19.2%, CO 11.7-27%, H_2S 0-1.8%, N_2 plus rare gases 39.4-53.2%. Kullerud's thermometer is not suitable for temp. determinations for natural sphalerites. (Authors' abstract)

GANEEV, I.G., ERMAKOV, N.P., and MEL'NIKOV, F.P.. 1973, Gas-liquid inclusions in synthetic quartz grown from NaCl solutions: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming

Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp 281-283 (in Russian; translation provided through the courtesy of A. Kozlowski). Authors at All-Union Inst. of Mineral Raw Materials,+ Moscow University

Investigation of the composition of inclusions in natural quartz proves that hydrothermal solutions, from which SiO_2, as well as majority of other minerals, have crystallized, have a chloride-bicarbonate-sodium composition with varying amounts of other ions. Assuming the parent character of solution in inclusions, large-scale migration of SiO_2 in similar cases ought to occur easily. But known experimental data on the solubility and crystallization of quartz do not support the possibility of transport of significant amounts of SiO_2 under such conditions.

On the basis of vertical zoning of ore bodies and the existence of a geothermal gradient during their formation, a model was proposed, explaining the mechanism of mobilization, transportation and redeposition of substances by water solutions of NaCl. The basis of the model is the hydrolysis of NaCl under a geothermal gradient with the formation of alkaline solutions in the lower parts of the veins, and essentially acid solutions in the upper parts, as a result of migration of HCl:

$$NaCl + H_2O = NaOH + HCl$$

Experimentally this is supported by growing quartz crystals in solutions of NaCl.

Mechanism of the process: in the lower part of the autoclave quartz and alkalies interact:

$$NaOH + SiO_2 + 2H_2O = Na[Si(OH)_5];$$

the saturated solution migrates by convection toward the upper zone, where silicate complexes hydrolize, forming crystalline quartz:

$$Na[Si(OH)_5] + HCl = SiO_2 + NaCl + 3H_2O;$$

The resultant crystals bear numerous GL inclusions of elongated shape with sharp outline and well developed relief; their dimensions range from 0.52 to 1.5 mm, mostly 0.4-0.5 mm. Individual inclusions bear a solid phase consisting of thin opaque needles, probably rutile. T of inclusions: 395-410°C with intense decrepitation on overheating. On cooling, the inclusions freeze suddenly to a dark mass at -58°C. On subsequent warming, the ice recrystallized and the last crystal disappears at -5.5°C. If the inclusion is cooled again before the last ice crystal melts, dendritic crystals of cryohydrate form rapidly.

Investigations of GL inclusions in synthetic quartz grown from solutions of NaCl as well as KCl, $CaCl_2$ etc. open new possibilities for the study of inclusions in natural minerals. (Authors' abstract.)

GARBUZOV, P.S., 1972, Peculiarities of ore mineralization occurrence in skarns of the Tyetyukhe ore district, in Papers of All-Union Symposium, Alma-Ata, 1972, Kazakh Scientific-Research Institute of Mineral Raw Materials, and Inst. of Geological Sciences, Academy of Sciences of Kazakh SSR, part 1, Alma-Ata 1972, pp. 144-150. (In Russian; abstract through the courtesy of A. Kozlowski). Author at DVPI, Vladivostok.

Vertical zonality of chemical composition of ores agrees with temperature zonality of mineral origin. Thus at the Osnovnoe ore body, from 0 level to +300m level, crystallization temperature decreased 9-10° per 100m; in the interval +300m - +435m there is a significant increase of temp. (50-55°C) and at levels higher than +435m toward the surface the temp. again decreases. On the basis of decrepitation data one may conclude that skarns and ores crystallized at temp. ranges 450-100°C, and the richest ores of Pb and Zn formed at 190-200 and 190-240°C respectively.

GEGUZIN, Ya.E., and DZYUBA, A.S., 1973a. The investigation of liquid inclusions in a rock-salt crystal in the entire temperature interval of their existence: Kristallografiya, v. 18, no. 4, p. 813-818 (in Russian).

The behavior of inclusions of saturated aqueous solution in natural single crystals of NaCl was examined from the temperature of crystallization to temperatures exceeding the critical state of the material of the inclusions, when it passed into the gaseous phase. Frames from motion picture sequences are presented, showing the behavior at temperatures up to 410°C, and after subsequent cooling. (ER)

GEGUZIN, Ya.E, and DZYUBA, A.S., 1973b. Elastic diffusion interaction of liquid inclusions in an NaCl single crystal: Kristallografiya, v. 18, no. 5, p. 1053-1056 (in Russian).

GEIJER, Per, 1971, Sulfidic "ball ores" and pebble dikes: Sveriges Geol. Unders., Ser. C, no. 662, Ar 65, Nr 8 p. 1-29 (in English).

"Ball ores" occur in several of the areas of sulfide mineralization in the Precambrian of central and southern Sweden. They consist of a sulfide matrix in which are embedded very numerous inclusions of rocks and/or minerals. These inclusions are rounded, often spherical. The common form of a ball ore body is dike-shaped. The characters of the ball ores have, somewhat vaguely, been ascribed to secondary influences. Comparison is now made with the "pebble dikes," mostly barren, which are known from several districts of hydrothermal sulfide mineralization in the western United States and in Australia. From this comparison it appears that the ball ores were formed by fluids injected under very high pressure, the rounding of the inclusions being due to attrition during this process and to corrosion. For the way in which the sulfides of the ball ores were introduced, several possible explanations are discussed. Most likely they were either injected in the solid state as a pulp, or were carried chemically in the injected fluid. A third theoretically possible explanation, implying that they were introduced metasomatically in an originally barren pebble dike, appears improbable. (Author's abstract)

GERLACH, Terrence M. and NORDLIE, Bert E., 1973, Magmatic gases compatible with magnetite-pyrrhotite assemblages in basaltic lavas (abst): Amer. Geophys. Union Trans. (EOS), v. 54, no. 11, p. 1219.

GIMADEEV, Sh.Sh., ANDRUSENKO, N.I. & SCHEPOT'YEV, Yu.M., 1973, Temperature of formation of quartz veins of gold-silver deposits in the N. Kamchatka region: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 55 (in Russian; translation through the courtesy of A. Kozlowski). Authors at Central Scientific-Research Geologic-Prospecting Institute, Ministry of Geology USSR, Territorial Geological Office of Kamchatka, Petropavlovsk.

The ore field is developed in the intersection of the Taygonossko-Murgal'skiy and Penzhinsko-Kondyrevskiy deep faults in the ranges of Okhotsk-Chukotskiy volcanic zone. Investigation of consolidated melt, partly crystallized, and essentially gaseous inclusions in rock-forming quartz of granodiorites revealed that crystallization of acid magmatic melt finished at temp. about 850°C. Gaseous solutions and their hydrothermal condensates caused the essential hydrothermal alteration of rocks resulting in secondary quartzites at a temp. of 420-340°C; subsequent alteration into a sericite-hydromica aggregate took place at the moderate temp. interval 290-160°C.

Formation of Au-Ag adularia-calcite-quartz veins was from hydrothermal, initially near-critical solutions in the temp. range 390-95°C under conditions of unevenly changing regime with temp. drops reaching 110°C. During amethyst crystallization boiling occurred, for a short interval, and the solutions were of a gaseous type. Productive associations precipitated in the temp. interval 310-150°C. Pressures, based on tubular inclusions in amethyst, at individual moments in the development of the series ranged from 190 to 240 atm. (Authors' abstract).

GLAÇON, J., PARK, F. & TOURAY, J.- C., 1973, La rétromorphose du talc dans les dolomies métallifères de Boukdema (Algérie); discussion du rôle des fluides: Mineral, Deposita (Berl.) v. 8, pp. 183-191. (In French with English abstract). First author at Université Paris VI, France.

The samples studied were collected in the Boukdema stratabound deposit (Algeria), where the association dolomite-quartz-talc-sphalerite occurs. Cryoscopic investigations of fluid inclusions in quartz indicate a wide salinity range in mineral forming fluids (4 to 28 weight $^0/_0$ NaCl eq). "Boiling" of hydrothermal fluids possibly explains this unusual characteristic. In this hypothesis thermometric data need no "pressure corrections" and one may conclude that quartz growth (and simultaneously talc dissolution) occurred in the 250°-200°C range. On the basis of this last indication, the relative role of T, f_{CO_2}, a_{Mg}/a_{Ca}, on talc stability is discussed in the mineralogical environment of Boukdema. (Authors' abstract)

GLYUK, D.S., and ANFILOGOV, V.N., 1973, Phase equilibria in the system granite-water-potassium fluoride at a water-vapor pressure of 1000 kg/cm^2: Akad. Nauk SSSR, Doklady, v. 210, no. 4, p. 938-940 (in Russian; translated in Doklady Acad. Sci. USSR, v. 210, p. 237-238). Authors at Inst. of Geochemistry, Siberian Division, USSR Academy of Sciences, Irkutsk.

Data are presented (graphically as a TX diagram) for many points in the range 0.2-1.0 wt. %, and also higher % KF, at 100-900°C. (ER)

GODOVIKOV, A.A., 1973, Introduction to mineralogy: Novosibirsk, Nauka Pub. House, 232 pp + 36 photos (in Russian).

Includes a 5-page summary of fluid inclusions, taken largely from Ermakov's papers on classification, (ER).

GOLIKOV-ZAVOLZHENSKIY, I.V., 1973, Phase state and chemical composition of fluid inclusions in quartz of aeschynite-bearing greisens (Central Kazakhstan): Abstracts of papers from the Fourth Regional Conference on Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, pp. 152-153 (in Russian; translation provided through the courtesy of A. Kozlowski) Author at Rostov Univ.

Aeschynite-bearing greisens developed by alteration of alaskite granites. In quartz of greisens two types of inclusions were found: 1. primary and pseudosecondary gaseous and essentially gasesous, homogenizing in gas phase and 2. essentially liquid two-, three-, and polyphase inclusions.

Polyphase and CO_2 bearing inclusions were found in quartz of all greisens, and polyphase CO_2-bearing were found in quartz-feldspathic greisen and in quartz veins. Relic inclusions occur only in apogranites and quartz-feldspathic greisen; here the highest concentration of inclusions was 10.6kg per m^3 (i.e., $\sim$0.3 wt.%; Ed.).

Three stages of greisen formation were distinguished:

1. Formation of apogranites and quartz-feldspathic greisens from gaseous solutions of bicarbonate-Na composition.

2. Formation of muscovite-quartz greisens from an unstable sometimes boiling liquid solution of sulfate-Mg composition.

3. Solutions (liquid) of Cl-Ca composition, highly concentrated and high-temperature. (Author's abstract)

GOLOVCHENKO, N.G., 1973, On mineral formation temperatures and chemical composition of solutions forming the Nikitovskoe mercury deposit: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 101 (in Russian, translation through the courtesy of A. Kozlowski). Author at Lvov Univ.

Two stages of mineralization are recognized: arsenopyrite-quartz (a) and quartz-antimonite-cinnabar (b). During stage (a) the following minerals were formed: quartz, calcite, arsenopyrite, chalcopyrite, galena (?), and probably pyrite. Primary and pseudosecondary inclusions in quartz have 70-80 vol % filling (F) and homogenize at 290-170°C in the liquid phase. Inclusions in calcite are rarer and homogenize at 190-150°C. Stage (b) includes the following minerals: cinnabar, antimonite, marcasite, sideroplesite, dickite, and quartz. Inclusions in quartz (F = 85-90%) homogenize at 160-90°C, in the liquid phase; the latest, post-cinnabar quartz generation gave T_h 110-90°C. P measured by use of inclusions bearing liquid CO_2 were 150-120 atm. Inclusions in cinnabar homogenize in the liquid phase at 145-105°C. (Author's abstract).

GONCHAROV, V.I., and SHUGUROVA, N.A., 1973, Volatile composition of near-surface hydrothermal solutions in the Au-Ag deposits of the NE of the USSR: Geokhimiya, 1973, no. 10, p. 1583-1585 (in Russian, abstract translated in Geochem. Internat., v. 10, no. 5, 1973, p. 1170; full translation available from Am. Geol. Inst.).

Gases in fluid inclusions of the Au-Ag deposits of the NE of the USSR were analyzed by microchemical methods. CO_2 and variable amounts of air were found, indicating near surface deposition. -A. Truesdell.

GOROVOY, A.F., MAISKIY, Yu.G., REZNIKOV, A.I., TKACH, B.I., SHTANCHENKO, M.S., AND SHELUKHIN, V.I., 1973, Fluid inclusions in minerals of hydrothermal occurrences from Central Donbass: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 94 (in Russian; translation provided through the courtesy of A. Kozloski). Authors at KIMI Kommunarsk, Rostov Univ., VKGRE, Voroshilovgrad.

Inclusions were examined in quartz, carbonates, fluorite, gypsum, galena, sphalerite, pyrite, cinnabar and layer silicates of polymetallic, gold, mercury and rock-crystal mineralizations of Carboniferous outcrops of Donbass.

Homogenization of inclusions occurs in gas or liquid phase, and occasionally with critical phenomena in CO_2-bearing inclusions. T_h in quartz and carbonates: 300-310, 220-260, 150-170, 80-120°C. Decrepigraphs usually have some maxima: quartz 60-100, 120-160, 220-260, 280-320°C; carbonates 70-120, 180-220, 240-280, 340-380; fluorite 60-100, 180-220°C; galena 260-320°C; sphalerite 80-120, 180-240, 280-320°C; pyrite 60-120, 220-300°C; cinnabar 60-120, 160-200°C; layer silicates 60-120°C. Several generations of inclusions in the minerals occur, providing significant changes of pressure and temperature. (Authors' abstract).

GORYAINOV, I.N., and ANDREYEVA, T.B., 1972, Chlorides of iron, nickel, copper and aluminum in copper-nickel ore of the Talnakh deposit: Akad. Nauk SSSR, Doklady, v. 204, no. 6, p. 1456-1459 (in Russian; trans. in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 204, p. 224-226). Authors at Research Institute of Arctic Geology, Leningrad.

Chemical composition of the chloride and sulfide phases of the ores (table 1), Fe-Ni-Cu interrelations in these phases (fig. 1), partial and multiple correlations of the metals, ubiquitous presence of chloride in a wide variety of the minerals, and presence of apatite in the ores are definite evidence here of the importance of chloride in transfers of the metals during formation of the ores. Presence of chlorides, apparently as a solid phase, in primary multiphase inclusions in the ore and the gangue minerals lends further support to that conclusion. (Authors' abstract, trans. in Intern. Geol. Review, v. 14, 1972, p. 1382).

GREENWOOD, H.J., 1973, Thermodynamic properties of gaseous mixtures of H_2O and CO_2 between 450° and 800°C and 0 to 500 bars: American Journal of Science, v. 273, p. 561-571.

GROSHENKO, A.R., 1973, A method of heating chamber calibration: Abstracts of papers at Fourth Regional Meeting on Thermobarogeochemistry of Mineral-Forming Processes at Rostov-on-Don, 24-30 Sept., 1973: Rostov, Rostov Univ. Press p.301-302 (In Russian; translation provided by Dr. E.I. Dolomanova of I.G.E.M., Moscow). Author at IGEM, USSR Academy of Sciences, Moscow.

1. Owing to the great diversity of instruments applied in thermometry by different laboratories and the absence of a single calibration technique, the results obtained by different research centers are often difficult to correlate.

2. A method of calibration is suggested to measure more accurately the temperature in heating chambers. This method takes account of three-dimensional isothermal fields present both inside instruments and in specimens under study. The coordinates of the inclusion under investigation in the isothermal field can be determined, so the temperature of the inclusion is measured quite accurately, with a maximum error of a few percent.

3. It is suggested to prepare reference specimens in a calibration platinum heating chamber specially designed at IGEM, USSR Academy of Sciences. The standards may consist of plates of various minerals with inclusions having stable and clearly defined homogenization points, after determination of their homogenization temperatures in the calibration chamber. Such standards permit any operational heating chamber to be calibrated. (Authors' abstract).

GROSHEV, A.K. AND TURCHINSKIY, V.P., 1973, Tectonic and temperature regime of origin of a beryllium-bearing stock: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 65-66 (in Russian; translation provided through the courtesy of A. Kozlowski). Authors at Inst. of Geology of Kirgiz SSR, Geological Board of Kirgiz SSR.

The stock occurs in a mass of green amphibole schists, gneisses, and consists of beryllium-bearing orthoclase-albite veinlets, and rarely of metasomatites of biotite of quartz-sericite.

The mineralization occurred in two stages; each began with beryllium mineralization and closed with a barren quartz-fluorite-calcite association.

The main Be mineral-phenacite-occurs in two generations in agreement with the above. The generations differ in morphology, some physical features and in trace elements. Phenacite I occurs with beryl, phenacite II, - with bavenite, milarite and bertrandite.

Crystallization temp. of phenacite I ranges from 390 to 380°C, phenacite II - 420-400°C, beryl - 370-260°C, bavenite and milarite - 370-350°C. The temperature range of mineral formation of stage I is 390-220°, stage II - 425-60°C. The highest temps. were noted at the beginning of stage II. The sudden increase of temp. of stage II solutions by 200°C was significant in their renovation. (Authors' abstract)

GULYAEV, A.P., MIROSHNICHENKO, L.A. AND CHUMACHENKO, P.M., 1971, On the possible form of tungsten transport in important stages in the origin of a rare metal deposit in Kazakhstan, p. 109-115, in Mineralogy and geochemistry of tungsten deposits (Materials of 2nd All-Union Symposium on Mineralogy, Geochemistry and Genesis of Tungsten Deposits of USSR): Leningrad, Leningrad Univ. Publishing House, 344 pp. (In Russian; abstract through the courtesy of A. Kozlowski). Authors at Inst. of Geological Sciences, Academy of Sciences Kazakh SSR.

The deposit is of skarn-greisen type (or so called apocarbonate-greisen type). It occurs in Cambrian metasedimentary rocks (schists, limestones, & dolomites) cut by large dike-like body of fine-grained granites of high silica-acidity and alkalinity, being probably the apical part of hidden intrusive. The ore bodies are greisens, veins and impregnation zones. The ore minerals are wolframite and cassiterite, in limestones, accompanied by near-vein mica-fluorite greisens with chrysoberyl. The veins contain topaz, and feldspar, fluorite, tourmaline, sericite, scheelite, pyrite, stannite, etc.

The skarns formed at high temp., 400-380°C, as indicated by deprepitation analysis of vesuvianite. The most important process of deposit formation there was the greisenization process. Decrepitation analysis proves that near-vein greisens formed at lower temps. (T_d of quartz 350-320°C) than near-fracture greisens (T_d of quartz 380-360°C).

In the solutions, tungsten was transported independent of Sn^{+4} Be^{+2}, Al^{+3}, and it was transported with K^+, Li^+, F^- & OH^-, probably as $K_2(WO_2.F_4)$, $K_2(WO_3.F_2)$, $K_3(WO_2.F_5)$, $K_2(W(OH)_n.F_{8-n})$, and $K_2(W(O,OH)_n.F_{8-n})$.

GUNIAVA, V.D., 1973, Temperature conditions of formation of greisens and secondary quartzites from Adzharia: Abstracts of papers at Fourth

Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 249 (in Russian; translation through the courtesy of A. Kozlowski). Author at Caucasian Inst. of Mineral Raw Materials, Tbilisi.

Greisens and secondary quartzites are developed in the SW part of Adzharo-Trialetskaya structural-metallogenic zone. Products of acid dissolution of rocks occur at external and internal side of the contact of subvolcanic syenite-dioritic intrusives, cutting a middle Upper-Eocene volcanogenic complex of trachy-andesite composition.

Investigations of T conditions of individual facies of metasomatites by homogenization and decrepitation methods have given following results;

1) T_D in °C of typomorphic minerals of vein greisens: tourmaline 460-420, pyrite 420-360, quartz 440-380; T_H of secondary and pseudo-secondary inclusions in quartz 320-290°C.

2) T_D of quartz and pyrite from equant greisen bodies 390-360 and 380-360°C, respectively.

3) T_D of quartz from secondary, halogene type quartzites 320-280°C.

4) T_D of quartz from secondary, sulfuric acid type quartzites 280-230°C.

(...) (Author's abstract, abbreviation by A.K.)

GUNTER, B.D., 1973, Aqueous phase-gaseous phase material balance studies of argon and nitrogen in hydrothermal features at Yellowstone National Park: Geochimica et Cosmochimica Acta, v. 37, pp. 495-513. Author at Southwestern State College, Weatherford, Oklahoma.

Quantitative analyses of aqueous phases and gaseous phases, gas flow rates, aqueous flow rates have been performed at twenty-five hydrothermal springs at Yellowstone National Park. Material balance calculations indicate that the inventory of argon and nitrogen in these features can be explained very well in terms of a ground water distillation model. The average rate for the release of nitrogen by both phases is 9.06 micromoles of nitrogen per mole of water discharged, and the average rate of release of argon by both phases is 0.248 micromoles of argon per mole of solution. A Rayleigh type distillation is considered in these calculations, and the distribution of argon and nitrogen between the aqueous and gasesous phases approaches equilibrium in most of the features. It is noted that these data are valid for these samples only at the time of emergence. There is no evidence for the addition of juvenile argon or nitrogen to the atmosphere by these springs at the present. (Author's abstract)

GUNTER, William D., FRANTZ, John D. & EUGSTER, Hans P., 1973, Mineral solution equilibria in the system $K_2O-MgO-Al_2O_3-SiO_2-H_2O-HCl$ (abst): Amer. Geophys. Union, Trans. (EOS), v. 54, no. 4, p. 487.

HALL, W.E., FRIEDMAN, Irving, and NASH, J.T., 1973, Fluid inclusion and light stable isotope study of the Climax molybdenum deposits, Colorado (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 649-650. First author at U. S. Geological Survey, Menlo Park, CA 94025.

Three molybdenite ore bodies and a late barren stage at the Climax mine are each related to a different intrusive phase of the Climax stock. Alteration zones spatially related to molybdenite ore bodies include an underlying silica zone, an approximately coincident K-silicate zone, and overlying greisen, sericitic, and argillic zones. All quartz and muscovite, and most sericite, are in equilibrium with water with a calculated $\delta^{18}O$ at 350°C of +3.0 to +5.6‰. $\delta^{18}O$ values of K-feldspar range from +7.2 to -4.5‰. This wide range indicates recrystallization of feldspar with isotopically light water. Calculated δD of water in equilibrium with sericite at 275°C is -92 to -144. This is the same range as δD of fluid inclusions in ore. Kaolinite in the argillic zone has $\delta^{18}O$ values of -0.9 to -2.2 and δD values of -16.2‰. Calculated water in equilibrium with kaolinite at 250°C has $\delta^{18}O$ values of -5 to -6.2 and δD of about -130‰. All temperatures were selected on the basis of homogenization temperatures of fluid inclusions in quartz. A plot of salinity versus δD of fluid inclusions trends from 18% equivalent NaCl and $\delta D = 92‰$ for early ore to <1% equivalent NaCl and $\delta D = 145‰$ for late mineralization.

The isotopic and fluid inclusion data best fit a model whereby the Climax ore bodies were formed from a hydrothermal system in which there was progressive mixing of heavy and light water. The light water in the late stages resembles present day meteoric water. The heavy (early) water may be magmatic or a heavy meteoric water. The latter possibility requires a change in meteoric water composition during the formation of the deposit. (Authors' abstract)

HANOR, J.S., 1973, The role of <u>in situ</u> densities in the migration of subsurface brines (abst.): <u>Geol. Soc. America Abstracts with Programs</u>, v. 5, no. 7, p. 651-652. Author at Dept. of Geology, Lousiana State Univ., Baton Rouge, Louisiana 70803.

Fluid inclusion studies have suggested that sedimentary brines were important constituents of the ore-forming fluids that produced Mississippi Valley Type ore deposits. A fundamental problem, however, is finding a mechanism by which such brines could have been driven up from the depths of a sedimentary basin into the tectonically elevated sites of ore deposition.

Using P-V-T-X data for NaCl solutions, <u>in situ</u> densities were calculated for subsurface waters in the Gulf Coast, Illinois, Alberta, and Michigan basins. It has been found that the increase in salinity with depth for most waters in each basin is just sufficient to counteract the tendency of increasing temperature to reduce brine densities. Water compositions have thus evolved in such a way as to produce a gravitationally stable column of fluid within each basin. Density gradients decrease with depth, however, and approach zero in the deeper parts of the basins. It is possible, therefore, that even minor changes in the heat flow regime of a basin or more local sources of heating at depth, such as intrusive igneous activity, would be sufficient to produce a gravitationally buoyant mass of heated, saline water. This gravitational instability could be effective in causing the upward migration of deep waters. The excess heating necessary to produce gravitational instability is consistent with the fact that apparent temperatures of ore deposition in Mississippi Valley Type deposits often exceed basin temperatures which could have been generated in normal geothermal gradients. (Author's abstract)

HARE, P.E., 1973, Quaternary diagenesis of amino acids (abst): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 652. Author at Geophysical Laboratory, 2801 Upton St., N.W., Washington, D.C. 20008.

Reactions of amino acids observed in samples of Quaternary age include deamination and decarboxylation to form the corresponding fatty acids, amines, and hydrocarbons as well as ammonia and carbon dioxide.

Also observed are racemization (and epimerization) reactions to form increasing amounts of the D-amino acid isomers. Amino acids also react with carbohydrates to form products similar to humic acids and kerogen.

A study of the amino acids in several deep sea cores shows that amino acids may react in different ways and at vastly different rates depending on the sediment fraction with which the amino acids are associated. Amino acids in the carbonate tests of Foraminifera from a Quaternary sediment showed extensive racemization while the amino acids in the clay fraction showed extensive deamination but little or no racemization.

A study of the amino acids in Quaternary fossils and in the various sediment fractions of Quaternary sediments gives information on the age of the sample, possible reworking of older fossil materials, temperature history, and the significance of amino acid diagenesis to such problems as the origin and development of more stable organic materials present in the sediment. (Author's abstract)

HARKER, R.S., 1973, Fluorite with cassiterite [in the tin-tungsten deposits of Cornwall and Devon, England]: Mineralogical Record, v. 4, no. 2, p. 94-95.

Fluid inclusion homogenization temperatures (uncorrected) are given for fluorite from the South Crofty mine of 310-335° (14 level,green) and 237-264 (15 level,purple). Fluorite from 10 level gave 357-377°C (inner green) and 317-347°C (outer purple). Inclusions (in fluorite?) from the Cu-Pb-Zn mine at Menheniot, Cornwall, gave 99-150°C. (ER).

HEKINIAN, R., CHAIGNEAU, M., and CHEMINEE, J.L., 1973, Popping rocks and lava tubes from the Mid-Atlantic rift valley at 36°N: Nature, v. 245, p. 371-373.

Dredge samples from 1360 fathoms decrepitated and jumped up to 100 cm, with a loud noise, for up to 3 days after recovery. The material is fresh glassy olivine basalt. Gas analyses made of this and the non-popping glassy margin of a pillow lava show major amounts of HCl, CO_2, CO, SO_2, and H_2 and minor to trace amounts of H_2S, CS_2, N_2 and hydrocarbons. Rapid quenching from >1100°C on extrusion at oceanic pressures of 250-300 bars is presumed to have precluded loss of the gas in the popping samples. (ER)

HENLEY, R.W., 1973a, Solubility of gold in hydrothermal chloride solutions: Chemical Geology, v. 11, pp. 73-87. Author at University of Otago, Dunedin, New Zealand.

The solubility of gold has been determined in chloride solutions in the temperature range 300-500°C corresponding to the inferred range for the formation of "hypothermal" gold deposits. The solutions were buffered with respect to HCl by a K-feldspar--muscovite--quartz assemblage, and to oxygen by the assemblage hematite-magnetite. Solubilities increased rapidly with temperature from about 10 p.p.m. at 300°C, to 500 and 1000 p.p.m. at 500°C at 1000 and 2000 bar, respectively.

These results are discussed in terms of possible solution species in this high-temperature region where molecular behaviour predominates in the solution equilibria. It is suggested that gold and other metals may be transported to the site of ore-deposition in undersaturated high-temperature solutions. Ore deposition may take place at lower temperatures where ionic gold chloride or sulfide species dominate the chemistry of the ore solutions. (Author's abstract)

HENLEY, R.W., 1973b, Some fluid dynamics and ore genesis: Inst. Min. Metallurgy, Trans., v. 82, sect. B, p. B1-B8. Author at Geology Dept. University of Otago, Dunedin, New Zealand.

Hydrothermal ore deposits are the fossil remnants of former fluid flow systems in the earth's crust, and their present-day analogues are the geothermal systems which occur in New Zealand, Japan, Mexico, etc. The physical characteristics of such systems are discussed, and it is shown that free convection of fluid is the heat- and mass-transfer process which operates in these areas. The components of geothermal systems are compared with a scheme for hydrothermal ore genesis, and some convective models are discussed which may apply to the range of conditions which have governed the formation of orebodies. An order of magnitude calculation shows that ore genesis at Morro Velho, Brazil, involved very high Rayleigh number convection. Some corollaries of the convective schemes concern the origin of pipe-shaped orebodies and the spatial distribution of lode deposits. (Author's abstract)

HEYL, A.V., LANDIS, G.P., & ZARTMAN, R.E., 1973, Isotopic evidence for the origin of Mississippi Valley-type mineral deposits: a review (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 668-669. Authors at U.S. Geological Survey, Denver, Colorado 80225.

Isotopic and geochemical data available from Mississippi Valley-type ore deposits place significant constraints on models of ore genesis. Lead from galena of all large deposits in the Mississippi Valley is appreciably enriched in radiogenic isotopes compared to the more ordinary lead of most other localities. Such data have generally been interpreted as signifying a shallow crustal source for the lead, from underlying Precambrian basement rocks and/or from Paleozoic sandstone and carbonate rocks. In detail, each district has a distinctive regional isotopic pattern that reflects direction of solution flow, hidden heat sources, and areas of localization of major deposits. Mafic dikes in Illinois and western Kentucky are spatially associated with ore deposits; their strontium isotopic composition is suggestive of a mantle derivation. Published fluid-inclusion filling temperatures and δS^{34} of sulfide mineral pairs, and δO^{18} and δC^{13} of limestone and dolomite indicate very small isotopic alteration halos adjacent to ore bodies. Ore fluids typically exhibit temperatures from 160° to 70°C and salinities in excess of 20 wt. % soluble salts. Temperature, δD, δO^{18} , and chemistry of fluid inclusion waters indicate that main ore fluids in many deposits probably were deep-circulating formation brines. δS^{34} data suggest derivation of sulfur from connate sea-water sulfate (or evaporites) and reflect low-temperature isotopic disequilibrium fractionation between reduced and oxidized sulfur species; the occurrence of sulfur isotopic disequilibrium prohibits recognition of exact sulfide precipitation mechanisms. These isotopic, fluid-inclusion, and chemical data indicate that (1) the main ore fluids were heated oil-field brines having largely a crustal source for lead and sulfur, and (2) regional disturbances, probably of lower crust-mantle origin, initiated large hydrologic systems that produced Mississippi Valley-type mineralization. (Authors' abstract)

HOAGLAND, A.D., 1973, Appalachian zinc-lead and the deposits of Middle Tennessee (abst.): Geol. Soc. America Abstracts with Programs, v. 5, no. 5, p. 404. Author at The New Jersey Zinc Company, Murfreesboro, Tennessee 37130.

Appalachian zinc-lead deposits are structurally deformed counterparts of the Mississippi Valley type. The significant mineralization is epigenetic and pre-orogenic. Primary permeability resulted from paleophysiographic and sedimentary phenomena such as karstification, reefs, etc. The ore fluids were warm Na-Ca-Mg-Cl brines carrying base metal ions. It is probable that the brines were derived from thick geosynclinal or basinal argillaceous sediments. These fluids invaded the permeable zones of accessible carbonate strata enhancing permeabilities by dissolution and alteration of limestone.

It is hypothesized that the ore minerals were deposited as a result of mixing with a second fluid system charged with H_2S. Ore deposition required that at least three conditions persisted over long periods of time: (1) continued replenishment of both fluid systems to provide adequate supplies of metal and sulphur, (2) continued dissolution and alteration of limestone to maintain permeability in the zone of deposition, and (3) a relatively constant hydrostatic balance between the two fluid systems to confine the zone of mixing within a relatively narrow vertical range and insure an adequate concentration of sulphide deposition.

A model for the Middle Tennessee deposits is suggested in which brines from the thick Middle Ordovician shales of the Appalachian geosyncline are introduced into the extensive karst system of the Lower Ordovician Knox and driven to depositional sites on the shelf areas of East and Middle Tennessee where adequate supplies of H_2S are assumed to have been present during the post Lower Ordovocian Paleozoic. (Author's abstract)

HOARE, J.M., and CONDON, W.H., 1973, Lherzolite xenoliths in tholeiite, Nanwaksjiak Crater, Nunivak Island, Alaska (abst.): Geol. Soc. America Abstracts with Programs, v. 5, no. 1, p. 55. Authors at U.S. Geological Survey, Menlo Park, California 94025.

Deformed and recrystallized lherzolite xenoliths of probable mantle origin occur in blocks of olivine tholeiite thrown out of Nanwaksjiak Crater on Nunivak Island, Alaska. The crater was excavated by a very violent eruption of gas-rich highly alkalic ash. The shape, size, and limited distribution of the blocks of lherzolite-bearing tholeiite indicate that they probably derive from a small body of rock that was intruded at shallow depth beneath the crater. It is assumed that the intrusion was facilitated by the gas-rich eruption which formed the crater, for lherzolite xenoliths are unknown in the less alkalic basalts elsewhere on Nunivak Island and are unreported elsewhere in the world. The occurrence of ultramafic xenoliths in basalts is governed by several factors, the most critical of which is probably the ability of the basalt magma to transport such dense material. It is suggested that ultramafic xenoliths are common in highly alkalic basalts because these basalts are relatively gas-rich and consequently rise rapidly and erupt violently. Ultramafic xenoliths are generally lacking in less alkalic basalts because they are relatively gas-poor, rise slowly, and erupt passively. The unusual occurrence of lherzolite in tholeiite at Nanwaksjiak Crater appears to support this hypothesis. (Authors' abstract)

HODGES, F.N., 1973, Solubility of water in silicate melts at high pressure (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 671. Author at Geophysical Laboratory, 2801 Upton Street, N.W., Washington, D.C. 20008.

The high-pressure solubility of water in simple (monomineralic) silicate melts is, to a large extent, a function of pressure ($^{P}H_2O$) and the number of oxygen atoms available in the silicate structure. The solubility of H_2O in forsterite (Mg_2SiO_4) melt at 20 Kb. is 20.2 ± 1.0 wt. % (1425 ± 10°C). This value (66 mole %) is equivalent to approximately 0.5 mole of water (H_2O) per formula oxygen. Values for solubility of H_2O in albite ($NaAlSi_3O_8$), enstatite ($Mg_2Si_2O_6$) and diopside ($CaMgSi_2O_6$) melts at 20 kb. (Eggler, 1973) are, within the limits of experimental error, identical to the value for forsterite when calculated on a per formula oxygen basis (0.5 mole H_2O/formula oxygen). Solubility values at 10 kb. for H_2O in enstatite (Kushiro and Yoder, 1969) and anorthite (Yoder, 1966) are, on a per formula oxygen basis, identical within the limits of experimental error; yielding a value of approximately 0.24 mole H_2O per formula oxygen. Preliminary data at 30 kb. indicate that the rate of increase of solubility decreases with increasing pressure. Although the data presented is for simple melts, its consistency for a wide range of rock forming silicate minerals indicates that it can be used to calculate the solubility of H_2O in complex natural magmas under conditions of the upper mantle. (Author's abstract)

HOLGATE, Norman, 1973, Dichroic pigment-layers in Blue John fluorite: Mineralog. Mag., v. 39, p. 363-365. Author at Dept. Geol., Univ. Glasglow, Scotland G12 8QQ.

The various coloring mechanisms that have been proposed are reviewed; H objects to the suggestion of colloidal calcium since this is an isometric structure and the coloring is dichroic. H suggests hydrocarbons as the most likely. (E.R.) (Editor's note: see also Braithwaite et al, this volume; the mechanism of formation is important in understanding the various inclusions in these materials.)

HOLLISTER, L.S., 1973a, The Khtada Lake (British Columbia) metamorphic complex: the role of CO_2 - rich fluid inclusions (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 5, no. 7, p. 672. Author at Department of Geological and Geophysical Sciences, Princeton University, Princeton, N.J., 08540.

Granulite facies rocks occur with plutonic rocks of the Coast Range Batholithic Complex, 80 km east of Prince Rupert. Metamorphic mineral assemblages suggest temperatures exceeding 700°C at a depth greater than 15 km. The "primary" fluid inclusions (solitary or clusters without geometric pattern) in quartz in the granulite facies rocks, associated amphibolite facies rocks, and associated biotite-hornblende-quartz dioritic rocks (∿250 measurements in 15 inclusion-bearing specimens) are predominantly nearly pure CO_2 (m.p. ≈ -57°C, apparent density 0.7 to 0.9 gm/cm^3, solid hydrate melts between +7 +10°C). The homogenization temperatures (to liquid) of the CO_2 can vary within a single quartz grain by as much as 19°C. CO_2-H_2O mixtures, with more than 20 volume per cent of H_2O, occur in only two specimens. H_2O-rich secondary inclusions (m.p. -0.5 to -3°C) typically occur in planes, often associated with planes of low density, secondary inclusions (0.1 to 0.75 gm/cm^3). Rare "primary" hydrous inclusions (m.p. -3 to -14°C) occur with some of the more abundant "primary" CO_2 inclusion clusters. Indirect evidence for the presence of hydrocarbon compounds in some inclusions is suggested by final melting temperatures of -60 to -65°C, preceded by a melting interval of a few degrees (homogenization temperatures (liquid) of these inclusions are between +2°C and -14°C).

Possible interpretations of these data for the Khtada Lake area are (1) the fluid phase, during metamorphism, separated into immiscible CO_2-rich and H_2O-rich phases; (2) the fluid phases re-equilibrated at several stages during uplift along a geothermal gradient between 50 and 65°C/km; (3) the immiscibility was probably facilitated by the presence of hydrocarbon compounds and dissolved solids in the fluid phase. Immiscible fluid phases,due to differences in solubilities of components in the two phases, may be a contributing factor to the development of some common textural features in metamorphic rocks, such as gneissocity and veining. (Author's abstract)

HOLLISTER, L.S., 1973b, Immiscible fluid phases during metamorphism, Khtada Lake area, British Columbia (abst.): Amer. Geop. Union, Trans. (EOS), v. 54, no. 11, p. 1225. See previous abstract.

HORN, R.A. & WICKMAN, F. E., 1973, The Na/K ratio of fluid in pegmatitic quartz and its genetic implications. A study by neutron activation analysis: Lithos, v. 6, pp. 373-387. Authors at Pennsylvania State University, University Park, Pa. 16802

Samples of quartz and its fluid inclusions (f.i.) from Black Hills pegmatites and from graphic granites were analyzed for Na, K, Rb and Cs by neutron activation analysis. The Na/K ratios of the whole quartz and its f.i. seem unrelated. The spatial locations for six samples from the Helen Beryl pegmatite were known. The Na/K ratios of their f.i. are mainly a function of their vertical positions in the pegmatite. The ratios of the central-ore quartz f.i. seemingly indicate a much higher temperature than those closer to the upper wall. This is consistent with the theory of pegmatite genesis by Jahns & Burnham. The f.i. of quartz from two graphic granites give very different Na/K ratios, seemingly related to differences in their formation history. (Authors' abstract)

HUANG, Liang-Wuu, and WYLLIE, Peter J., 1973, Melting relations of muscovite-granite, with application to anatexis in the crust and subduction zones (abst): Amer. Geophys. Union, Trans. (EOS), v. 54, no. 4, p. 481.

HUGHES, T.H., and LYNCH, R.E., Jr., 1973, Barite in Alabama: Geol. Survey Alabama Circular 85.

Includes some studies of fluid inclusions and the origin of the deposits (p. 20-23), including a brief mention of the design of a circulating fluid heating stage. Fluorite associated with barite from the Weaver property, Bibb County, had T_H for primary incs. = 73-91°C; secondary 28-40°C. The deposits are epigenetic, strata-bound, and low-temperature, and formed between stages of the Appalachian orogeny. (E.R.)

IKORNIKOVA, N. Yu., and EGOROV, V.B.,1968, Experimentally determined PTFC diagrams of aqueous solutions of Li, Na, K, and Cs chlorides, in Hydrothermal Synthesis of crystals, A.N. Lobacher, ed: Moscow, "Nauka" Press, (in Russian; translated by Consultants Bureau; 1971, p. 34-51).

Detailed data are given on the systems listed, including data on the system NaCl-H_2O at 60, 70, 80, and 90% filling; P 160-2680 Kg/cm^2; T 190-770°C; and concentrations of 1-6 molal. These data presented differ significantly from those of Lemmlein and Klevtsov, (1961), that are normally used for calculating pressure corrections for homogenization temperatures, because more complete corrections were made for thermal expansion in the later work. The differences result in differences in pressure corrections at up to ∿20°C. (ER).

IKORSKIY, S.V., 1973, Extraction of bitumens from inclusions in minerals by heating: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 305-306 (in Russian; translation provided through the courtesy of A. Kozlowski). Author at Geol. Inst. of Kola Division of Acad. Sci. of USSR, Apatity.

1. Extraction of bitumen is performed in an apparatus consisting of ampoule (pyroxene, quartz) (sic.) with a tube of small diameter having at the end a small glass bulb bearing a desiccant and an empty glass bulb (100-500 ml). Before heating the apparatus is evacuated. A horizontal tube electric furnace is used for heating.

2. On breaking of the inclusions the vapors of the bitumens move toward the vacuum bulb of the apparatus and precipitate on the cold walls of the tube at its connection with the furnace. Temperature is controlled by observation of the precipitates having luminescence in UV light (sic). When the heating is finished, this part of the tube is cut out for investigations on the bitumen.

3. This method provides a solution to the following problems: a) to ascertain the presence of bituminous substance in minerals when its amount in the mineral is low: 0.00n% from a sample of 15-20g; b) by comparison of the temperatures of escape of bituminous vapors with thermometric data one may determine the type of inclusions bearing bituminous substances; to study temperature of alteration of bitumens in the inclusions.

As illustrations, some data are given from investigations of bituminous inclusions in minerals of alkaline rocks.(Author's abstract)

IKORSKY, S.V., and POLYAKOV, A.I., 1973, Results of an investigation of gases in magmatic rocks of East African rift zones: Geokhimiya, 1973, no. 6, p. 816-823 (in Russian; translated in Geochem. Internat., v. 10, no. 3, 1974, p. 620-626). First author at Geological Institute of the Kola Branch of the USSR Academy of Sciences, Apatity.

The content of gases in Neogene-Quaternary magmatic rocks from East African rift zones varies from 0.03 to 2.31 cm^3/kg of the rock. Extraction of gases was carried out by crushing the rock in evacuated ball mills. Determinations (43 samples) were chiefly made for effusive rocks of the Eartern rift zone. Saturated and unsaturated hydrocarbons, hydrogen, CO and CO_2 have been established in gas samples. A slight enrichment in hydrocarbon gases of volcanic rocks having been formed by crystallization of primary mantle melts is noted in comparison with effusive rocks arising during crystallization of residual melts. (Authors' abstract).

INGERSON, Earl, 1973, Review of "Composition of Fluid Inclusions", U.S. Geol. Survey Prof. Paper 440JJ: Amer. Mineral., v. 59, 1974, p. 1340.

IRVING, A. J. & WYLLIE, P. J., 1973a, Melting relationships in CaO-CO_2 and MgO-CO_2 to 36 kilobars with comments on CO_2 in the mantle: Earth and Planetary Science Letters, v. 20, pp. 220-225. Authors at University of Chicago, Illinois, 60637.

The melting curves of $CaCO_3$ and $MgCO_3$ have been extended to pressures of 30 kb by experiments in piston-cyclinder apparatus. At 30 kb, the melting temperatures of calcite and magnesite are 1610° and 1585°C, respectively. New data for the magnesite dissociation reaction permit the location of an invariant point for the assemblage magnesite + periclase + liquid + vapor near 26 kb-1550°. New data are also presented for the calcite-aragonite transition at 800°C, 950°C and 1100°C. At pressures above 36-50 kb, calcite and magnesite melt at temperatures lower than the solidus of dry mantle peridotite. Natural and experimental evidence suggests that carbon dioxide in the Earth's mantle could be present in a variety of forms: (a) a free vapor phase, (b) vapor dissovled in silicate magma, (c) crystalline carbonate, (d) carbonate liquid (e) carbon-bearing silicate analogs, or (f) carbonato-silicates (such as scapolite, spurrite, tilleyite, and related compounds).(Authors' abstract)

IRVING, A.J., and WYLLIE, Peter J., 1973b, Melting relationships in $CaO-MgO-CO_2$ compared with the solidus for mantle peridotite (abst.): Amer. Geophys. Union, Trans. (EOS), v. 54, no. 4, p. 479.

IVANOVA, G.F. AND STUDENIKOVA, Z.V., 1971, Physico-chemical characteristics of conditions of origin of greisen wolframite deposits (E. Transbaikalia), p. 122-130, in Mineralogy and geochemistry of tungsten deposits (Materials of 2nd All-Union Symposium on Mineralogy, Geochemistry and Genesis of Tungsten Deposits of USSR): Leningrad, Leningrad Univ. Publishing House, 344 pp (In Russian; abstract through the courtesy of A. Kozlowski). Authors at Institute of Geochemistry and Analytical Chemistry, Acad. of Sciences USSR, Moscow.

Deposits were investigated in the districts of Khangilay-Shily, Durulguy, Zun-Undur, Soktuy, Aldakachan, and Antonova Mt. The most common of vein ore bodies, with quartz and wolframite, were studied by thermobarometric methods. All inclusions in minerals homogenize in the liquid phase, proving the hydrothermal origin of ores. Decrepitation temp. of wolframites from a number of deposits range from 240 to 330°C, and those of quartz - 200-330°C. $T_{hom.}$ of inclusions in quartz were 240-302°C. Taking into account corrections for pressure, the real crystallization temp. did not exceed 400°C. Pressure at one of deposits (Spokoyne) was about 1650 atm. The main components of inclusions (water leachate method) are as follows: Na (5.1), K(4.4), Ca (3.1), Cl (5.9), F (2.5) gm/l, and varying amounts of CO_2. Ionic strength of solutions varies from 0.29 to 0.76, mean 0.60, and the general concentration was 3-4 wt %. Values of pH for 300°C range from 6.35 to 7.08. The most probably form of tungsten under hydrothermal conditions is H_2WO_4, and partly HWO_4^-; polytungstate ions, such as $HW_6O_{21}^{5-}$, are less probable ones. The authors discuss the possibility of oxyfluoride- and thio-complexes of tungsten at temp. about 300°C. Calculated activity $a_{Fe^{+2}}$ was not lower than 2.8×10^{-11} gram-ion/liter = 1.5×10^{-6} mg/liter and $a_{WO_4^{2-}}$ not $<6 \times 10^{-8}$ gram-ion/liter, when $a_{Ca^{2+}}$ was equal 10^{-6} gram-ion/l, permitting precipitation of wolframite rather than scheelite.

(Authors abstract)

IVASIV, S.M., 1973, Physico-chemical conditions of formation and temperature zoning of the Itakinskoe gold-ore deposit: Abstracts of papers at Fourth Regional Conference on Thermobarogeochemistry of Mineral-Forming Processes, 24-30 Sept., 1973: Rostov, Rostov Univ. Press, p. 274 (in Russian; translation provided through the courtesy of A. Kozlowski). Author at L'vov Univ.

Geological-mineralogical (Mel'nikova, 1970) and mineralthermometric (Ivasiv, 1970) studies prove that the Itakinskoe deposit belongs to the polystage pneumatolytic-hydrothermal type, formed under high-, moderate-, and low-temp. conditions. Development of ore may be divided into 2 stages: a) pneumatolytic-hydrothermal; and b) hydrothermal. To stage a) the quartz-molybdenite (420-360°C) and quartz-tourmaline (430-340°C) substages belong; to stage b) quartz-arsenopyrite (310-230°C), quartz-polymetallic (300-220°C), quartz-antimonite (220-150°C) and quartz-carbonate (180-110°C). Results of mineralthermometric mapping (by means of homogenization of inclusions in quartz from associations with gold, and polymetallic sulfides) prove that temp. of origin of ores increase with depth (average values 15-20°C/100m) and from W toward E (5-10°C/100m). At the boundary of blocks, in a fault zone, a sudden T increase (30-40°C in 15-20 m) was ascertained, as a result of post-ore disruption of the temperature regime.

These peculiarities suggest two types of zoning: from pulsation (i.e., stages) and zoning during precipitation.(Author's abstract)

JACKSON, Herman, 1973, Metamorphic pore fluid composition at Marble Canyon, Texas (abst.): Geol. Soc. Amer. Abstracts with Programs, no. 3, p. 263-264. Author at Department of Geology, Northeast Louisiana University, Monroe, Louisiana 71201.

Contact metamorphism of dolomite at Marble Canyon, Texas, in the eastern margin of the Diablo Plateau, has produced a bleached aureole of brucite marble. Dolomite was decomposed by the reaction: dolomite = calcite + periclase + CO_2. The periclase subsequently hydrated to both the familar "onionskin" brucite as well as parallel aggregates of platy brucite. Individual platelets in the parallel aggregates of brucite are parallel to the intrusive contact and are presumed to have formed before cessation of magmatic movement and contact metamorphism.

Calculated equilibrium curves for reactions in the system MgO-CO_2-H_2O indicate that hydration of the periclase occurred in a fluid of mole fraction $H_2O \geqslant 0.95$. Because periclase hydration occurred before the end of the metamorphic episode, it is concluded that the metamorphic pore fluid was similar. This conclusion is somewhat surprising in view of the rather large amount of CO_2 liberated in decomposition of dolomite and leads inescapably to the conclusion that the fluid composition in the rock being metamorphosed was externally controlled. I believe the fluid composition was controlled by aqueous fluid expelled from the crystallizing granitic magma.

Calculations show that the aqueous fluid (steam) expelled from a granitic magma may be sufficient in volume to completely flush the pore space of a contact aureole such as that at Marble Canyon as many as one-hundred times.(Authors' abstract)