

mica. Alteration of these F-rich aluminosilicate phases ($F/(F+OH) \approx 0.8$) leads to F-poor muscovite ($F/(F+OH) \approx 0.05$) and fluorite of hydrothermal origin. The hydrothermal fluid is thus enriched in fluorine by post-magmatic reactions with F-rich aluminosilicate phases. Experimental and petrographic data suggest that whereas fluorine may aid concentration of metals such as Sn and W by magmatic processes, the affinity of magmatic fluorine for aluminosilicate phases does not favor the formation of residual F-rich ore-forming fluids. Such fluids may be produced by post-magmatic reaction between aqueous solutions of many possible origins and F-rich granitic rocks, independent of their crystallization. (Author's abstract)

MANNING, D.A.C., 1982, Partitioning of tungsten between granitic melts and a coexisting aqueous phase: *Bull. Mineral., suppl.*, v. 105, p. 53 (in French).

The partition coefficient of tungsten between "minimum melts" in the system Qz-Ab-Or and aqueous phase have been determined at 800°C and 1 kb for pure H₂O and fluoride and chloride solutions. The coefficients are strongly dependent on concentration for experiments with pure H₂O and NaCl solutions. With an NaCl solution, tungsten is partitioned strongly in favor of the aqueous phase and has a solubility maximum in the melt of 0.5 wt. %. With pure H₂O, the solubility maximum in the melt is between 1 and 2 wt. %; for lower concentrations, tungsten is partitioned in favor of the melt. In the presence of fluorine, tungsten is apparently partitioned in favor of the melt. However, for certain melt compositions, a crystalline phase (possibly WO₃) precipitates, which complicates the interpretation. Preliminary experiments suggest that tungsten is partitioned almost equally between the melt and carbon-bearing [CO₂?] fluid.

The different behavior of tungsten in the presence of F or Cl probably reflects the behavior of these elements in granitic systems. F is partitioned strongly in favor of the aluminosilicate melt with depolymerization and partial destruction of the melt structure, which favors the incorporation of tungsten complexes. On the other hand, Cl has little effect on the aluminosilicate melt structure if one considers its [W] low solubility in these melts. Tungsten complexes cannot be easily incorporated [in the melt structure] which explains the partitioning of tungsten towards the aqueous phase. These experimental data can be applied directly to certain occurrences of tungsten associated with the fluorine-rich granites of Cornwall (England). (Abstract translated courtesy R. Bodnar)

MARAKUSHEV, A.A., 1981, The fluid regime in the formation of diamond-containing rock: *Geol. Rudnykh Mestorozh.*, no. 4, p. 3-17 (in Russian; translated in *Internat. Geol. Review*, v. 24, no. 11, p. 1241-1252, 1982). Author at Lomonosov Moscow Univ.

Diamond forms in the mantle during crystallization of peridotite and eclogite magmas, by the reactions: $2CO + CH_4 \rightarrow 3C + 2H_2O$ and $CO_2 + CH_4 \rightarrow 2C + H_2O$. Diamond-bearing peridotite and eclogite magmas were introduced into disjunctive structures of platforms; in the process, the high-pressure mineralization was best preserved in the volcanic environment of the upper parts of pipes. The composition of kimberlites is determined by the compositions of peridotites and eclogites which are replaced by the kimberlite magmas and inherit their high-pressure mineralizations. (Author's abstract)

MARIGNAC, Christian, 1982, Geologic, fluid inclusions, and stable isotope studies of the tin-tungsten deposits of Panasqueira, Portugal - a discussion: *Econ. Geol.*, v. 77, p. 1263-1266. Author at Lab. Metal., Ecole Nationale Supérieure de Geol. Appliquée, P.O. 452, 54001 Nancy Cedex,

France.

A criticism of Kelly and Rye 1979 (Fluid Inclusion Research--Proc. of COFFI, v. 12, 1979, p. 84-86) concerning aspects of the mechanism and timing of vein opening at Panasqueira, Portugal. (E.R.)

MARSHALL, J.D., 1982, Isotopic composition of displacive fibrous calcite veins: reversals in pore-water composition trends during burial diagenesis: *J. Sedimentary Petr.*, v. 52, no. 2, p. 0615-0630. Author at Dept. Geol., Leicester Univ., Leicester, UK.

Stable isotope and petrographic analyses of diagenetic calcite ("cone-in-cone" and "beef") veins from British Jurassic and Lower Cretaceous shales have been used to determine the environment of precipitation of fibrous calcites. Successive growth took place by antitaxial displacive addition at the vein margins, away from primary sedimentary laminations or early diagenetic concretions. Carbon and oxygen isotopic ratios ($\delta^{13}\text{C} \pm 0$ and $\delta^{18}\text{O} -4$ to -11%) indicate a relatively late diagenetic origin for the veins after tens or probably hundreds of meters of burial, and after cessation of bacterial activity and considerable modification of the oxygen isotopic composition of the pore water. Vein growth was discontinuous and took place in waters of changing isotopic and trace-element composition. Changes are not unidirectional and are unlikely to result from the simple evolution of a single connate pore water; reversals in isotopic trends indicate that precipitation took place during periods of renewed (lateral?) groundwater flow, trapping different sources of bicarbonate-bearing solution. (Author's abstract)

MARTIGNOLE, J. and NANTEL, S., 1982, Geothermobarometry of cordierite-bearing metapelites near the Morin anorthosite complex, Grenville province, Quebec: *Can. Min.*, v. 20, p. 307-318. First author at Dept. géol., Univ. Montreal, Case postale 6128, Succursale "A," Montreal, Quebec H3C 3J7.

Involves some discussion of the volatile content of cordierites vs. the composition and pressure of a volatile phase. (E.R.)

MARTIN, R., MULLIS, J., NUNGAESSER, W. and GALETTI, G., 1982, The whewellite of the "terres noires" of la Drome (France): *Schweiz. Mineral. Petrogr. Mitt.*, v. 62, p. 1-13 (in French). First author at 4 chemin du Léman, CH-1260 Nyon, Switzerland.

The whewellite deposit of Condorcet in the Drome is the second discovered in France. It is located in the Oxfordian marls. The x-ray values correspond well to those of the synthetic whewellite. The results of chemical analysis are very near to the theoretical values. The morphology of the crystals of whewellite and the mineral paragenesis in the septarian seem to have been conditioned by the physicochemical variations of the growth-environment. (Authors' abstract)

The whewellite contains methane inclusions with Th of -70°C , indicating that the methane is not pure (more than 1 mol.% heavier hydrocarbons). (H.A. Stalder)

MARTIN, S., 1981, Episyenitization and mineralization in the Hyverneresse (North Millevaches Plateau-French Massif Central) leucogranite; petrography, mineralogy, geochemistry, fluid inclusions: Doctoral dissertation, Univ. Clermont-Ferrand, France, 228 pp. (in French).

Indexed under fluid inclusions. (E.R.)

MASTERSON, W.D., IV, 1981, Epithermal gold mineralization in the Velvet

district, Pershing County, Nevada: M.A. thesis, The Univ. Texas at Austin, Austin, TX.

Gold mineralization in the Velvet District occurs in an eastward dipping sequence of Miocene tuffs, flows, and tuffaceous sediments on the west flank of the Trinity Range in Pershing County, Nevada. Numerous north-northeast trending normal faults extend through the district. These faults served as conduits for ascending hydrothermal fluids which deposited gold and silver along poorly defined zones of brecciation, argillic alteration, and quartz veining. Concentration of gold does not exceed a few parts per million and is highest in zones of intersecting fractures.

The hydrothermal solutions which deposited the gold were the near-surface expression of a larger geothermal system. Meteoric water leached gold, silver, arsenic, antimony, and other metals from the surrounding rock as it percolated downward towards a deep heat source. The hot fluids escaped upward along fracture zones and precipitated precious metals in veins near the surface. Fluid inclusion studies indicate that the quartz veins were deposited in the temperature range 218-264°C from fluids which had salinities equivalent to 0.2-0.8 weight percent NaCl. $\delta^{18}O$ of quartz veins varies from -2.5 to +6.7‰, and the low values appear to define a zone of concentrated fluid flow and potential subsurface mineralization in the southeast part of the district. The lowest value, -2.5‰, indicates that the ore fluid must have been Tertiary meteoric water with $\delta^{18}O$ equal to -13‰.

Reaction of hydrothermal fluids with wall rock produced an alteration assemblage of illite-kaolinite-quartz which underlies most of the shafts, adits, and prospect pits in the district. The illite-kaolinite-quartz assemblage is laterally gradational into a kaolinite (or dickite)-smectite-alunite-quartz assemblage which is indicative of lower temperatures. Pyrite and other sulfides are rare, but limonite and jarosite are widespread in surface outcrops. Alteration of tuffs released abundant silica which precipitated as quartz veins and discharged in hot springs at the bottom of lakes, where thick deposits of diatomaceous earth accumulated. (Author's abstract)

MATHEZ, E.A., DIETRICH, V.J. and IRVING, A.J., 1982, Abundances of carbon in mantle xenoliths from alkalic basalts: *Terra Cognita*, v. 2, p. 199-200. First author at Dept. Geol. Sci., Univ. Washington, Seattle, WA 98195, USA.

In mantle xenoliths from volcanic rocks, C exists as CO₂ in fluid inclusions and as an elemental form in microcracks and on inclusion walls. Carbonate is usually present as well and is generally believed to have been introduced after eruption. Both absolute amounts of C and relative abundances of its various forms were determined in a suite of representative xenoliths. Interior portions of samples were crushed to coarse (<1.4 mm) fragments, washed in cold 1N HCl, and fused with a flux. Fusion in an oxidizing atmosphere liberated all elemental C and vapor of CO₂, which was then determined by titration. In contrast, only vapor was liberated from samples fused in a reducing atmosphere. A similar procedure was followed for unwashed samples.

A significant proportion of the C in nearly all samples is removed by acid-washing. The soluble fraction must reside on grain boundaries and is presumed to be carbonate. In samples collected from environments in which caliche is present, carbonate contamination from meteoric sources is suspected. In others, carbonate probably also originated by post-eruptive redistribution of C from host lavas.

Most acid-washed Cr-diopside spinel lherzolites contain 10-40 ppm

(by wt.) total C. These concentrations are considerably lower than those determined from previous analyses. The range in C contents of four Al-augite pyroxenites is 40-80 ppm, and one of the amphibole-phlogopite-apatite-spinel lherzolites from Nunivak Is., Alaska contains 85 ppm C.

The average C:CO₂ ratio for all samples is 0.06. Assuming that elemental C results from the reaction $2CO \rightarrow C + CO_2$, then the vapor from which C precipitated consisted of ~30 mole % CO. (Authors' abstract)

MATHIESON, G.A., 1982, The Cantung E-zone scheelite skarn orebody, Tungsten, N.W.T., Canada; a revised genetic model: MS thesis, Queen's Univ., Kingston, Ontario, Canada, 156 pp.

Indexed under Fluid Inclusions. (E.R.)

MATHIESON, G.A. and CLARK, A.H., 1982, The Cantung E-Zone scheelite skarn orebody, tungsten, N.W.T., Canada: a revised genetic model (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 558. Authors at Dept. Geol. Sci., Queen's Univ., Kingston, Ontario, K7L 3N6, Canada.

Models proposed for this large exoskarn deposit by Zaw and Clark (1977; 1978) and Dick (unpubl. Ph.D. thesis, 1980) differ regarding: (i) the relations between contact metamorphism and skarn formation and (ii) the temporal relations of "anhydrous" (gt-cpx-sch-po-cpy) and "hydrous" (amph and/or bi-sch-po) skarns.

Textures in foliated contact hornfels demonstrate that metamorphism, of hornblende hornfels facies, was essentially complete prior to skarn development. New fluid inclusion data show that, whereas considerable hydrous skarn formed simultaneously with the anhydrous facies, a progressive increase in the relative volume of hydrous skarn occurred as temperatures decreased from ca. 505°C to 270°C (Th corrected for 1 kbar; after Zaw and Clark). This transition was not paralleled by changes in fluid salinity, which remained in the range 4-14 wt.% NaCl equivalent. Th values vary widely on a small scale, but there is no evidence of fluid boiling. The hydrous skarns are not strictly retrograde, and scheelite was probably not redistributed during skarn evolution.

A high proportion of scheelite (and apatite) grains contain inclusions with $0^\circ C < T_m < 10^\circ C$, suggesting the presence of CO₂, and indicating local fluid immiscibility. Thus, temporary blockage of fluid channelways may have caused increases in fluid XCO₂ and, critically, calcium activity, which favored scheelite precipitation.

Comparison of the P-T conditions delimited for the unusually rich E-Zone orebody reveals that it formed at shallower depths and lower temperatures than the majority of Cordilleran tungsten skarns (cf. Newberry & Einaudi, 1981). (Authors' abstract)

MATKOVSKII, O.I., BARTOSHINSKII, V.Z., GRITSIK, V.V. and SHKLYANKA, V.M., 1982, Mineralogy of barite from the Beregovo deposit: Mineral. Zh., v. 4, no. 6, p. 62-72 (in Russian). Authors at L'vov State Univ., L'vov, USSR.

Barite in the Beregovo deposit of the Ukrainian Carpathians accompanies alunite, Au-polymetallic, and kaolinite mineralization. Five crystallomorphic types of barite crystals were distinguished, based on measurements by goniometer. Study of the fluid inclusions in the different morphol. types showed that the highest temp. (295-200°) barite (2 types) was related to the main (polymetallic) stage of mineralization. Two other types formed at 120-100° during the culmination of argillization accompanying the sulfide stage. The lowest temp. barite sepd. together with chalcedony in siliceous metasomatites. (Modified from CA 98: 129383e)

MATUZENKO, M.Yu., L'VOV, S.N. and ZAREMBO, V.I., 1982, Model calculations on the standard thermodynamic functions for the formation of polyatomic ions in aqueous solution at 298-623K: *Geokhimiya*, no. 5, p. 720-725 (in Russian).

MATUZENKO, M.Yu., YEGOROV, V.Ya., ZAREMBO, V.I. and PUCHKOV, L.V., 1982, Thermodynamic parameters of aqueous solutions of alkali carbonates at 298-573 K: *Geokhimiya*, no. 3, p. 381-386 (in Russian).

MAYER, Erwin and BRUGGELER, Peter, 1982, Vitrification of pure liquid water by high pressure jet freezing: *Nature*, v. 298, p. 715-718. Authors at Inst. Anorganische und Analy. Chemie, Univ. Innsbruck, A 6020 Innsbruck, Austria.

The vitrification of pure liquid water by projecting a thin jet of liquid water at high speed into a liquid cryomedium is reported. The influence of the experimental parameters on the cooling rate and the devitrification of the jet-frozen vitrified material have been investigated. A structural difference between vitrified liquid water and amorphous solid water prepared from the vapor phase is inferred from a comparison of the X-ray diffraction patterns. (Authors' abstract)

MAZOR, E. and THOMPSON, J.M., 1982, Evolution of geothermal fluids deduced from chemistry plots: Yellowstone National Park (U.S.A.): *J. Volcanol. Geotherm. Res.*, v. 12, p. 351-360. First author at Geo-Isotope Group, Isotope Dept., Weizmann Inst. Sci., Rehovot, Israel.

Large amounts of chemical data, obtained in geothermal fields, may readily be sorted-out by the aid of a simple set of graphs that provide a clear over-all picture and facilitate the understanding of geochemical processes taking place. As a case study, data from several hundred samples of the thermal springs at the well-known Yellowstone National Park are discussed.

The pattern obtained seems to indicate: (1) geochemical similarity between the spring groups of Heart Lake, Shoshone, Upper, Midway, Lower and Norris Geyser Basins, i.e., a geochemical uniformity of major spring groups located over 40 km apart; (2) these groups may be described as originating from a common fluid, most resembling the composition of Norris waters, accompanied by CO₂ and other volatiles, that react with igneous rocks, forming local variations; (3) the secondary reactions occur at (medium) depth, before the ascent to the surface; (4) extensive concentration--dilution processes occur during the ascent to the surface.

The water of the Mammoth group may be described as originating from the same Norris-like fluid that has been diluted (low Na and Cl contents) and intensively reacted with carbonaceous rocks, thus gaining in Ca, Mg, SO₄ and HCO₃. (Authors' abstract)

MAZOR, Yu.V., MEL'NIKOV, F.P., SEREGIN, A.M. and SOKOLOV, B.A., 1982, Use of thermobarogeochemical methods in oil-gas and coal geology, in N.P. Ermakov, ed., *Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry*: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 121-124 (in Russian).

The possibilities are considered, connected with use of fluid inclusion study methods in petroleum-gas geology, especially inclusion investigations in low-T minerals: gypsum, anhydrite, calcite and salts, which provide new information about parameters of oil formation and ways of hydrocarbon migration. (Authors' abstract, translated by A.K.; note - abstract of this paper was not published in the Abstract Volumes of the Vladivostok Symposium, A.K.)

MEGRELISHVILI, Zh.Sh., 1982, Conditions of formation and location of metasomatites at the Bektakar china stone deposit (Georgia): *Izvestiya Vyssh. Uchebn. Zaved.-Geologiya i Razvedka*, no. 9, p. 153-154 (in Russian). Author at Moscow Geol.-Prosp. Inst., USSR.

The deposit consists of quartz, quartz-sericite (Th 180-240°C), quartz-hydromica-kaolinite (Th 460-520°C), quartz-adularia-albite-sericite (Th 280-420°C) and quartz-adularia-epidote-chlorite metasomatites. (A.K.)

MEL'NIKOV, F.P., 1982^a, Perspectives of development of cryometric studies of inclusions of mineral-forming solutions, in *Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits*, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 31-37 (in Russian).

The author discusses various principles of freezing stage construction and concludes that L nitrogen freezing stages are the best devices. There are listed data on mineral-forming fluids obtainable by freezing method. Cryometric studies may be divided into four groups: 1. Cryometry of low-concentration solutions; 2. Cryometry of high-concentration solutions; 3. Cryometry of gases; 4. Cryometry of hydrocarbons in inclusions. Habit of crystallohydrates is described, but without quoting the typical features of various compounds. Also cryometry of CO₂ and hydrocarbons is presented briefly. (Abstract by A.K.)

MEL'NIKOV, F.P., 1982^b, Thermobarogeochemical studies of hydrocarbons in inclusions, in *Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits*, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 184-189 (in Russian).

Data on hydrocarbon occurrences in various ore deposits of various genetic types are quoted. The problems of paragenetic and genetic connection of endogene mineral formation with oil origin are discussed, as well as scientific and practical importance of studies of hydrocarbon inclusions in endogeneous minerals. (Author's abstract translated by A.K.)

MEL'NIKOV, F.P., DEMIN, Yu.I. and POLYANSKIY, Ye.V., 1982, Temperature regime and dynamics of thermal fields of granite intrusives in the Born-Gorkhon ore field, in N.P. Ermakov, ed., *Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry*: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 59-62 (in Russian).

Computer calculations of thermal field; abstract of this paper was not published in the Abstract Volumes of the Vladivostok Symposium. (A.K.)

MELNIKOV, F.P., KULIKOV, I.V. and GROMOV, A.V., 1979, Multiphase inclusions in fluorite of Tryny-Auz deposit: Deposited in V.I.N.I.G.I., no. 3965-79, Moscow, 1979.

As quoted in Kulikov et al., 1982, this volume. (E.R.)

MELNIKOV, F.P., KULIKOV, I.V. and GROMOV, A.V., 1982, Physico-chemical conditions of fluorite ore formation of Tyrny-Auz (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 207-208. First author at Moscow State Univ., Moscow, USSR.

The Mo-W skarns at Tyrny-Auz (largest deposit of this type in the North Caucasus) were followed by high-temperature fluorite ores, originated in special and paragenetic connection with rhyolite bodies and explosive breccias. Fluorite, andradite, sulphides, calcite, scheelite, and quartz are main minerals of these ores. Being saturated with large multiphase inclusions of highly concentrated mineralizing solutions these minerals,

and fluorite in particular, are extremely interesting for thermobarogeochemical studies.

The Tyrny-Auz fluorite forms colorless transparent crystals mostly of an octahedral habit, containing numerous multiphase highly concentrated inclusions. The mode of their distribution in the crystals and the equilibrium form of the vacuoles as negative crystals relate these inclusions to the primary ones. The inclusions are distributed remarkably irregularly: there are sites with inclusions occupying about 5% of the host mineral volume, and, at the same time, sites completely devoid of any. The sizes of some inclusions are striking, reaching 15-20 mm and more in diameter, while their average size is 0.1-1.0 mm. The described inclusions contain both gaseous and liquid phases and from 3-4 to 10-20 daughter minerals per vacuole. Inclusions with maximum amount of solid phases are mainly encountered in the fluorite of the lower levels, their number as well as their volume decreasing gradually towards the upper layers. The number and composition of the solid phases - are quite often drastically different in the neighboring inclusions within one zone of the host-crystal. Traces of boiling of the solutions are observable. Thus, it can be readily concluded that these large oversaturated inclusions form under transient conditions, when an accelerated growth of minerals out of heterogeneous solutions leads to the formation of large cavities. The transient conditions of crystallization are also evidenced by a higher amount of defects in the fluorite structure.

X-ray examination of the highly concentrated inclusions have revealed these solid phases: magnetite, pyrite, pyrrhotite, chalcopyrite, sphalerite, quartz, calcite, halite, sylvine, graphite and others. They dissolve when heated in a wide range of temperatures 200-700°C. The ore minerals are the last ones to disappear (the temperature of dissolution is 700-820°C). Above 800°C the inclusions seem to be homogenized into the liquid phase, although we failed to see that moment due to the gradual "depressurization" of the vacuoles occurring at these temperatures and sometimes accompanied by a remarkable dissolution of their walls. Such observations on fluid inclusions in fluorite have been attempted for the first time, as well as the X-ray identification of a wide range of the daughter ore minerals.

The concentration of the dissolved chlorides NaCl + KCl in the inclusions was found to be 60-70%. The pressure at the lower levels of the deposit was found by Lemlein's method to be about 1200 bar.

It is thus concluded that the fluorite of the Tyrny-Auz deposit was crystallized out of concentrated high-temperature brines under transient conditions of tectonic activity. (Authors' abstract)

MEL'NIKOV, F.P. and MITIN, S.N., 1982, Studies of gas-liquid inclusions in halite from Upper Jurassic evaporite formations of the East Kuban' and Chernoles depressions, in N.P. Ermakov, ed., Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 117-121 (in Russian).

For abstract, see Fluid Inclusion Research--Proceedings of COFFI, vol. 12, 1979, p. 117. (A.K.)

MELTON, C.E. and GIARDINI, A.A., 1982, The evolution of the Earth's atmosphere and oceans: Geophys. Res. Lett., v. 9, p. 579-582. Authors at Dept. Chem., Univ. Georgia, Athens, GA 30602

A model describing the evolution of the present atmosphere and hydrosphere has been developed, based in large part on the analyses made by these authors of the gases evolved on crushing or graphitizing diamonds.

See Giardini and Melton, 1981, Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 69; Melton and Giardini, 1981, Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 138, and v. 13, p. 161-162. (E.R.)

MERCOLLI, Ivan, 1982, The fluid inclusions in the nodules of quartz of the dolomitic marbles from the region of Campolungo (Ticino): Schweiz. mineral. petrogr. Mitt., v. 62, p. 245-312 (in Italian; English abstract). Author at Istituto di cristal. & petro. del Politecnico Fed. di Zurigo, ETH-Zentrum, 8092 Zurigo.

A layer in the Triassic dolomitic marbles of the Campolungo area contains nodules of quartz, calcite, tremolite and talc. The fluid inclusions in the quartz nuclei of these nodules are the main argument of this work.

From the mineralogical and structural analysis it could be deduced that the quartz nuclei (partial with fluorite) of the nodules are anterior to the alpine metamorphism. Presumably they are either the product of an older hydrothermal activity or sedimentogenic material. They show a boudinage parallel to S_0 and S_1 (respectively the sedimentary layering and the alpine foliation originated by the isoclinal fold of the dolomitic marbles) or a remobilization in lenses parallel to S_2 (second alpine foliation generated by the local folding of the isoclinal folds) and discordant to S_0 and S_1 .

The reaction rim separating the quartz core from the dolomitic marble is a chaotic undeformed (postkinematic) fabric of tremolite and calcite. Important is the difference between the tremolite in the marble (prismatic, parallel to S_1 , rich in Al and poor in F) and the tremolite in the nodules (big radiate aggregates of acicular crystals poor in Al and rich in F).

The fluid inclusions, all secondary, could be classified as follows:
- CO_2 rich inclusions a) with more than 85% of CO_2 ; b) with less than 85% of CO_2 ; and c) with impure CO_2 ;

- aqueous inclusions (about 5% NaCl solution),
- multiphase inclusions with 40-50% solution of NaCl (at room temperature they contain a NaCl crystal), a gas bubble and an unknown birefringent solid phase (the last is not always present).

The multiphase inclusions coexist always in the same fractures with the very CO_2 -rich (a) inclusions. These two types of inclusions must therefore be cogenetic. The consequence is that the fluid at this time must have been unmixed in two phases (CO_2 and NaCl solution).

Relative age relationship show that the aqueous inclusions represent the last fluid stage.

The evolution of the nodules and the associated fluid phases could be summarized as follows:

- formation of the quartz nuclei in the dolomitic sediment;
- boudinge or remobilization of the quartz during the predominantly kinematic phase of the alpine metamorphism and synkinematic crystallization of prismatic tremolite in the siliceous layers of the dolomitic marble during the thermal phase;
- formation of a reaction rim around the quartz nodules; to this stage corresponds an unmixed fluid phase with CO_2 and a highly concentrated NaCl solution;
- talc is formed after tremolite and the fluid phase is represented by inclusions with less than 85% CO_2 ;
- crystallization of a later talc generation together with the contamination of the CO_2 ;
- end of the diaphthoretic phase related with the aqueous inclusions.

For the building of the reaction rim, the thermo-barometric data indicated by the fluid inclusions agree with a temperature of about 500°C.

obtained by the calcite thermometer. The pressures instead are low for all inclusion types (ca. 2 kbar). This could be explained with a drastic lowering of the pressure after the climax of the metamorphism (in this area 4-7 kbar); at the same time the cooling was very slow. Such a development was postulated for the Leventina valley by Werner et al. (1976) and fits well the data obtained from the inclusions. (Author's abstract)

MEYER, H.O.A., 1982, Mineral inclusions in natural diamond, in International Gemological Symposium Proc., 1982, D.M. Eash, ed., Gemological Inst. Am., Santa Monica, CA, p. 445-456.

MICHELS, D.E., 1982, A simple formula for saturation temperature/pressure of NaCl solutions: Trans. Geothermal Resources Council, v. 6, p. 95-97. Author at Republic Geothermal, Inc., 11823 E. Slauson Ave., Santa Fe Springs, CA 90670.

The saturation temperatures and pressures of NaCl solutions throughout the geothermally interesting range can be calculated by: $psia = \exp[6.7028 - 10^{-7}(\text{ppm Cl}) - 3712/(\text{°F}+460)]$.

Results of this equation agree with tabular data generally to within ± 2.5 percent of psia for NaCl concentrations up to 15 weight percent and 300°C. At higher NaCl concentrations different sets of tabular data are themselves out of conformance while the equation yields intermediate values.

This equation can be adapted to mixed-salt brines and to dynamically flashing systems by including modifiers for just the second term in the brackets. (Author's abstract)

MIKHAYLOVA, N.G. and APLONOV, V.S., 1982, Method of preparation of water leachates from minerals, in Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 111-115 (in Russian).

Grinding of minerals and then leaching has two imperfections: sorption of ions on ground mineral surface and opening to the leaching water of all solid inclusions in mineral, including relatively soluble ones. The alternative is inclusion opening by decrepitation, although during decrepitation not all inclusions are opened. In experiments quartz from a pegmatite vein from Karelra was used. It was crushed by hand in a metal mortar to a grain size of 0.5-1.0 mm, washed in weak solution of HCl and then cleaned by distilled water to negative reaction for Cl. The cleaned quartz was divided into three parts: one part was ground; the second one calcined at 500°C for one hour (Td 420-450°C) and then ground; the third one ground and then calcined at 500°C for one hour. The determinations of NH₄, K, Na, Ca, Mg, F, Cl, SO₄ and HCO₃ showed that the totals of anions and cations are characterized by 10% error; samples that were decrepitated and then ground yielded lower ion contents than those ground and then decrepitated, but decrepitated and then ground samples are very close to those only ground. Thus, grinding rather than decrepitation should be recommended. (Abstract by A.K.)

MILLER, Christine and RICHTER, Wolfram, 1982, Solid and fluid phases in lherzolite and pyroxenite inclusions from the Hoggar, central Sahara: Geoch. J., v. 16, p. 263-277. First author at Inst. für Min. & Petr., Univ. 4, A-6020 Innsbruck.

Major and trace elements have been determined in spinel lherzolite, spinel pyroxenite and garnet websterite xenoliths from the Hoggar and in their host basanites and nephelinites. Transition metal and REE abundances

do not support a genetic link between these ultramafic rocks and the lavas erupted at the surface. Mineral chemistry and textures suggest a complex evolution and subsolidus reequilibration in the range 800-1,000°C. High-density CO₂ fluid-inclusions define minimum pressures of 10-12 kb. Thus the ultramafic xenoliths came from a relatively low pressure regime within an inhomogeneous lithospheric mantle segment characterized by a disturbed geotherm. (Authors' abstract)

MILLER, M.B., 1982, A petrographic and fluid inclusion study of some scheelite-bearing quartz veins, Cabarrus County, North Carolina: MS thesis, Univ. North Carolina, Chapel Hill, North Carolina, 85 pp.
Indexed under Fluid Inclusions. (E.R.)

MILLERO, F.J., MUCCI, Alfonso, ZULLIG, James and CHETIRKIN, Peter, 1982, The density of Red Sea brines: *Marine Chem.*, v. 11, p. 463-475. Authors at Rosenstiel Sch. Marine & Atmosph. Sci., Univ. Miami, Miami, FL 33149.
The densities of artificial and real Red Sea brines have been measured at 25°C with a vibrating tube densimeter. Measurements were also made on mixtures of Red Sea brines with seawater and pure water. The results have been used to characterize the density - composition relations of waters across the interface of brine and average Red Sea waters. The results for the real and artificial brines are in reasonable agreement.
The composition of the brines and mixtures with seawater have been characterized by conductivity measurements of weight diluted samples. The conductivity salinities were found to be conservative to within ±0.07% for the mixtures.

The densities of brines and mixtures of brines and seawater were estimated from apparent molal volume data using Young's rule. The calculated densities for all of the solutions were found to be in good agreement with the measured values, demonstrating the applicability of Young's rule to concentrated natural waters. (Authors' abstract)

MILLERO, F.J., RICCO, J. and SCHREIBER, D.R., 1982, PVT properties of concentrated aqueous electrolytes. II. Compressibilities and apparent molar compressibilities of aqueous NaCl, Na₂SO₄, MgCl₂, and MgSO₄ from dilute solution to saturation and from 0 to 50°C: *J. Solution Chem.*, v. 11, no. 10, p. 671-686. Authors at Rosenstiel Sch. Marine & Atmospheric Sci., Univ. Miami, Miami, FL 33149.

The relative sound velocities ($U-U^0$) of aqueous NaCl, Na₂SO₄, MgCl₂, and MgSO₄ solutions were measured from 0.05m to saturation and from 0 to 45°C. The sound speeds were combined with our earlier work and fitted to a function of molality and temperature to standard deviations within 0.3 m-sec⁻¹. The adiabatic compressibilities, β_s , were determined from the sound speeds and used to calculate adiabatic apparent molar compressibilities, $K_{\phi,s}$, isothermal compressibilities, β , and apparent molar compressibilities, K_{ϕ} , were determined from the adiabatic values using literature data for expansibilities and heat capacities. The values of K_{ϕ} have been extrapolated to infinite dilution using an extended limiting law. The resulting K^0 at various temperatures are in reasonable agreement with literature values. The results of this study have been combined with our earlier results to derive a secant bulk modulus equation of state for NaCl, Na₂SO₄, MgCl₂, and MgSO₄ solutions valid from 0 to 50°C and 0 to 1000 bar. (Authors' abstract)

MIRONOVA, O.F., 1982, Present state of methods of analysis of bulk composition of inclusion gas phase, in Use of methods of thermobarogeochemistry

during prospecting and studies of ore deposits, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 58-64 (in Russian).

Gas analysis should be preceded by microscopic and decrepitation studies for finding optimum conditions of analysis of gases. Letnikov's recommendation that any sample should be heated to 700-800°C for gas release, may lead to changes of gas composition. Any method of inclusion opening causes change of its equilibrium due to sharp P decrease. Mechanical crushing needs special materials for mills or mortars; contamination by H₂ is particularly dangerous, as well as gas sorption on ground mineral. Thermal method of inclusion opening is used more commonly and is better for data for thermodynamic calculations. Also it may be used for complete release of water. High-T fractions are enriched in CO₂ and/or CH₄, synthesized on heating from various carbon compounds dispersed in rocks or minerals. The greatest doubts are caused by gas analysis of rocks, because gases of various origin are then mixed. No single method of gas release can be recommended for universal use, but the individual methods should be considered for a given study.

The volumetric method of analysis may be used for individual inclusions but for bulk analyses other methods should be used like mass spectrometry (difficulties in H₂O determinations and distinguishing CO vs N₂) and gas chromatography (use of appropriate detector). (Abstract by A.K.)

MIRONOVA, O.F., SALAZKIN, A.N., SAVEL'YEVA, N.I. and KOPNEVA, L.A., 1982, Methods and devices for geochemical mapping of endogeneous processes, in N.P. Ermakov, ed., Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 131-135 (in Russian).

For abstract, see Fluid Inclusion Research--Proceedings of COFFI, vol. 11, 1978, p. 140-141. (A.K.)

MISHRA, Biswajit and MUKHERJEE, Asoke, 1982, Preliminary studies on fluid inclusion geothermometry of quartz-sulfide veins from Zawar area, Rajasthan, using a heating stage with kanthol strips (abst.): [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies, 22-23 March, 1982, Indian Inst. Tech., Bombay, p. 30-31 (unpaginated). Authors at Dept. Geol. & Geophy., I.I.T., Kharagpur - 721 302.

A newly fabricated heating stage, using kanthol strips, has been devised for study of fluid inclusion homogenization temperature \approx 500°C. Primary inclusions in sphalerite, quartz and carbonate (dolomite) present in quartz-sulfide veins from Zawar area, were subjected to heating runs. Inclusions in the host minerals are characterized by (i) a wide variation in gas:liquid ratio, (ii) all homogenizing in liquid state and (iii) occasional presence of cubic daughter crystals. Inclusions in light honey-yellow colored sphalerite show relatively lower temperature of homogenization (280-298°C) than that of the dark reddish-brown colored ones (310-338°C). Inclusions in quartz show a wide range of homogenization temperature (191-362°C) which includes the thermal range exhibited in sphalerite and recrystallized carbonate (277-344°C). Cubic daughter crystals in inclusions in quartz become completely soluble with the trapped liquid at somewhat higher temperature (345-352°C).

Assuming that the uncorrected filling temperatures register the temperatures of crystallization, the following tentative inferences seem justified: (i) crystallization of quartz was protracted in time preceding and succeeding those of sphalerite and recrystallized dolomite, (ii) constituents of quartz-sulfide veins indicate ^(ca.) thermal condition beyond the thermal regime of diagenesis but within that of greenschist facies of

metamorphism, (iii) quartz-sulfide veins (and recrystallized dolomite) may therefore signify metahydrothermal fluid activity, (iv) as such, the assumption that such veins are cogenetic with the main ore lodes is not tenable and the thermal condition of vein materials may not reflect that of the ore lodes. (Author's abstract)

MOHAN, P.C. and JAIRETH, S., 1982, A new model of microscope heating and freezing stage (abst.): [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies, 22-23 March, 1982, Indian Inst. Tech., Bombay, p. 50 (unpaginated). Authors at Dept. Earth Sci., Univ. Roorkee, Roorkee.

A simple, inexpensive, but accurate microscope heating stage giving acceptable results has been developed. The stainless steel heating stage uses a thin semicircular ring of high alumina tube with a kanthal wire (22 S.W.G.) winding as a heating element. The heating element is enclosed in circular transparent fused quartz discs and the sample rests on the upper disc. A stainless steel ring containing another transparent fused quartz disc separates the heating chamber from the objective. A chromel-alumel thermocouple is introduced close to the sample. Two holes in the stainless steel chamber open just above the upper disc. These holes can be used for introducing chilled air for freezing studies. The stage has been designed for all objectives up to magnification of 12.5 x. For higher magnifications, i.e. 20 or 32 x, objectives with working distance of at least 6 mm are necessary.

Trial runs show that heating stage can be used easily to 600°C, which can be attained within half an hour. By using liquid nitrogen, the stage can cool the sample to temperatures below -100°C. (From the authors' abstract)

MOISEENKO, V.G., MIRONJUK, A.F. and ZAIKIN, I.D., 1982, Evolution of ore forming fluids (according to thermobarogeochemical data) (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 208-209. Authors at Amur Complex Res. Inst., Blagoveshchensk, USSR.

The thermobarogeochemical investigations of Sn deposits of the cassiterite-silicate and cassiterite-sulphide formations, Au deposits of the poor- and low-graded sulphide formation and W deposits of the skarn-greisen formation [give] evidence the alkaline-alkaline earth-bicarbonate-chloride composition of the ore-forming solutions.

The composition of fluid inclusions in cassiterite, scheelite and gold (minerals of main ore stages), was studied in order to estimate the specific features of the hydrothermal solutions which form deposits of various kinds of mineral resources. In the inclusions of cassiterites Na significantly prevails over K, relatively high contents of NH_4 , HCO_3 , Cl and CO_2 are determined. The salt content of the inclusions in cassiterite is defined by the following generalized ranges of ions (in the order of decreasing concentration): $\text{Na}^+ - \text{NH}_4^+ - (\text{Ca}^{2+}, \text{Mg}^{2+}) - \text{K}^+$; $(\text{HCO}_3^-, \text{Cl}^-) - (\text{S}, \text{F}^-)$. CO_2 (predominant phase), CO, CH_4 , N_2 , H_2 , H_2S are present in the gaseous component of the fluid. The hydrotherms of main ore stages of gold and tungsten deposits are defined by anion concentration ranges similar to those of the tin-ore deposits, although they differ in a reduced role of Na and an increased relative concentration of Ca for the tungsten deposits and of Ca and Mg for gold deposits.

The hydrothermal solution compositions vary along the lateral during transition from the oceanic to the continental crust. For example, the gold deposits of marginal and intercontinental volcanic belts are formed by fluids of an alkaline-bicarbonate nature, while the marginal zone are characterized by increased role of Na⁺ in the solutions, and decreased ratio of the reduced forms of carbon to the oxidized ones. Spacial and temporal

changes of ore-forming fluid composition have also been determined.
(From the authors' abstract)

MOISEENKO, V.G., MIRONYUK, A.F. and ZAYKIN, I.D., 1982, Regularities of composition of gas-liquid inclusions in cassiterites of tin ore deposits of the [Soviet] Far East on the basis of thermobarogeochemical data, in N.P. Ermakov, ed., Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 24-32 (in Russian).

The composition of gas-liquid inclusions was studied by water-leachate and gas-chromatography methods in cassiterites of the tin-ore deposits belonging to the cassiterite-silicate and cassiterite-sulfide formations (the deposits Silin, Arsen'yevshoe, Yantarnoe, Dubrovskoe, Solnechnoe, Festival'noe, Val'kumey, Khinganskoe and Goluboe). The inclusion fluids in cassiterites are alkaline-alkaline earth-Cl-HCO₃ plus sometimes with S, frequently with Na>>K. Fluids of the main ore stage, when cassiterite precipitated, had near-neutral, weakly alkaline reaction and low redox potential. Salt and gas composition of fluids changed from deep to upper levels of the ore bodies. (Authors' abstract, translated by A.K.; note: abstract of this paper was not published in the Abstract Volumes of the Vladivostok Symposium, A.K.)

MOISEENKO, V.G. and SAKHNO, V.G., 1982, Deep fluids, volcanism and ore formation of the Pacific belt: "Nauka," Moscow, 192 pp., 1000 copies printed, price 2 rubs 80 kopecks (in Russian). Authors at Amur Complex Sci.-Research Inst., Blagoveshchensk-on-Amur, USSR.

The authors discuss the peculiarities of volcanism of some structures of Pacific, transitional zone and continent margin on the basis of studies of samples from islands, island arcs of W part of Pacific, marginal seas and volcanic zones of Asian continent. Analysis is made with use of petrologic method. The book presents new data on the content of gas components and salt composition in inclusions in minerals of volcanic rocks. Peculiarities of gas composition and their evolution is shown against the background of general theory of volcanism in the transitional zone from ocean to continent. In the same scale are presented the features of ore mineralizations connected with various types of volcanic activity. The data on gas and salt composition in rocks presented in the book were obtained by use of advanced analytical methods. (Author's abstract, translated by A.K.)

MOLDOVANYI, E.P. and LOHMANN, K.C., 1982, Isotopic identification of diagenetic environments, Sligo Formation, southwest Texas (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 568. Authors at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109.

Isotopic analyses of individual calcite cements within the reefal facies of the Lower Cretaceous Sligo Formation, southwest Texas, indicate multiple phases of cementation at relatively shallow burial depth. Moreover, variations in composition of individual generations of cement indicate that diagenetic conditions varied along the Sligo shelf and shelf margin.

Fibrous isopachous cements consisting of inclusion-rich radiaxial calcite have an average isotopic composition of -2.0‰ $\delta^{18}\text{O}$ and +3.2‰ $\delta^{13}\text{C}$ (PDB). These values are indicative of a marine precursor and approximate the composition of the original marine carbonate components. The earliest generation of equant spar which has an average $\delta^{18}\text{O}$ composition of -3.5‰ and a range in $\delta^{13}\text{C}$ from +3.0‰ to -3.0‰ (PDB) defines

a trend characteristic of cementation in a shallow phreatic environment with evidence of localized vadose recharge. This generation is followed by a cloudy spar having an average $\delta^{18}\text{O}$ composition of -5.8% and a range in $\delta^{13}\text{C}$ from $+2.5$ to -7.0% (PDB). Two-phased fluid inclusions and extremely light carbon composition suggest cementation at increased burial temperatures prior to and in conjunction with hydrocarbon migration. A final generation of equant spar which fills fractures and late stage voids has a composition of -7.8% $\delta^{18}\text{O}$ and $+2.5\%$ $\delta^{13}\text{C}$ (PDB) and must represent cementation in an even deeper, and higher temperature, phreatic environment.

Integration of isotopic and petrographic data has enabled us to discriminate among multiple phases of cementation to determine the exact timing and environment of hydrocarbon migration. In the case of the Sligo Formation, hydrocarbon migration occurred subsequent to the earliest generation of spar and prior to late stage fracture formation. (Authors' abstract)

MOOKERJEE, Dipica, 1982, Determination of temperature of uranium mineralization from fluid inclusion studies in Dhabi uranium deposit, Madhya Pradesh (abst.): [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies, 22-23 March, 1982, Indian Inst. Tech., Bombay, p. 36 (unpaginated). Author at Atomic Mineral Div., Hyderabad.

From the fluid inclusion and mineral paragenesis studies of Dhabi hydrothermal vein type uranium deposit in granite in Sarguja district of Madhya Pradesh, it is found that microclinization and sericitization has taken place around 500°C , secondary quartz crystallization around 200°C , uranium mineralization around 150°C , pyrite deposition at less than 150°C and finally the carbonate gangue deposition.

Absence of inclusions in the minerals like fluorite, calcite etc. as also the rarity and fineness of fluid inclusions indicate that the processes of mineralization operated over a long period of time(sic). (Author's abstract)

MOON, S.M., 1982, Fluid inclusion studies on amethyst deposits around Eonyang district in Gyeongsangnam-Do: Master's thesis, Dept. Geol., Graduate Sch., Busan National Univ. (in Korean; English abstract).

The Eonyang amethyst deposits are amethyst and quartz crystal-bearing hydrothermal veins which filled vugs in Cretaceous granites.

Th of polyphase inclusions in quartz were measured with a Leitz microscope heating stage (Model 350).

Most of the fluid inclusions are primary and mainly composed of liquid plus a minor gas phase.

The observed filling temperatures are 260°C to 360°C or higher in crystalline quartz_A and 230°C to 360°C or higher in vein quartz_A.

The salinity deduced from Tm NaCl are 32 to 44 wt.% in crystalline quartz_A and 34 to 38 wt% in vein quartz_A.

Data from geological, mineralogical and fluid inclusion studies reveal that the amethyst mineralization in the Eonyang district proceeded at high temperature with high salinity. Hence the amethyst deposits of Eonyang district are considered to be of high temperature hydrothermal origin. (From the author's abstract)

MOORE, B.J., 1982, Analyses of natural gases, 1917-80: Bureau of Mines Information Circular 8870, 1055 pp. Author at Section of Helium Resources Eval., Br. of Helium Resources, Helium Field Opns., Bureau of Mines, Amarillo, TX.

This publication contains 12,554 analyses of gas samples from oil and gas wells and natural gas pipelines in 39 States and 24 foreign countries. These gas samples were collected in the period 1917-80 as part of the Bureau of Mines survey for helium occurrences. The gas analyses contained herein were made by several methods over the period covered. Analytical work on samples collected early in the period was done on the Orsat apparatus. The one-cut apparatus and four-cut fractional distillation equipment were added later. In 1949, a mass spectrometer was acquired and used for all gas analyses made after that time. Helium analyses throughout the period covered were made on special helium analytical equipment designed and built by the Bureau of Mines' Helium Operations Laboratory. (Author's abstract)

MOORE, E.L., ULMER, G.C. and GRANDSTAFF, D.E., 1982, Interaction of basalt and continental ground water at 200 and 300°C (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 450. Authors at Dept. Geol., Temple Univ., Philadelphia, PA 19122.

Samples of Columbia River basalt were reacted with a basaltic-type simulated ground water at 200 and 300°C, 300 bars, and water:rock mass ratios of 5, 10, and 20 in a Dickson rocking autoclave. Results were somewhat different from equivalent experiments conducted with sea water. (Mottl and Holland, GCA, 1978) A major decrease in solution pH, such as that found with sea water, was not observed. Calculated steady-state solution conditions at 300°C, and a mass ratio of 10 are: pH = 7.7 (neutral pH = 5.5), log fO₂ = -31, log fS₂ = -11, and Eh = -0.74. Reaction products identified include: potassium feldspar, quartz, illite, and smectite. Calculations indicate that the solution also became slightly supersaturated with calcite, although none was identified in reaction products. Fe, Mn, Cu, and Pb concentrations were low, in contrast to sea water experiments. Concentrations of Mg, Na, and ΣCO₂ in solution decrease; K, Si, and H₂S increase and Ca and SO₄ remain fairly constant. Calculated steady-state conditions of the 200°C solution are: pH = 7.7 (neutral pH = 5.5), log fO₂ > -39, log fS₂ < -17, and Eh > -0.68. The solution was slightly supersaturated with quartz and calcite. Again a major decrease in pH was not observed, similar to that at 300°C. Concentrations of Mn, Cu, and Pb were low, and high concentrations of Fe occurred in colloidal suspension. Concentrations of Ca in solution decrease and Mg, K, Si, Fe, and SO₄ increase. (Authors' abstract)

MORASSE, Suzanne, 1982, Preliminary study of the petrography and petrology of the fluid phase present in the quartz-chalcopyrite veins of Scott Canton, Chibougamau, Quebec: Unpublished B.Sc.A. diss., Univ. Quebec à Chicoutimi, Quebec, Canada, 52 pp.

A quartz vein containing chalcopyrite was the subject of the present investigation due to the fact that it is located very close to a large pluton of tonalitic composition, within the Abitibi greenstone belt of the Canadian Shield. The principal aim of this dissertation was to identify the fluid phases present in the quartz. The tectonic effects suffered by the quartz necessitated a careful petrographic study to decipher the deformation and recrystallization features and their relation to the generation of inclusions. The preliminary microthermometric data helped in identifying three distinct generations of fluid inclusions in the most preponderant quartz type which is "heterogranular granoblastic" in nature. This discrimination was possible through their homogenization temperatures, volumetric ratios (V/T), the salinity and the presence of 3-phase inclusions (CO₂ L+V and H₂O L). Possible signs of boiling and a generation of

high temperature inclusions $> + 400^{\circ}\text{C}$ have also been noted indicating a probable connection with the Chibougamau Pluton. This work clearly underlined the necessity of further work to determine the interrelations between the three generations of inclusions and the magmatic and metamorphic history of the area. (Author's abstract)

MOROZOV, A.I. and SOLOVKINA, O.A., 1982, Studies of complex formation in the system $\text{KCl}-\text{AlCl}_3$ by IR spectroscopy: Zhurn. Neorg. Khimii, v. 27, no. 2, p. 326-330 (in Russian). Authors at Inst. of General and Inorg. Chem. of Acad. Sci. USSR, Moscow.

The paper discusses IR absorption spectra of compounds KAlCl_4 and KAl_2Cl_7 that possibly may be found as dms in inclusions of salt-rich fluids. (A.K.)

MOROZOV, A.I., SOLOVKINA, O.A. and EVDOKIMOV, V.I., 1982, Compound KAl_2Cl_7 and its thermal stability: Zhurn. Neorg. Khimii, v. 27, no. 8, p. 2075-2079 (in Russian). Authors at Inst. of General and Inorg. Chemistry of Acad. Sci. USSR, Moscow.

See previous entry. (A.K.)

MORRISON, G., 1982, Geology of the La Negra Mine vicinity, State of Queretaro, Mexico: MS thesis, Colorado Sch. of Mines, Golden, Colorado, 118 pp.

Indexed under Fluid Inclusions. (E.R.)

MOSKOVSKII, G.A., GOLOVIN, B.A. and GARYAINOV, V.A., 1982, Study of inclusions in salt minerals from drill-core and sludge samples (areas of the near-edge zone and the central part of the Caspian syncline), in Nov. Dannye Geol., Geokhim., Podzemn. Vodam Polezn. Iskop. Solenosnykh Basseinov, [Vses. Solevoe Soveshch. "Solenosnye Form. Prakt. Znach. Ikh Izuch."], 2nd 1979, (Pub. 1982), A.L. Yanshin and M.A. Zharkov, eds.,: Izd. Nauka, Sib. Otd., Novosibirsk, USSR, p. 115-119 (in Russian).

A study was made of the inclusions in halite from petroleum-exploration borehole samples and the role of secondary inclusions in minerals, in hydrocarbon (hc) migration through salt strata. The K^+ , Mg^{2+} , and SO_4^{2-} concentrations in liquid inclusions in halite provided a means of estg. the composition of the subsurface salt formations, except where the salts were strongly deformed. Examination of the morphol. of hc accumulations in salts showed the existence of 4 main types: (1) drops and films of liquid petroleum in intercrystal voids, (2) gas-liquid hc inclusions in interstices, (3) gas hc inclusions largely held within mineral crystals, and (4) solid hydrocarbons (oxidized petroleum). The sequence sep'd. in chromatog. detn. of the gas phase of a salt core was CH_4 ; C_2H_6 ; C_2H_4 ; C_3H_8 ; C_3H_6 ; iso- C_4H_{10} ; C_4H_8 ; C_4H_{10} ; neo- C_5H_{12} ; iso- C_5H_{12} ; amylene; C_5H_{12} ; 2,2-Me butane; 2,3-Me butane; 3-Me pentane; and $\text{Me}_2(\text{CH}_2)_4$. Similarity to the hc indexes for rocks underlying the salt strata indicates a vertical migration path of hydrocarbons through the salt beds. (CA 98: 201734q)

MOTYKA, R.J., MOORMAN, M.A. and POREDA, Robert, 1982a Fluid geochemistry of Hot Springs Bay Valley, Akutan Island, Alaska: Trans. Geothermal Resources Council, v. 6, p. 103-106. First author at Alaska Div. Geol. & Geoph. Surveys, Box 80007, College, AK 99708.

Several thermal springs and a fumarole field occur in Hot Springs Bay Valley on Akutan Island. The thermal springs are low in Mg, SiO_2 -rich, and moderately concentrated in Na-Cl, a chemistry typically associ-

ated with hot-water hydrothermal systems. B/Cl ratios indicate the several sets of springs are derived from a common parent hot-water reservoir. Application of silica, cation, and sulfate-water oxygen-isotope geothermometry gives a range of 160-190°C for the parent reservoir. Recent geophysical investigations performed in cooperation with the Geophysical Institute, U of Alaska, identified a broad zone of apparent low resistivity underlying the lower part of the valley in the vicinity of the thermal springs. Relatively high CH₄ content and low H₂/CH₄ ratios occur in gases from both the thermal springs and from the fumarole field located at the head of the valley about 4 km southeast of the hot springs. The similarity in H₂/CH₄ suggests underlying reservoirs are similar in both areas. Both sites have a ratio of ³He/⁴He WRT atmospheric levels of about 7.0. (Authors' abstract)

MOTYKA, R.J., MOORMAN, M.A. and POREDA, Robert, 1982. Fluid geochemistry of the Makushin geothermal area, Unalaska Island, Alaska: Geother. Resources Council, Transactions, v. 6, p. 107-110. First author at Alaska Div. Geol. & Geoph. Surveys, Box 80007, College, AK 99708.

Several fumarole fields and numerous thermal springs occur on the eastern flanks of Makushin volcano. The thermal springs at Makushin are typically near-neutral in pH, have very low chloride levels (10 ppm), and are comparatively rich in Mg, Ca, SO₄, HCO₃ and SiO₂. Similarities in cation and isotopic compositions of Makushin thermal springs and local surface streams indicate the thermal waters are locally derived meteoric waters. These surface waters infiltrate to relatively shallow depths where they are heated by steam and gases rising from a vapor-dominated zone. Predominate fumarolic gases are CO₂, N₂, and sulfur gases. All samples showed a significant level of H₂ and a high H₂/CH₄ ratio. The ratio of ³He/⁴He WRT atmospheric levels range from 4.5 to 6.0. Fumaroles and hot springs in the upper parts of Glacier and Makushin Valleys form a roughly linear trend, suggesting their distribution may be structurally controlled. (Authors' abstract)

MU, Zhiguo, HUANG, Fusheng, CHEN, Chengye, ZHENG, Shuhui, FEN, Sulan, LIU, Daren and MEI, Yongwen, 1982, Oxygen, hydrogen and carbon isotope studies of Piaotang and Xihuashan quartz vein-type tungsten deposits, Jiangxi Province: Tungsten Geology Symposium, Jiangxi, China, sponsored by ESCAP/RMRDC and Ministry of Geology, PRC, 12-22 Oct., 1981: Pub. by ESCAP/RMRDC, Bandung, Indonesia, p. 385-401 (in English). First author at Dept. Geol., Peking Univ.

Oxygen, hydrogen and carbon isotope compositions of rocks minerals and their fluid inclusions are measured for Piaotang and Xihuashan wolframite-quartz vein tungsten deposits occurring in endo-contact and exo-contact zones of the granitic intrusive. Comparative studies of both mines are made. The isotope data are presented relative to PDB and SMOW. Routine analytical precision is maintained for all analytical procedures. The δ¹⁸O values of vein quartz for both mines are 13.01 (38) ± 0.95 and 12.50 (33) ± 0.67 respectively. The δ¹⁸O values of wolframite are 5.35 (22) ± 0.90 and 5.86 (19) ± 0.52. The depositional temperatures of both mines calculated from the δ¹⁸O quartz and wolframite are 332 (24) ± 30°C and 368 (20) ± 30°C. The range of δ¹³C values of the vein carbonates are -3 to -9. The isotope composition of the water of the primary fluid inclusions in two mines are: δD = -63.5 (64) ± 11.6 and -63.5 (40) ± 20.6, δ¹⁸O = 6.65 (24) ± 0.87 and 7.23 (29) ± 0.51 respectively. Isotopic compositions of the modern meteoric water in this region are -38.7 (14) ± 10.2 for δD and -6.13 (14) ± 0.97 for δ¹⁸O. The isotope values of the magmatic water

extracted from the primary fluid inclusions of the quartz in the igneous rock are: $\delta D = -64.2 (8) \pm 6.3$, $\delta^{18}O = 9.8 (8) \pm 1.04$. The main conclusion of the isotope studies may be summarized as follows: the tungsten mineralization is of hydrothermal origin related to granite. The ore-bearing fluids were mainly derived from magmatic waters. The mineralization exhibits pulsatory features. The granite is of S-type formed by crystal remelting of Precambrian submarine volcano-sediments in which certain horizons are relatively rich in tungsten. (Authors' abstract)

MU, Zhiguo, ZHENG, Shuhui and CAO, Zhengmin, 1982, Hydrogen, oxygen and carbon isotope studies of the minerals and their fluid inclusions in the Shangbao pyrite deposit, Laiyan County, Hunan Province: *Geol. Review*, v. 28, no. 4, p. 367-370 (in Chinese with English abst.). Authors at Geol. Dept., Beijing Univ.

The mineralization in the deposit occurs in the outer part of the contact zone between a small granite body and the Hutian Limestone. The principal paragenetic minerals include pyrite, fluorite, quartz and carbonate minerals.

The isotopic analytic techniques used in the paper are: the BrF_5 method, to extract oxygen in the minerals and water; the uranium furnace method, used to extract hydrogen in the water; the H_3PO_4 method, used to extract carbon in the carbonates; and the vacuum decrepitation and crushing techniques, used to extract water in fluid inclusions of the minerals.

Stable isotope studies of fluid inclusion water of the minerals indicate that the δD_{H_2O} values of ore-forming fluids range from -33.3 to -98.9 per mil (SMOW), δD_{H_2O} of present-day meteoric waters from -21.41 to -36.78 per mil (SMOW), $\delta^{13}C$ of carbonates from -1.18 to -4.74 per mil (PDB), and $\delta^{18}O$ of the minerals from +2.29 to +16.15 per mil (SMOW). All the above mentioned data imply that the deposit is an hydrothermal deposit of magmatic origin, and it is possible that the surface water was involved in the mineralization at a late stage. (Authors' abstract)

MUDRINIĆ, C., 1982, Ore matter sources and geochemical characteristics of antimony deposits in Serbia and Macedonia (Yugoslavia) (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 34-35. Author at Belgrade Univ., Belgrade, Yugoslavia.

The antimony deposits can be divided according to their mineralogical and chemical compositions as follows: (1) polymetallic Sb-As + Pb-Zn; (2) bimetallic Sb-As or As-Sb; and (3) monometallic Sb and rarely As.

Ore metals may have been transferred mainly as complex ions of the $Sb_2S_3^{3-}$, As_3^{3-} types in alcal solutions however, the role of chlorides, fluorides and sulphates should not be ignored, either. Th of fluid inclusions in cleiophane, quartz and calcite range from 330 to 160°C for the polymetallic deposit type. Crystallization temperatures in the monometallic and bimetallic deposits were 200°-90°C. This affects the mineral compositions, with a great variety of minerals emerging in the polymetallic deposits. Subsequent differentiation of ore components (even in a case of telescoping) brings their mineral composition actually to 3-2 minerals. (From the author's abstract)

MUENOW, D.W., RAI, C.S., SHARMA, S.K., MATSON, D.W. and BYERS, C.D., 1982, Temperature dependence of CO_2 solubility in high-pressure quenched glasses of diopside composition: a combined high-temperature mass spectrometric and Raman spectroscopic investigation (abst.): *EOS, Trans. Am. Geophys. Union*, v. 63, p. 451. Authors at Hawaii Inst. Geophys., Univ. Hawaii, Honolulu, HI 96822.

Carbon dioxide solubilities in CO₂-saturated high-pressure quenched glasses of diopside composition (formed by quenching CO₂-saturated diopside melt under 20 kbar pressure from 1580 to 1730°C in a solid-media high-pressure apparatus, using both talc and boron nitride furnace assemblies) have been investigated. A combination of thermogravimetric/mass spectroscopy and Raman spectroscopy were used. Mass pyrograms of these glasses show, in addition to CO₂ gas, small amounts of CO, CH₄ and H₂O. The amounts of CO, CH₄ and H₂O vary from sample to sample, but in the glasses quenched from the same temperatures at a constant pressure (20 kbar) the total carbon content of the samples is constant within the experimental errors, and is independent of the amount of H₂O observed. The CO₂-solubility shows a linear and negative temperature dependence. We do not observe any maximum in the solubility curve as reported previously by others.* The solubility of carbon-containing species in the Di melt at 20 kbar and in the temperature range 1580-1730°C is $(-2.4 \pm 0.67) 10^{-3}$ wt% carbon per °C.

The Raman spectra of CO₂-charged Di glasses show that the CO₂ in these glasses exists as CO₃²⁻. The intensities of the $\nu_1(A_1)$ band of CO₃²⁻ also show a negative temperature dependence. The observed large ($\sim 90 \text{ cm}^{-1}$) splitting of the $\nu_3(E')$ mode of CO₃²⁻ ions in the spectra indicates that CO₃²⁻ ions are present in at least two distinct sites in these glasses. This interpretation is consistent with the observed bimodal release pattern for CO₂ in the mass programs.

It is concluded that the differences between the present data and those reported previously* using β -track radioautography technique are most likely due to isotopic inhomogeneities between ¹⁴C and ¹²C in the samples. [*Amer. Min. (1980) 65, 885-899.] (Authors' abstract)

MUFFLER, L.J.P., NEHRING, N.L., TRUESDELL, A.H., JANIK, C.J. CLYNNE, M.A. and THOMPSON, J.M., 1982, The Lassen geothermal system: Proc. Pacific Geothermal Conf. 1982 Part 1, Univ. Auckland Geothermal Inst., Auckland, NZ, p. 349-356.

MULLIS, J., 1982, Stern-quartz: Schweizer Strahler, v. 6, no. 4, p. 125-140 (in German and French).

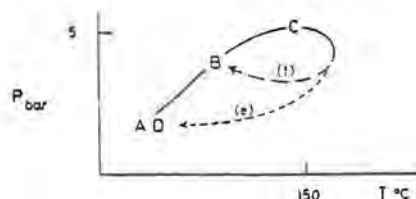
The name Stern comes from the starlike aggregation of small quartz crystals. Star-quartz out of cavities in non-metamorphic sediments and in a volcanic rock are described. All the star-quartzes have grown on cryptocrystalline quartz (chalcedony), that induces the crystallographic direction of the star-quartzes. On the basis of microthermometric investigations chalcedony and star-quartz have crystallized at low temperature (below 200°C and 1200 bar). (Abstract by H.A. Stalder)

MULLIS, J. and SIGL, F., 1982, The genesis of opal, chalcedony and quartz from Gran Canaria (volcanic island W of Maroc): Schweizer Strahler, v. 6, no. 4, p. 155-176 (in German and French).

In the foreground are investigations on quartz crystals from different habits (stemlike, scepter, cuplike...) out of cavities from a volcanic rock. These quartzes (C) have normally grown on opal and chalcedony (A,B) and are covered by a second generation of opal (D). The following table compiles all the effected investigations:

In the discussion the model given in the figure for the genesis is proposed. Several questions are still open, and it is planned to continue these investigations. (Abstract by H.A. Stalder) Continued next page.

SiO ₂ -succession	A	B	C	D
Name	opal with low-cristobalite (lussatite)	chalcedony	quartz, low quartz with mimetic lamella	like A
Optic invest. Elongation 2V	+	-	+ >5°	+
n	1.44-1.45	1.532-1.540	1.544-1.553	1.443-1.450
X-ray analysis	low-cristobalite	quartz	quartz	low-cristobalite
Etching			brasillian twins	
Cathodoluminescent	?	dark and bright growth-bands	dark and bright growth-lamella	dark brown, unstructured
Microthermometry			I-inclusions =water vapor II-inclusions =water and water vapor Th 120°-180°C	
Raman spectroscopy			I = H ₂ O only	
γ-Irradiation			no coloring	



Approximate P-T-conditions for the SiO₂-species A, B, C, D. The cycle e can be repeated several times; only cycle f is realized.

MUNOZ, J.L. and GUNOW, A.J., 1982, Fluorine index: a simple guide to high fluorine environments (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 573. Authors at Dept. Geol. Sci., Univ. Colorado, Boulder, CO 80309.

Although the association of high-fluorine mica with porphyry molybdenum deposits is well-documented, the definition of just how much F must be present to recognize an anomalously high-fluorine mica is a more difficult question. This results from the fact that the distribution of F between mica and fluid is a complex function of temperature, mica composition, and fluid composition. We have used our thermodynamic data on F-OH exchange in micas to construct graphs for both biotite and muscovite/phengite in which weight % F is plotted vs. weight % MgO; both graphs are contoured with lines we call fluorine index (FI). FI may range from 0 to 15, and increases with HF activity in magma or fluid. A difference of one FI unit corresponds exactly to a difference of 0.25 in log fugacity ratio (f_{H_2O}/f_{HF}) in fluid which equilibrated with the mica, assuming comparable equilibration temperatures.

Sericite and biotite from the Henderson molybdenite deposit have FI's ranging from 9 to 11.5; in contrast, comparable mica from porphyry copper deposits at Santa Rita and Bingham range from 4 to 7.5; the latter values overlap significantly at the lower range with micas from unmineralized granitic rocks. In spite of the method's simplicity, relative FI's from Henderson micas correlate remarkably well with relative log (f_{H_2O}/f_{HF}) values for the same micas which were rigorously calculated from structural formulae and thermodynamic data.

Advantages for using FI values include (1) simplicity; only weight %

F and MgO are required, (2) FI values are directly proportional to relative HF activities, (3) the method is easily applicable to exploration. (Authors' abstract)

MURAMATSU, Yoichi and NAMBU, Matsuo, 1982a, Fluid inclusion studies of pyrometasomatic iron-copper ore deposits and igneous rocks at the Kamaishi mining district, Iwate prefecture, Japan (I) Fluid inclusions in igneous rocks: J. Japanese Assoc. Mineral., Petrol., & Econ. Geol., v. 77, no. 5, p. 7-17 (in Japanese; English abstract). Authors at Res. Inst. Miner. Dress. Metall., Tohoku Univ., Sendai, Japan 980.

Fluid inclusions in quartz from several igneous rocks as well as from barren quartz veins were studied as a part of investigation into the origin of ore-forming fluids and mineralization of the pyrometasomatic iron-copper ore deposits in the Kamaishi mining district, Iwate prefecture, Japan. Igneous rocks are mainly composed of diorite-diorite porphyrite intruded before the mineralization, Ganidake granodiorite related to skarnization and mineralization, and Kurihashi granodiorite intruded after the mineralization.

Polyphase, liquid and gaseous inclusions are observed in quartz of those igneous rocks. It is found that polyphase inclusions, which mainly contain halite, are abundant in quartz of the diorite-diorite porphyrite and Ganidake granodiorite, but remarkably poor in that of the Kurihashi granodiorite. This tendency is in good agreement with those of both chlorine and copper contents in the igneous rocks.

Th of fluid inclusions in quartz from the Ganidake granodiorite ranges from 247 to over 380°C. On the basis of the data on Tm NaCl in polyphase inclusions, it is deduced that the salinity of fluid would have been in a range between 30 to 50 wt.% NaCl equiv.

From these results of investigation, it is inferred that the original ore-forming fluid was high in both temperature and salinity, and that highly saline fluid played an important role on the transportation of metal elements. It is also deduced from the distribution of polyphase inclusions in the rocks that highly saline fluid would have originated in some deeper parts of the Ganidake granodiorite, along which the ore deposits are distributed. But the relation between the intrusion of the diorite-diorite porphyrite and mineralization has been left unsolved. (Authors' abstract)

MURAMATSU, Yoichi and NAMBU, Matsuo, 1982b, Fluid inclusion studies of pyrometasomatic iron-copper ore deposits and igneous rocks at the Kamaishi mining district, Iwate prefecture, Japan (II) Fluid inclusions in the Shinyama pyrometasomatic ore deposit: J. Japanese Assoc. Mineral., Petrol., & Econ. Geol., v. 77, no. 5, p. 181-190 (in Japanese; English abstract). Authors at Res. Inst. Miner. Dress. Metall., Tohoku Univ., Sendai, Japan 980.

Th and salinities of fluid inclusions in quartz and calcite collected from the Shinyama pyrometasomatic iron and copper ore deposit of the Kamaishi mine, Iwate prefecture, Japan, were measured by means of the heating- and freezing-stage microscope.

Fluid inclusions are generally several microns in size. Most inclusions are liquid inclusions, but some of them are gaseous inclusions. Polyphase inclusions are not recognized.

Most Th of liquid inclusions in quartz and calcite which are considered to have been formed at the main stage of sulfide mineralization, range from 290 to 334°C. The Th has a tendency to increase from the upper level to the lower, but no tendency is recognized laterally, that

is, from the igneous rock side to the limestone side. Salinities of liquid inclusions in quartz range from 4.2 to 15.0 wt.% NaCl equiv. No relationship is recognized between the Th and salinity.

On the other hand, most of the Th and salinities of liquid inclusions in vein quartz range from 284 to 310°C, and from 5.5 to 7.9 wt.%, respectively.

From the result of the present inclusion study, it is inferred that the ore-forming fluids had relatively high salinities, and that the densities of fluids varied remarkably from the main stage of sulfide mineralization to the post-ore vein quartz. (Authors' abstract)

MURAMATSU, Yoichi and NAMBU, Matsuo, 1982, Fluid inclusion study on the contact metamorphic tungsten ore deposits of the Yaguki mine, Fukushima prefecture, Japan: *Mining Geol.*, v. 32, no. 2, p. 107-116 (in Japanese; English abstract). Authors at Res. Inst. Miner. Dress. Metall., Tohoku Univ., Sendai, Japan 980.

The filling temperature and the salinity of fluid inclusions in minerals from the pyrometasomatic copper-iron and tungsten ore deposits of the Yaguki mine were measured by means of a microscope with heating and freezing stages. The present works aim at the clarification of mineralization relationships between the two kinds of deposits. The results could be summarized as follows:

(1) The ranges of Th of fluid inclusions in quartz, scheelite, and epidote from the tungsten deposits are 200°-340°C (265°C), 220°-330°C (270°C), and 230°-330°C (290°C), respectively (parentheses indicate arithmetical mean values). And the ranges of the salinity of the former two minerals mentioned above are 1.0-2.9 and 2.9-10.5% in NaCl equiv. concentration, respectively.

(2) The range of Th of fluid inclusions in quartz and calcite from copper-iron deposits is 200°-360°C (291°C), which is almost the same as that of the Akagane mine, Iwate Prefecture. The salinity could not be measured because of a minute inclusion size.

(3) The results of the fluid inclusion study indicate that the mineralization stage of tungsten is later than that of copper-iron. This process of mineralization is supported by the mineral succession and mineral assemblages obtained from the field evidence and the microscopic observation.

(4) The Th of inclusions from copper-iron ore deposits decreases distinctly toward the upper level, whereas those of inclusions from tungsten ore deposits are confined to a narrow range in spite of the depth.

(5) There is a linear relationship between Th and the salinity of fluid inclusions in quartz from the tungsten deposits, while scheelite occupies a very narrow area in the diagram of Th vs. salinity of inclusions. From these facts it is inferred that scheelite crystallized under the condition of narrow ranges of both temperature and salinity. (Authors' abstract)

MURTHY, V.R., 1982, Isotopic and trace element evidence for mantle metasomatism (abst.): *EOS, Trans. Am. Geophys. Union*, v. 63, p. 612. Author at Dept. Geol. & Geophy., Univ. Minnesota, Minneapolis, MN 55455.

A primary prerequisite for any postulated mantle source of basalts is that it be capable of yielding, upon melting, liquids with appropriate trace element content as well as the trace element ratios observed in natural basalts. This constraint, when examined in the light of data of diagnostic lithophile trace elements such as K, Rb, Sr, etc., rules out anhydrous lherzolitic mantle from both the suboceanic and subcontinental

region as an adequate source material for basalt generation. The trace element data, coupled with scant Nd and Sr isotopic data clearly emphasize the role of hydrous minerals such as amphibole and mica and other trace element rich accessory minerals, in creating appropriate local mantle environment from which basaltic melts can be derived. This "enrichment" process is attributed to mantle metasomatism, for which abundant petrologic and chemical evidence is now available. It is suggested that such a metasomatism is a necessary precursor for alkaline magmatism in both the continental and oceanic mantles, and possibly for tholeiitic magmatism as well. Data from xenoliths and nodules show evidence for migration in and out and consequent gain and loss of fluids extremely enriched in compatible trace elements and volatiles. Isotopic data indicate that such metasomatic processes in the mantle can both be ancient and recent, suggesting that the chemical heterogeneity of the mantle represents a continuum of processes of melt and residua formation and the refertilization and subsequent melting of earlier formed residua. The metasomatic fluids may be derived from the deeper fertile mantle or may be connected to the tectonic process of lithosphere subduction and recirculation in the mantle. (Author's abstract)

MYSEN, B.O., 1982, Experimental results relevant to fluid-melt and fluid-mineral element partitioning in the upper mantle (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 449. Author at Geophys. Lab., Carnegie Inst. Washington, 2801 Upton St., NW, Washington, DC 20008.

Experimental fluid-mineral and fluid-melt element partitioning data at upper mantle pressures and temperatures are available for elements Na, K, Ce, Sm, and Tm and for components in the systems CaO-MgO-SiO₂-H₂O-CO₂ and Na₂O-Al₂O₃-SiO₂-H₂O-CO₂-HF. The solubility of these components in aqueous fluids increases by at least an order of magnitude between 10 and 30 kbar, and may increase by 300-500 %/100 °C temperature decrease. For rare earth elements (REE) in the upper mantle, C(fluid) > C(melt) > C(mineral) for all major peridotite minerals and typical silicate melts and for all CO₂/(CO₂+H₂O). Their solubilities in CO₂ and H₂O-fluids differ by a factor of ~4 as compared with diopside components, for example, where the difference is greater than an order of magnitude.

Alkali- and alkaline-earth solubilities in aqueous fluids may exceed 10 wt%, but decrease rapidly with increasing H₂O/CO₂. Recent data on HF/H₂O indicate that HF enhances alkali and alumina solubilities.

Low K/Rb and Sr/Rb of andesitic magmas compared with abyssal tholeiite may be due to an H₂O-rich flux through the source region of andesite melt in the upper mantle. Their REE patterns often also reflect such a process. The strong light REE and alkali enrichments in alkali basalt may also be explained with the aid of a CO₂-rich fluid precursor to the partial melting process. Irregularities in radiogenic isotope ratio relations (e.g., ⁸⁷Sr/⁸⁶Sr versus ¹⁴⁴Nd/¹⁴³Nd) may also be understood if metasomatic fluids fluxed the magma source regions. (Author's abstract)

NABELEK, P.I., LABOTKA, T.C., O'NEIL, J.R. and PAPIKE, J.J., 1982, Fluid-rock interaction during contact metamorphism of argillites and limestones evidenced from stable isotopes (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 574.

NAHNYBIDA, Cynthia, HUTCHEON, Ian and KIRKER, Jill, 1982, Diagenesis of the Nisku Formation and the origin of late-stage cements: Can. Min., v. 20, p. 129-140. Authors at Dept. Geol. & Geoph., Univ. Calgary, Calgary, Alberta T2N 1N4, Canada.

Late-stage calcite, dolomite and anhydrite cements, which occur in

Upper Devonian dolostones of the Nisku Formation, west-central Alberta, have been examined using thin-section petrography, fluid inclusion micro-thermometry, stable-isotope data and electron-probe microanalysis. The entire diagenetic sequence is interpreted to be: selective dissolution of fossils, dolomitization, extensive stylolitization, precipitation of calcite cements before, during and after stylolitization, and late-stage anhydrite emplacement. Fluid inclusion data indicate that the late calcite cements were deposited at temperatures of between 140 and 155°C from solutions approximately 2.4-3.7 m NaCl (equivalent). At the present depth of burial of 2.5 km and H₂O activities estimated from NaCl-equivalent contents of the aqueous phase in fluid inclusions, the minimum temperature of dehydration of gypsum to anhydrite would range from 75°C (fluid pressure) to 135°C (lithostatic pressure). The temperature range determined in this study, though moderately high, is not inconsistent with published bore-hole temperatures and vitrinite-reflectance data. Gypsum was not observed; these temperatures would represent a minimum range at the 2.5 km burial depth. Isotopic data for sulfur and oxygen in both "early" and "late" anhydrites show a distinct separation and may indicate that sulfate, introduced into solution by dissolution of "early" anhydrite, was being reduced during the precipitation of "late" anhydrite. (Authors' abstract)

NAKAMURA, Takeshi and KIM, M.Y., 1982, Macrostructures of vein filling in ore veins, with special reference to those of plutonic tungsten-tin-copper veins at the Otani mine, Kyoto Prefecture, Japan: *Min. Geol.*, v. 32, no. 2, p. 85-94 (in Japanese; English abstract). First author at Fac. Sci., Osaka City Univ., Japan.

Concepts on hypogene mineral zoning, mineral association, mineral paragenesis, and mineralization stage relating to macrostructures of vein filling in ore veins are briefly discussed.

As an example of plutonic ore vein, macrostructures of vein filling of plutonic tungsten-tin-copper vein at the Otani mine, Kyoto Prefecture, Japan, one of representatives of plutonic tungsten-tin veins related genetically to granitoid of Late Cretaceous in the Inner zone of Southwest Japan, are examined. Based on macrostructures of vein filling on the order of ore body, three major mineralization stages, called stage I, stage II, and stage III from earliest to latest, are distinguished by major tectonic breaks. Sequence of mineralization, characteristic features of each mineralization stage, and variations of Th and salinity ranges of fluid inclusions in minerals from stage I to stage III are summarized. (Authors' abstract)

NALDRETT, A.J., INNES, D.G., SOWA, J. and GORTON, M.P., 1982, Compositional variations within and between five Sudbury ore deposits: *Econ. Geol.*, v. 77, p. 1519-1534. First author at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

Relevant phase equilibria data indicate that Cu, Ni, Zn, Pt, and Pd are likely to become enriched in the residual liquid of a fractionating sulfide melt whereas Co, Rh, and Ru will concentrate in the early crystallizing monosulfide solid solution. The correspondence between the experimental data and natural observations is strong evidence that the zoning is the consequence of the fractionation of a sulfide melt, with the residual liquid being expelled progressively into the footwall. (From the authors' abstract)

NAPOLIS, E.M., 1982, Fluid inclusion study of core samples from the Malitbog thermal area, Tongonan geothermal field, Philippines (abst.):

hydrocarbons into the reservoir probably preceded or accompanied fracture genesis; and (5) methane concentration may have decreased since fracture initiation.

The geologic mechanism specifically responsible for creating the fractures remains unknown. The potential for using fluid inclusions to document changing methane concentration within a reservoir could be significant to studies of hydrocarbon migration. (Authors' abstract)

NARR, Wayne and CURRIE, J.B., 1982, Origin of fracture porosity - example from Altamont field, Utah: Am. Assoc. Petr. Geol. Bull, v. 66, no. 9, p. 1231-1247. First author at Gulf Res. & Dev. Co., P.O. Drawer 2038, Pittsburgh, PA 15230.

The occurrence of natural fracture systems in subsurface rock can be predicted if careful evaluation is made of the geologic processes that affect sedimentary strata during their cycle of burial, diagenesis, uplift, and erosional unloading. Variations in the state of stress within rock arise, for example, from changes in temperature, pore pressure, weight of overburden, or tectonic loading. Hence geologic processes acting on a sedimentary unit should be analyzed for their several contributions to the state of stress, and this information used to compute a stress history. From this stress history, predictions may be made as to when in the burial cycle to expect fracture (joint) formation, what type of fractures (extension or shear) may occur, and which geologic factors are most favorable to development of fractures.

A stress history is computed for strata of the naturally fractured Altamont oil field in Utah's Uinta basin. Calculations suggest that fractures formed in extension, that the well-cemented rocks are those most likely to be fractured, that fractures began to develop only after strata were buried to great depth, and that the fracture system continued to develop as strata were uplifted and denuded of overburden. Geologic evidence on fracture genesis and development is in accord with the stress history prediction.

Stress history can be useful in evaluating a sedimentary basin for naturally fractured reservoir exploration plays. (Authors' abstract)

Fluid inclusion evidence is used in several ways to reconstruct the fracture system history. (E.R.)

NASEDKIN, V.V. and BOYARSKAYA, R.V., 1980, Minerals in volcanic-glass pores: AN SSSR Izvestiya, Ser. Geol., no. 11, p. 90-97 (in Russian; translated in Int'l. Geol. Review, v. 24, no. 9, p. 1101-1108, 1982). Authors at Inst. Geol. Ore Deposits, Petrog., Mineral. & Geochem., USSR Acad. Sci., Moscow, USSR.

Two samples of obsidian from the Arteni deposit (Armenian SSR) were chosen for study. They were investigated with an S4 scanning electron microscope equipped with a microprobe. Mineral inclusions whose composition led to a tentative identification as oldhamite (CaS), metallic iron, manganese spinel and zinc spinel, magnetite, amphibole and silica gel were found in the pores. The surface of the glass around the pore was rich in the volatiles Cl and S. Two stages of mineral formation, high-temperature and low-temperature, are distinguished. Oldhamite, spinel and ores [magnetite probably meant--IGR editor] formed during the high-temperature stage and the silica gel and amphibole in the low-temperature stage. It is demonstrated that the scanning electron microscope can be used to study mineral inclusions and mineral-forming fluids. (Authors' abstract)

NAUMENKO, V.V., 1981, Endogene ore mineralization in the epochs of tectonic-magmatic activation in Europe: "Naukova Dumka," 216 pp., 500 copies printed, price 2 rubls. (in Russian). Author at Inst. Geochem. and Physics of Minerals, Kiev, Ukraine.

The book quotes a number of Th data for various ore deposits, essentially from the Russian literature. (A.K.)

NAUMKIN, P.A., EFIMOVA, M.I., SOLYANIK, V.A., PORECHIN, A.A. and YAKOVETS, V.A., 1982, Petrochemical and temperature parameters of Upper Cretaceous granitoids from Askol'd Island, in N.P. Ermakov, ed., Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 55-59 (in Russian).

For abstract, see entry Efimova, Naumkin, Mikhaylova and Ovcharek in Fluid Inclusion Research--Proceedings of COFFI, vol. 11, 1978, p. 58. (A.K.)

NAUMKO, I.M., MAMCHUR, G.P. and YARYNICH, O.A., 1982, Peculiarities of minerogenesis in the Volynian cavity pegmatites revealed from carbon isotopic composition of carbonates: Dopovidi Akad. Nauk Ukr. RSR, Ser. B. Geol., Khim., Biol., no. 7, 1982, p. 14-16 (in Ukrainian; English and Russian abstract)

NAUMOV, G.B., SALAZKIN, A.N., NIKITIN, A.A., MIRONOVA, O.F. and SAVEL'YEVA, N.I., 1982, Results of studies of fluid haloes in ore fields of Eastern Transbaikalia, in Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 225-231 (in Russian).

Wide haloes of hydrothermal alteration were found in the granite wall-rocks of ore deposits. Different saturation by volatiles was established for granites of ore-bearing and barren areas and differences in mineral-forming solution compositions were determined for various stages of mineral formation. The above data may be used for determination of relative degree of "opening" of geological structures, their influence on the distribution of ore bodies, depth of ore mineral formation and mechanism of processes of ore formation. (Authors' abstract translated by A.K.)

NAUMOV, V.B., 1982, Possibilities of determination of pressure and density of mineral-forming media on the basis of inclusions in minerals, in Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 85-94 (in Russian).

The author reviews the methods of P determination based on the CO₂-H₂O system, the Th-Td Naumov and Malinin methods and the so-called "Lemlein-Klevtsov method" with use of the chloride dms [but without quotation of the critical remarks given by Roedder and Bodnar, Fluid Inclusion Research--Proceedings of COFFI, vol. 13, 1980, p. 210-211]. He presents moreover a newly calculated table of dP/dT values for NaCl solutions up to Th 500°C. Also four typical examples of calculation of fluid density from fluid inclusions are shown: 1) one-phase inclusions, 2) two-phase inclusions, 3) LH₂O + LCO₂ + GCO₂ inclusions, 4) LH₂O + G + dms. (A.K.)

NAUMOV, V.B. and IVANOVA, G.F., 1982, Genetic relations of rare-metallic mineralization with acid magmatism with reference to the study of microinclusions and indicator microcomponents (abst.): IAGOD Sixth Symp.,

Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 82-83. Authors at Inst. Geochem. & Chem., Moscow, USSR.

The deposits are defined by the following specific features: high temperatures (500°-200°C, mostly 400°-250°C) and pressures (2.6-0.1 kbar, mostly, 1.5-0.5 kbar) of ore mineralization that are significantly higher than temperatures and pressures at the most probable depth of occurrences of deposits (1-3 km) with the gradient 50°C/km and lithostatic load of rocks 270 bar/km.

Recent 5 years' investigation results of melt microinclusions have provided estimation of the acid magma crystallization parameters: the temperature varies from 1200° to 550°C, water pressure from less than 0.1 to 6.1 kbar, water concentration in the melt from less than 0.1 to 13.9 weight %. The process of formation of some hypabyssal granite massifs involved a remarkable rise of water pressure and concentration. Melts with minimal water concentration (0.1-0.5 weight %) are characterized by maximal temperatures, while low-temperature melts are characterized by a high water pressure (3-5 kbar) and a high water concentration (3-8 weight %). The region of coexistence of silicate melts and hydrothermal solutions has been found within 950-550°C. Evolution of physicochemical parameters in the "melt-solution" system has been observed. (From the authors' abstract)

NAUMOV, V.B. and KHODAKOVSKIY, I.L., 1982, Hydrothermal mineral formation from thermobarometric and thermodynamic data, in N.P. Ermakov, ed., Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 80-86 (in Russian).

For abstract, see Fluid Inclusion Research--Proceedings of COFFI, vol. 11, 1978, p. 149. (A.K.)

NAUMOV, V.B., KOVALENKO, V.I. and KOSUKHIN, O.N., 1982, Parameters of crystallization of ongonite magmas from studies of melt inclusions: Akad. Nauk SSSR Doklady, v. 267, no. 2, p. 435-437 (in Russian). First author at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow.

The authors studied all facies of Li-F acid rocks: volcanic, subvolcanic dikes and stocks, hypabyssal massifs and chamber pegmatites. Melt inclusions in minerals of ongonite-type rocks yielded the following Th: ongorhyolites, Durben-Dort-Ula (Mongolia), apatite 1200-1170°C, quartz 1180-760°C; ongonite dike, Dadal-somon (Mongolia), quartz 1050-830°C, topaz 730-680°C; subvolcanic ongonite stock, Ary-Bulak massif, Transbaikalia (USSR), topaz 930-580°C, quartz 110-620°C; ongonite dike, Ongon-Khayrkhan (Mongolia), topaz 1020-920°C, quartz 550-540°C; Li-F granites, Baga-Gazryn (Mongolia), quartz 860-790°C; amazonite pegmatites, same location, topaz 720-640°C; granites, Khingilay-Shily, E. Transbaikalia (USSR), topaz >650°C; Li-F granites, Yugodzyr massif (Mongolia), topaz 650-600°C; chamber pegmatites, Volyn (USSR), topaz 760-600°C. Water content in inclusion melt ranges from 0.2 to 10 wt. %, PH₂O 90-4200 bars. Ongonite melts have low viscosity and due to this fact inclusions need rapid quenching (>350°C/min), otherwise melt "boils" with segregation of large number of G bubbles. Water concentrates in melts during evolution of melt on T decrease. (Abstract by A.K.)

NAUMOV, V.B. and SAMOYLOVICH, L.A., 1982, Practical peculiarities of use of homogenization method, in Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 141-145 (in Russian).

Three essential problems are discussed that have to be solved correct-

ly for successful use of fluid inclusion homogenization method in practical prospecting and studies of raw material deposits: 1) most correct selection of material for homogenization, 2) most correct and exact experiments with homogenization, 3) most correct use of results of homogenization of inclusions. (Authors' abstract translated by A.K.)

NÉGRONI, J.M., 1982, F-Ba-Pb-Zn mineralizations in the structural and metallogenetic evolution of the lead-zinc Pontgibaud mining district (France): Bull. BRGM, Sec. II, v. 2, no. 3, p. 237-242 (in French, English abstract). Author at IMGM, Dépt. gisements miniers, Ecole des mines d'Alès, 6, avenue de Clavières, 30107 Alès Cedex, France.

Generally integrated in the Pontgibaud mining district, the fluorite-barite mineralizations are extensively present in the Saint-Jacques d'Ambur vein deposits, NW of the main Pb-Zn vein axis. The distribution and geometry of the structures show a different kind of formation compared to that of the Pb-Zn veins with quartz gangue. The filling texture are typical of open fractures (banded structures, geodes).

Three mineralization types can be distinguished:

- hypersilicified tectonic breccias (BTH),
- quartz-barite-fluorite veins with some sulfides,
- quartz-fluorite veins.

Diversification and predominance of gangue minerals are related to an impoverishment of sulfide minerals corresponding to a change in the composition of the fluids and in the conditions of crystallization. The fluorite biphasic fluid inclusions show a strong salinity. The homogenization temperatures are near to 130°C.

Chronologically, the F-Ba-Pb-Zn mineralizations represent a late stage and probably the ultimate stage in the evolution of the Pontgibaud district, corresponding to a distinct metallogenetic period recognized elsewhere in the French Massif Central. (Author's abstract)

NEHRING, N.L., DES MARAIS, D.J. and TRUESDELL, A.H., 1982, Thermal decomposition of hydrocarbons in the Cerro Prieto, Mexico, geothermal reservoir: Geother. Resources Council, Transactions, v. 6, p. 305-307. First author at U.S. Geol. Survey, Menlo Park, CA 94025.

The distribution of low-molecular-weight hydrocarbons (C1-7) in geothermal systems depends on hydrocarbon source and temperature/time regime. In the Cerro Prieto, Mexico, geothermal reservoir, thermal decomposition of coal to form methane is extensive at temperatures near 340°C. In high-temperature wells, only methane, ethane, propane, and benzene are present. At temperatures near 290°C, thermal decomposition is extensive, as evidenced by such intermediate products as n-butane, n-pentane, and C4 and C5 branched hydrocarbons. The wide variety of hydrocarbons and low concentrations of methane relative to other hydrocarbons in surface samples indicate only moderate thermal decomposition of the source carbon and intermediate hydrocarbons. (Authors' abstract)

NEKRASOV, I.J. and KONIASHOK, A.A., 1982, The system Au-Fe-Sb-S under hydrothermal conditions at 300-600°C: Akad. Nauk SSSR, Dokl., v. 265, no. 1, p. 180-185 (in Russian).

NERONSKIY, G.I., LEVITSKIY, Yu.T., OSTAPENKO, N.S. and BELOUSOV, V.I., 1982, Problem of thermovacuum decrepitation of gold, in N.P. Ermakov, ed., Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 165-170 (in Russian).

For abstract, see Fluid Inclusion Research--Proceedings of COFFI, vol. 13, 1980, p. 173. (A.K.)

NEWTON, R.C. and HANSEN, E.C., 1982, Nature and origin of fluids in charnockitic metamorphism (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 448. Authors at Dept. Geophys. Sci., Univ. Chicago, Chicago, IL 60637.

Whole rock, mineral and fluid inclusion analysis of incipient charnockite formation from lower-grade rocks at Kabbaldurga, South India, and Cone Peak, California, reveal the following characteristics of the metamorphism:

1) Conversion of migmatitic gneisses to charnockites was, in some cases, virtually isochemical in terms of major and minor elements, and must have been effected by a pervasive vapor. H₂O constituted 0.1-0.3 of the total vapor; the major volatile species was CO₂.

2) Locally high activities of F at Kabbaldurga and S at Cone Peak were characteristic.

3) Temperatures were ~750°C and pressures were 5.5 kbar at Kabbaldurga and 8.0 kbar for Cone Peak.

4) Weak retrogression in the waning stages partially destroyed orthopyroxene.

Anatexis was closely associated with charnockitic conversion at both localities but was not causative. Both leucosome and restites were converted to charnockite by increasingly dry solutions along shear veins. Similar relations of anatexis and charnockitization were deduced by B.L. Weaver (Contr. Min. Pet. 71, 271, 1980) at Madras from trace element studies and C.R.L. Friend (Nature 294, 550, 1981) at Kabbaldurga from field relations. Available evidence indicates that continued streaming of CO₂ can lead to dry, depleted and refractory high grade granulites without extraction of a partial melt.

Possible sources of the copious CO₂ necessary for conversion of whole terranes include decarbonation of mantle peridotite in a subcontinental plume, destruction of shelf carbonates or evaporates in the closing phase of a Wilson Cycle, or decarbonation of subducted shelf sediments under a continental foreland. (Authors' abstract)

NIKISHOV, K.N. and SAFRONOV, A.F., 1981, Some aspects of the genesis of chromite and magnesium garnet from inclusions in diamonds and from kimberlitic rocks: Dokl. Akad. Nauk SSSR, 1981, v. 256, no. 5, p. 1215-1217 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 256, p. 139-140, 1982).

The possibilities that such inclusions may have been melt inclusions at one time should be kept in mind. (E.R.)

NIKOLAEVA, O.V., RYZHENKO, B.N. and GERMANOV, A.I., 1982, Reduction of sulfate by hydrocarbons and alcohols in aqueous solutions at 200-300°C: Geokhimiya, no. 5, p. 726-742 (in Russian; translated in Geochem. Int'l., v. 19, no. 3, p. 88-104).

NIKOL'SKIY, N.S., 1981, Metastable crystallization of natural diamonds from the fluid phase: Dokl. Akad. Nauk SSSR, 1981, v. 256, no. 4, p. 954-958 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 256, p. 126-129, 1982).

NISHIWAKI, Chikao, 1982, Tectonic stress and metallogenesis; primarily with reference to porphyry copper genesis: Mining Geol., v. 32, no. 4,

p. 291-304 (in Japanese; English abst.).

In earlier papers the author has reported that porphyry copper deposits in the southwest Pacific island arcs strongly favor a compressional stress environment, such as plate collision zones, while kuroko and related volcanogenic massive sulphide deposits favor extensional horizontal stress environment. In this paper he attempts to show how the physical and chemical effects of tectonic stress are implicated to metallogenesis. How this would control the metallogenesis particularly in the case of porphyry copper was investigated and described in the latter half of the paper.

From the results of many in-situ stress measurements two areas, one for extensional and the other for compressional stress regions, are selected, and the stress values in terms of depth are illustrated in Figure 1. Two sets of in-situ measurements at the present plate collision sites are superimposed on Figure 1-B and found to be in harmony with that of the compressional region. Average stress gradients by depth are also shown in Figure 1 and their value at the selected depth and their average P are tabulated in Table 1. Figure 4 schematically contrasts the porphyry intrusions under extensional and compressional environments, and their cooling processes were traced by the P-T diagram shown in Figure 6. Numerical values of the points of interests are given in Table 2 and 3. In the case of the "compressional" B-series in Fig. 4 the second boiling begins at lower temperature, 900° or lower, and at a lesser depth, when about 50% of the magma body is already made up of crystals. The boiling will generate very saline fluid, composed of approximately 50% of alkali chlorides, which again dissolves more chalcophile metals than dilute fluid. The higher confining pressure also inhibits the large volume increase which would have been caused by the second boiling under lower pressure. The increase is about 10-20% (Fig. 7), of which 5-10% could be absorbed by ductile deformation of the host rock. But when further boiling causes the inner pressure to become still higher, final brittle failure takes place resulting myriads of minute cracks in the solid rock mass around the magma body (Fig. 4, B-b). The metalliferous saline hydrothermal solution will rapidly permeate outward through these minute cracks. Opening and extension of the cracks will continue outward and upward. Due to the contact with wall rock, encounter with circulating meteoric underground water and continuous upward migration, temperature and salinity will be lowered rapidly, by 700°C to 200°C and 50 wt% to less than 10 wt% respectively. Together with intense chemical reaction with wall rock metal solubility will be reduced rapidly. More than 90% of metal content in the starting solution will be precipitated before it reaches to the surface. This is an ideal case for porphyry-type disseminated copper deposition.

By contrast, in the case of the lower confining pressure of the "extensional" A-series of Figure 4, magma may initiate a second boiling earlier, thus at higher temperature, at a deeper level, but with lower confining pressure, and with a far lower crystal ratio, say about 10% solid. The salinity of the separated fluid is lower but the volume increase of the total magma mass is far larger being 50% or more (Fig. 4, Fig. 6, Fig. 7 and Table 3). This large increase in volume may cause extrusion of the magma, often accompanied by explosion. Deep fractures caused by extensional deviatoric stress, coupled with high inner pressure, may lead a system of wider hydrothermal veins, instead of numerous minute cracks. Deposition of metal sulphides may occur at shallower depth in the case of wider veins than of porphyry copper type dissemination in myriads of minute cracks in and around intrusive stocks. The overflow of magma or of metalliferous solution to the surface through vein fracture will

cause greater loss of metal from its original containment in the mother magma. Shallower ore deposits have more chance to be washed off by later erosion. There may be sporadic network of copper sulphide dissemination but its size is limited. If this overflow of magma, accompanied by metalliferous solution, from magma or leached from surrounding rock mass, occurs under the sea especially in an ocean basin, the most of exhaled metal can be trapped by deep sea water, and concentrated as volcanogenic massive sulphide deposits, often associated with small metal dissemination at their roots. (From the author's abstract)

NORMAN, D.I. and NGUENE, F.R., 1982, Genesis of Sn-granites and Sn deposits in light of Rb-Sr isotope, fluid inclusion, and petrographic studies (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 210-211. Authors at New Mexico Inst. Mining & Tech., Socorro, NM, USA.

Tin-granites and -deposits at Mayo Darle, Cameroon and Franklin Mts., Texas (U.S.A.) were studied. Both are composite biotite-granites which intruded volcanics. Sn mineralization occurs near the upper contacts of the granites. The granites have hematitic alteration and alteration of biotite to chlorite and muscovite which increases in intensity near Sn mineralization. Thin section study indicates that some K and SiO₂ was introduced to the granite during alteration.

Fluid inclusion studies at Mayo Darle indicate Sn mineralization by boiling 500 ± 20° fluids of 55 eq.wt% NaCl. Similar fluids are observed in quartz grains in the granite. Rb-Sr isotopic study of fluid inclusion waters indicate the fluids from quartz grains fall on the isochron, i.e., were trapped at near the time of granite crystallization. Fluids in cassiterite and quartz gangue are plot way off the granite isochron and have high amounts of radiogenic Sr. The ore depositing fluids were not directly derived from the granite magma.

We postulate that saline fluids passing through the granite altered biotite thereby releasing K, Rb, radiogenic Sr and Sn. Alteration of Fe-Ti oxides resulted in hematite and mobilization of Sn. As the fluids ascended they reacted with the granite resulting in an altered rock high in K, Rb with Sn mineralization and altered Rb-Sr systematics. (From the authors' abstract)

NORMAN, D.I. and TRANGCOTCHASAN, Yongyut, 1982, Mineralization and fluid inclusion study of the Yod Nam tin mine, southern Thailand, in Metallization Associated with Acid Magmatism, A.M. Evans, ed.: New York, J. Wiley, p. 261-272. First author at Dept. Geosci., New Mexico Inst. Mining and Tech., Socorro, NM 87801.

The Yod Nam tin mine is a primary tin deposit which occurs in a two-mica granite of late Cretaceous to early Tertiary age in southern Thailand. Mineralization occurs in a fracture between two intrusive phases of the granite and took place in three stages. An early cassiterite-hematite-quartz-wolframite stage was followed by deposition of sulphides, chlorite, fluorite, cassiterite, wolframite and quartz. K-feldspar and magnetite were the last to be deposited. The alteration assemblage is chlorite-pyrite-quartz-muscovite which extends no more than 50 cm into the granite.

Fluid inclusion studies on cassiterite, quartz and fluorite indicate deposition from 500-250°C fluids of variable salinity, 0-8 eq.wt.% NaCl and at a pressure of 1 kbar. CO₂-rich inclusions were observed, but only in quartz. These data are similar to results of fluid inclusion studies on primary tin deposits throughout the world.

Two models for tin mineralization at Yod Nam are proposed: one involves meteoric-connate waters and the second, post-magmatic fluids.

High mineralization temperatures and high CO₂ content of some depositing fluids lead us to favor ore deposition by fluids derived from a crystallizing magma. (Authors' abstract)

NORMARK, W.R., DELANEY, J.R., MORTON, J.L., KOSKI, R., BARNES, I., STEVENSON, A., HAYBA, D., BARGAR, K., JOHNSON, M.P. and CLAGUE, D., 1982, Hydrothermal vents and sulfide deposits on the southern Juan de Fuca Ridge (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 913. First author at U.S. Geol. Survey, 345 Middlefield Road, Menlo Park, CA 94025.

We made acoustic-transponder-positioned dredging and photogeologic studies on a recent U.S. Geological Survey cruise to locate a series of hydrothermal vents within the axial valley of the Juan de Fuca Ridge. The 1-km wide axial-valley floor is remarkably flat for at least 20 km along strike. Detailed study of a 12-km segment of the ridge axis showed that sheet flows and lava lakes constitute about 90% of the valley floor. Fine-scale bathymetric relief, indicated by deep-tow pinger records from the University of Washington camera sled, reveals a shallow (~10 m) apparently continuous axial depression in the northern 5 km of the study area. The presence of vent communities, photographed on nearly all crossings of the axial depression, implies that the associated vents may be continuous along strike. In contrast to the vent systems along the Galapagos Rift and the East Pacific Rise at latitude 21°N, these hydrothermally supported benthic communities are associated with lava-lake collapse features. The fauna appear to differ significantly from those reported at other submarine-vent localities. Sphalerite and pyrite also were recovered from one of the photographed vent areas. (Authors' abstract)

NORMARK, W.R., LUPTON, J.E., MURRAY, J.W., DELANEY, J.R., JOHNSON, H.P., KOSKI, R.A., CLAGUE, D.A. and MORTON, J.L., 1982, Polymetallic sulfide deposits and water-column of active hydrothermal vents on the southern Juan de Fuca Ridge: Marine Tech. Soc. J., v. 16, no. 3, p. 46-53. First author at U.S. Geol. Survey, Menlo Park, CA.

Includes a discussion of the mineralogy and geochemistry of the vent deposits, the ³He plume, etc. (E.R.)

NORTON, D.L., 1982, Fluid and heat transport phenomena typical of copper-bearing pluton environments: southeastern Arizona, in S.R. Titley, ed., Advances in Geology of the Porphyry Copper Deposits, Southeastern North America, p. 59-72.

NORTON, Denis, 1982, The redistribution of aqueous silica in hydrothermal systems: the formation of quartz veins (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 578. Author at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

Quartz veins--their form, distribution and content--record a detailed chronology of the structural, chemical and thermal events that form hydrothermal ore deposits. Quantitative models of the transient processes that form quartz veins have been derived from the mathematical theory of magma-hydrothermal systems, transport properties of fluids in the H₂O system, and standard state thermodynamic data for SiO₂(qtz) \rightleftharpoons SiO₂(aq). Calculated gains and losses of quartz in model systems are useful exploration guides to ore deposits in the lithocap region of porphyry copper plutons.

Aqueous silica, advected from source regions into the lithocap, plugs flow channels with quartz because of local equilibrium and irreversible rates of change in aqueous silica concentration. Synchronous dispersion

of thermal energy from the pluton into this region reopens flow channels as fractures propagate in response to large increases in pore fluid pressures. Temperatures at which quartz is deposited in these zones of upward-flowing fluids are \leq the maximum in $\log K(\text{qtz})$ at pressures < 1 kb. There is a close correlation between temperatures at which quartz veins form in the model system and homogenization temperatures reported for fluid inclusions in quartz from many types of ore deposits. (Author's abstract)

NOSIK, L.P. and PASHKOV, Yu.N., 1982, Methods of studies of isotope composition of inclusion content and problems of interpretation of the results obtained, in *Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits*, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 64-73 (in Russian).

Thermal opening of inclusions theoretically may cause isotope fractionation, but experiments did not confirm this supposition. Presently the isotope composition of He, Ar, O, H, C and S in inclusions is determined; CO_2 , CH_4 , CO, H_2 , SO_2 , H_2S and noble gases are the components of G mixture in inclusions, O_2 presence, although occasionally reported, is doubtful. The SO_2 - H_2S equilibrium is discussed, as well as decomposition of organic matter. During mechanical opening of inclusions, a part of filling may be fixed in precipitates on the walls of inclusions. For isotope studies the authors recommend thermal method of inclusion opening on the basis of their investigations. The possibility is shown of use of partitioning of isotope of elements in compounds in inclusions and in the crystal lattice of the host mineral for evaluation of physico-chemical conditions of mineral formation. (Abstract by A.K.)

NOVIKOV, N.P., BOGDANOV, A.A., ZUEV, B.K., KUNIN, L.L., MIKHAYLOVA, G.V. and NOVIKOVA, N.N., 1982, Gas formation in silicate glasses under action of high intensity radiation: *Akad. Nauk SSSR Doklady*, v. 262, no. 2, p. 335-338 (in Russian). Authors at Inst. Geochem. & Anal. Chem. of Acad. Sci. USSR, Moscow.

The measurements proved that in the fracture space formed under action of high-intensity radiation, gaseous oxygen occurs in amount sufficient for wedging of silicate glass. Thermodestruction is the possible cause of gas formation. Processes accompanying oxygen formation were studied. (A.K.)

NOZETTE, S. and WILKENING, L.L., 1982, Evidence for aqueous alteration in a carbonaceous xenolith from the Plainview (H5) chondrite: *Geochim. Cosmochim. Acta*, v. 46, p. 557-563.

OHMOTO, Hiroshi and LASAGA, A.C., 1982, Kinetics of reactions between aqueous sulfates and sulfides in hydrothermal systems: *Geochimica Cosmo. Acta*, v. 46, p. 1727-1745. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

The rates of chemical reactions between aqueous sulfates and sulfides are essentially identical to sulfur isotopic exchange rates between them, because both the chemical and isotopic reactions involve simultaneous oxidation of sulfide-sulfur atoms and reduction of sulfate-sulfur.

The rate constants obtained in this study were used to compute the changes in the isotopic fractionation factors between aqueous sulfates and sulfides during cooling of fluids. Comparisons with data of coexisting sulfate-sulfide minerals in hydrothermal deposits, suggest that simple cooling was not a likely mechanism for coprecipitation of sulfate and

sulfide minerals at temperatures below 350°C. Mixing of sulfide-rich solutions with sulfate-rich solutions at or near the depositional sites is a more reasonable process for explaining the observed fractionation.

The degree of attainment of chemical equilibrium between aqueous sulfates and sulfides in a hydrothermal system, and the applicability of aO₂-pH type diagrams to mineral deposits, depends on the ΣS content and the thermal history of the fluid, which in turn is controlled by the flow rate and the thermal gradient in the system.

The rates of sulfate reduction by non-bacterial processes involving a variety of reductants are also dependent on T, pH, [ΣSO₄²⁻], and [ΣS²⁻], and appear to be fast enough to become geochemically important at temperatures above about 200°C. (From the authors' abstract)

OKRUGIN, V.M. and OKRUGINA, A.M., 1982, Mineralogical and genetic peculiarities of subsurface volcanogenic ore formation in Kamchatka (abst): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 211-212. Authors at Inst. Volcanology, Petropavlovsk-Kamchatsky, USSR.

[A wide variety of ore deposit types formed from] colloidal hydrothermal chloride-carbonate-sodic solutions at 430-150°C. Their formation was accompanied by a local boiling which provided elements of an independent structure-forming role of the mineralizing medium. The ore bodies are surrounded by distinct aureoles of heating and by anomalous K and Hg content. (From the authors' abstract)

ONTOEV, D.O., 1982, Mineral parageneses and their typomorphic peculiarities in the formations of multistage endogenous deposits (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 186-187. Author at Inst. Geol. of Ore Deposits, Petrography, Mineral. & Geochem., Moscow, USSR.

The following Th values for stages of mineralization with typical parageneses of basic minerals have been determined for the deposits of the molybdenite-sulphide-wolframite groups related with high-alkaline granites (Zabaikaljie, Central Kazakhstan, Peru, etc.): pre-ore feldspathic stage 500-400°C; microcline-molybdenite stage 400-340°C; quartz-sulphobismuthite-wolframite stage 360-250°C; quartz-polysulphide-hübnerite stage 300-180°C; fluorite-quartz-carbonate stage. (From the author's abstract)

ORLYANSKIY, Yu.N. and OKLADNIKOVA, L.A., 1982, The system Na₃AlF₆-Na₂SO₃-H₂O at 50°C: Zhurn. Neorg. Khimii, v. 27, no. 7, p. 1870-1871 (in Russian). Authors address not given.

The solubility isotherm may be pertinent to dm identification in specific fluid inclusions; see also next entry. (A.K.)

ORLYANSKIY, Yu.N., OKLADNIKOVA, L.A. and BOCHAROVA, N.D., 1982, The system Na₃AlF₆-Na₂SO₄-H₂O at 75°C: Zhurn. Neorg. Khimii, v. 27, no. 7, p. 1869-1870 (in Russian). Authors address not given.

The solubility isotherm may be useful for interpretation of dms in inclusions in alkaline pegmatites etc.; see also previous entry. (A.K.)

OSBORNE, L.W., Jr., 1982, Fluid inclusions and geochemistry of selected veins and mantos in the Leadville district, Colorado: MS thesis, Colorado State Univ., Fort Collins, Colorado.

Indexed under Fluid Inclusions. (E.R.)

OSHURKOVA, O.V. and PARILOV, Yu.S., 1982, Use of capillary isotachophoresis

during analysis of salt composition of fluid inclusions by water leachate method, in Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 115- (in Russian).

The method was evaluated, based on the separation of analyzed mixture of electrolytes for pure electrolytes under action of direct current in hydrodynamic stream induced in capillary. The method makes possible the simultaneous determination of anions and cations from very small volumes of solutions. The conditions of simultaneous determination of Na, K, NH₄, Ba, Mg, Li, Al, Ca, Cl, CNS, NO₃, SO₄ and CO₃ are given in the paper. (Authors' abstract translated by A.K.)

OSTROVSKIY, I.A., 1982, Thermodynamics of reactive gases under conditions of the Earth's mantle: Izvestiya Akad. Nauk SSSR - Ser. Geol., no. 5, p. 5-12 (in Russian). Author at IGEM of Acad. Sci. of USSR, Moscow.

The paper presents extrapolation of $\int_{TDP}^P V_T dP$, $\ln f$ and isobaric potentials of formation ΔG_f° to T 4000 K and P 250 kbar for Cl₂, F₂, HCl, HF, H₂O, H₂S, S₂, SO₂, SO₃, SiCl₄, SiF₄ and SnCl₄. (A.K.)

OVCHINNIKOV, L.N., 1982, Geochemical model of hydrothermal ore formation (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 36-38.

OVCHINNIKOV, L.N., BANSHCHIKOVA, I.V. and VASIL'YEV, Ye.V., 1982, Inclusions of melts and solutions - direct proof of ore-generating role of magmas, in N.P. Ermakov, ed., Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 33-37 (in Russian).

For the abstract, see Fluid Inclusion Research--Proceedings of COFFI, vol. 11, 1978, p. 158; note the changed title. (A.K.)

OVCHINNIKOV, L.N., KOZLOV, Ye.D. and RAFAL'SKIY, R.P., 1982, The solubility of stibnite in chloride solutions at elevated temperatures: Geokhimiya, no. 9, p. 1290-1297 (in Russian).

PADOVANI, E.R., SHIREY, S.B. and SIMMONS, Gene, 1982, Characteristics of microcracks in amphibolite and granulite facies grade rocks from southeastern Pennsylvania: J. Geoph. Res., v. 87, no. B10, p. 8605-8630. First author at Nat'l. Sci. Foundation, Washington, DC 20550.

Our observations of the microcracks in a small suite of samples of amphibolite and granulite facies rocks of variable composition show that (1) most cracks are partly or completely sealed, (2) the minerals that seal microcracks are unrelated to phase equilibria associated with granulite facies metamorphic conditions, and (3) the present crack porosity is related to bulk composition rather than to metamorphic grade. All observed cracks (open, healed, sealed) appear to have formed in response to tectonic stresses associated with retrograde metamorphism. (Authors' abstract)

PAGEL, M., 1982, Granites and uranium deposits in Portugal: typology, alterations and mineralizations, in Vein-Type and Similar Uranium Deposits in Rocks Younger than Proterozoic, Panel Proc. Series: Vienna, Int'l. Atomic Energy Agency, IAEA-TC-295/20, p. 323-347 (in French; English abstract). Author at Centre de rech. sur la géol. de l'uranium et Centre de rech. pétrographiques et géochimiques, Vandoeuvre, France.

The granites surrounding the three Portuguese uranium deposits studied here (Urgeirica, Bica and Cunha Baixa) are characterized by high

and variable uranium tenors, ranging from 4 to 17 ppm at the surface, compared with thorium tenors of 20 to 37 ppm. The minor minerals containing the uranium and thorium are as follows: uraninite with low ThO₂ tenors, xenotime, monazite, zircon and, to a lesser extent, apatite. On the sides of the uranium-bearing veins, intense sericitic alteration is caused by low-salinity aqueous fluids (1.1 to 5.8% eq.wt. NaCl) at variable temperatures rising to 200-250°C. Several generations can be identified from detailed chemical data on the white micas: magmatic muscovite, deuteritic muscovite and phengite occurring along the borders of the mineralized veins. There is evidence of a complex evolution of the fluids within the country rock enclosing the uranium-bearing veins, suggesting that the primary uranium mineralizations are of hydrothermal origin. (Author's abstract)

PALIN, J.M. and NORMAN, D.I., 1982, Volatiles in phyllosilicates, Copper Flat porphyry deposit, southwest New Mexico - a potential exploration tool (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 223. Authors at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Whole rock surface and drill core samples, containing phyllosilicate minerals, have been collected from the Copper Flat porphyry deposit before development. The ore deposit is not exposed at the surface, and the host Laramide quartz monzonite stock shows no well defined zoning of alteration about the known orebody. Upon heating, phyllosilicates release H₂O and significant amounts of other volatiles. The volatile contents of biotite, chlorite and sericite have been measured in an attempt to define the Copper Flat orebody.

The most abundant of the thermally evolved volatiles are: CO₂, CO, CH₄, H₂S, SO₂, and H₂. Carbon dioxide, CO, H₂S, and He appear to be spatially distributed about the orebody. Carbon dioxide is enriched by a factor of 3 and H₂S depleted by a factor of 4 in samples over the orebody. Carbon monoxide shows the greatest decreasing gradient outward from the orebody. However, an independent relationship between CO and CO₂ has not been verified.

The data indicate that the volatile contents of phyllosilicates may provide a tool for delineating drilling targets for hydrothermal mineral deposits which have undefined alteration patterns. (Authors' abstract)

PALMA, V.V. and CLARK, A.H., The San Rafael tin-copper lode system, Puno, S.E. Peru: a Cornwall-type deposit in the central Andean tin belt (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 7, p. 71. Authors at Dept. Geol. Sci., Queen's Univ., Kingston, Ontario, K7L 3N6, Canada.

The Central Andean tin belt has, as a productive entity, been extended northwestwards for over 250 km through the recent emergence of the San Rafael mine (14°12'00"S.; 70°20'15"W.) as a major source of Sn concentrates (ca. 900 tonnes metal, 1980). The San Rafael "vein," in part of exceptional grade (+ 10% Sn), is a laterally-extensive, structurally-complex, lode, with marginal, chloritic, wall-rock replacement.

Hydrothermal activity was spatially related to an Upper Oligocene (27 Ma), epizonal, stock of cordierite-biotite monzogranite, emplaced into Upper Ordovician metaclastics. The wide occurrence of brine inclusions in quartz phenocrysts reveals that, prior to ore deposition, the intrusion was permeated by high-temperature (T homogenization, 400-510°C), saline (+38 equiv. wt.% NaCl), aqueous fluids. A similar, perhaps contemporaneous, hydrothermal phase generated essentially barren tourmaline-quartz veins and fine-breccia sheets (lode stage I). These controlled the dispo-

sition of the mineralized lode structures, which comprise multiple, anastomosing, quartz-chlorite veins and breccias, within which deposition of botryoidal cassiterite ("wood tin;" Stage II) was followed by those of subordinate acicular "needle-tin," and of massive chalcopyrite (Stage III). Both economic lode stages formed at temperatures (Th) in the range 210-415°C, and involved fluids of low-to-moderate salinity (<20% NaCl). Confining pressures were low (<165 bars), but boiling was very local and unrelated to either ore grade or brecciation intensity.

Botryoidal cassiterite is concentrated below 4600 m a.s.l., as is the later needle-tin, whereas chalcopyrite was deposited mainly between 4700 and 5000 m a.s.l. The lode thus displays a distinct, Sn vs. Cu, polyascendant, zonation, independent of temperature of fluid salinity. Unlike most Sn veins in Bolivia, and, indeed, elsewhere, the San Rafael lode is, in structure and mineralogy, very similar to the major Sn-Cu lodes of Cornubia, U.K. (Authors' abstract)

PAL'MOVA, L.G., 1982, Improvement of prospecting criteria by thermobarogeochemical methods, in N.P. Ermakov, ed., Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 144-146 (in Russian).

For abstract, see Fluid Inclusion Research--Proceedings of COFFI, vol. 11, 1978, p. 159. (A.K.)

PANCHAPAKESAN, V., 1982, A suggested classification of inclusions in minerals (abst.): [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies 22-23 March, 1982, Indian Inst. Tech., Bombay p. 51-54 (unpaginated). Author at Indian Inst. Tech., Powai Bombay 400 076.

An elaborate classification, into 47 categories, based mainly on the phase assemblage at room T. (E.R.)

PANOV, B.S., 1981, Genetic peculiarities and prospecting criteria of fluorite mineralization of Donbass and Priazov'ye, in Fluorite of Ukraine (criteria of prospecting), p 20-41 (in Russian): "Naukova Dumka" Publ. House, Kiev, 140 pp., price 1 rubl. 10 kopecks.

In the Donets Basin Th in the fluorite deposits are as follows: Pokrovo-Kireevskoe deposit 280-80 (fluorite; P 750-830 atm for Th 280-220°C, pH 6.2-7.0 ± 0.8), 220-190°C (quartz), 150-90°C (carbonates); Dal'niy mine 145-132°C (fluorite), 100-90°C (carbonates), 140-138°C (quartz); mine Vostochno-Dolomitnyi near town Dokuchaevsk 170-140°C (P 136 atm, pH 6.6, total salt conc. 9.3-4.3%, in fluorite), 175-130°C (quartz), 140-135°C (dolomite), 120-80°C (calcite, total salt conc. 2.5%, pH 7.4-8.8); mines Severnyi and Yuzhnyi near town Komsomol'sk 175-117°C (fluorite, P 130-120), 110°C (amethyst), 140-115°C (calcite); in Priazov'ye, Petrovsko-Gnutovskoe deposit 250-105°C (fluorite, 10.5-11.4 wt. % total salt conc., pH 7), 260-220°C (calcite), 250-200°C (parisite). (A.K.)

PARILOV, Yu.S., 1982, Physico-chemical conditions of accumulation of hydrothermal-sedimentary sulfide ores in the deposits of Kazakhstan: Akad. Nauk SSSR Doklady, v. 266, no. 5, p. 1224-1227 (in Russian). Author at Inst. Geol. Sci. of Acad. Sci. of Kazakh SSR, Alma-Ata.

Ores from the pyrite-polymetal deposits: Shakliya, Mirgalimsay, Tekeli, Atasuy, Ridder-Skolovskoe, Orlovskoe, Zhayren, and Nikolaevskoe were investigated by vacuum decrepitation. Td ranges 40-80°C; inclusions are filled by water solution with 3-28% of total salts and 0.5-7% of gases. Ions consist of (Cl,F)>SO₄>HCO₃; (Na,K)>(Ca,Mg)>NH₄>Fe; gases of H₂S, SO₃, CO₂, N₂ and Ar. (Abstract by A.K.)

PARILOV, Yu.S., MUKANOV, K.M. and MIKHALEVA, V.A., 1982, Temperatures and compositions of ore-forming solutions of lead ore deposits of Alaigyr (central Kazakhstan): *Izv. Akad. Nauk Kaz. SSR, Ser. Geol.*, no. 2, p. 38-44 (in Russian). Authors at Inst. Geol. Nauk im. Satpaeva, Alma-Ata, USSR.

The Alaigyr Pb ore deposit is localized in Givetian-Frasnian volcano-genic rocks (quartz-feldspar porphyries) and limestones. Com. concns. of ores occur in hydrothermally altered porphyries and tuffs. The vein mineralization includes galena, pyrite, sphalerite, etc. Fluid inclusions in ores have a high content of gases (17%), with CO₂, H₂S, CO, NH₃, H₂, N₂, and Ar. Based on the fluid-inclusion studies, the composition of ore-forming solutions, from both the pre-ore and ore stages, is estd. Vacuum decrepitation of the inclusions indicated that the hydrothermal metasomatism began at ~600°; concluding mineral formation in barite veinlets occurred at 310 to 260°. (C.A. 96: 220720g)

PARRY, W.T. and DOWNEY, L.M., 1982, Geochemistry of hydrothermal chlorite replacing igneous biotite: *Clays & Clay Min.*, v. 30, no. 2, p. 81-90. Authors at Dept. Geol. & Geoph., Univ. Utah, Salt Lake City, UT 84112.

Hydrothermal chlorite replaces igneous biotite in the Gold Hill, Utah, quartz monzonite. Chemical compositions of coexisting biotite and chlorite determined by electron microprobe and wet chemical methods were used to evaluate chemical mass transfer during the alteration process. Secondary fluid inclusions in quartz of granite have Th 171-251°C (avg. 216°C). P est = 200-500 bars. (E.R.)

PASCAL, M.-L. and ROUX, Jacques, 1982, Thermodynamic properties of (Na, K)Cl-H₂O solutions between 400 and 800°C, 1-2 kb; a review of exchange equilibria with sodium-potassium silicates: *Geochim. et Cosmo. Acta*, v. 46, p. 331-337 (in French; English abstract). Authors at CRSCM 1A, rue de la Férollerie, 45045 Orleans Cedex, France.

Several independent determinations of the difference in Gibbs free energy of formation (from the elements at 25°, 1 bar) between NaCl⁰ and KCl⁰ in aqueous solutions (molality >0.5) are derived from equilibrium data between alkali feldspars, feldspathoids (nepheline-kalsilite), micas (muscovite-paragonite) and hydrothermal (Na, C)Cl-H₂O solutions. These results along with other data from the literature are discussed. The relation:

$\Delta G^0_f, KCl^0 - \Delta G^0_f, NaCl^0(J) = -16,500(\pm 2,500) - 18(\pm 4) T(K)$
is proposed from 400 to 800°C and 1 to 2 Kbar. (Authors' abstract)

PASHKOV, Yu.N., 1982, Problems of use of method of decrepitation, in *Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits*, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 64-73 (in Russian).

Decrepitation is used for revealing of zones of hydrothermal impregnation, prospecting for hidden ore bodies, determination of G in industrial sands etc. That method is also sometimes used for determination of T of mineral formation, which is incorrect without special interpretation. Until present, the theory of decrepitation is based on only one supposition, that after homogenization P inside inclusion sharply increases causing the breaking of inclusion walls. Attempts at mathematical description of this phenomenon led to the conclusion that Td depends on mechanical resistivity of host mineral, size of inclusions and distance from the grain surface. The author also briefly characterizes various principles of recording of decrepitation effects. (Abstract by A.K.)

PASTERIS, J.D., 1982^a Evidence of potassium metasomatism in mantle xenoliths (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 462. Author at Dept. Earth & Planet. Sci., Washington U., Box 1169, St. Louis, MO 63130.

Sulfides are among the metasomatic phases in veined peridotites (e.g., Harte & Gurney, 1975). At least 3 mantle xenolith suites contain K-Fe-Ni-sulfides: Frank Smith, South Africa (Clarke, 1979); Bulfontein, South Africa; Malaita, Solomon Is. (Pasteris, unpub. data). The Malaita sulfides occur in Cpx megacrysts with abundant features strongly suggestive of incipient partial melting (Pasteris, 1981). One large (several mm) complex sulfide intergrowth consists predominantly of Po+Pn. It also contains irregular bodies and veinlets of K-Fe-Ni-(Cu)-sulfide, glass patches, crystal inclusions, and crystals in glass; it is surrounded by patches and partial rims of glass. In reflected light, one sees in the Cpx host, minute silicate regions of comparatively lower reflectivity--presumably glass. They have higher Mg, Al, and Fe than the host Cpx, and are substantially enriched in K. Most of the glasses (inhomogeneous) within and rimming the large sulfide bleb have no K, but one large region adjacent to the sulfide has considerable K and compositionally resembles the minute regions of partial melt in the host Cpx. These features suggest introduction of a K-enriched fluid into the megacryst, which 1) caused incipient melting along fractures in the Cpx, 2) produced complete melting in or introduction of melt into areas around the sulfide, and 3) possibly caused K-metasomatism of preexisting sulfides or introduced new K-sulfides into them. Furthermore, small amounts of Cu are detected in the K-sulfide, but not in the enclosing Po-Pn intergrowth, suggesting that Cu also may have been introduced by the K-bearing fluid. Such assemblages are particularly important because of their implications for fluid movement and large-scale introduction of trace elements and because of our concern for the potassium budget in mantle rocks. [Malaita xenoliths from P.H. Nixon: Nixon & Boyd, 1979.] (Author's abstract)

PASTERIS, J.D., 1982^b Kimberlites: insight into the mantle (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 613.

PATERSON, C.J., 1982, Oxygen isotopic evidence for the origin and evolution of a scheelite ore-forming fluid, Glenorchy, New Zealand: Econ. Geol., v. 77, p. 1672-1687. Author at Geol. Dept., Univ. Otago, Dunedin, New Zealand.

The Glenorchy lode field in the Otago Au-W-Sb metallogenic province of New Zealand is hosted by metasediments of pumpellyite-actinolite facies to lowest greenschist facies. The lodes cut schistosity at a high angle and consist of anastomosing veins of quartz-scheelite-calcite-pyrite-arsenopyrite within zones of crushed and deformed schist up to 6 m wide.

The temperature of metamorphism was estimated by oxygen isotope geothermometry to be between 370° and 445°C, although pumpellyite stability experiments by Schiffman and Liou (1977) suggest that 400°C would be the upper limit. Oxygen isotope geothermometry gave a temperature range of mineralization of 280° to 350°C. Relative temperatures can be more reliably stated--mineralization occurred after metamorphism at a temperature at least 80°C less than that of metamorphism.

The ore-forming fluid $\delta^{18}\text{O}$ was in the range 7 to 10 per mil, and on this evidence could have been either metamorphic or magmatic in origin, but because there is no spatial association between Au-W-Sb mineralization and igneous activity in the Otago area, a metamorphic origin is favored. A model for the origin and isotopic evolution of the ore-forming fluid is proposed whereby the fluid was derived from metamorphic dehydration reac-

tions in rocks of at least upper greenschist facies. The fluid was trapped in the rocks until uplift of the schist pile led to hydraulic fracturing and release of the fluid to existing fault zones. The fluid migrated rapidly upward, retaining a constant $\delta^{18}\text{O}$ value, and deposited hydrothermal minerals which were ^{18}O enriched relative to those in the country rock. Ore-forming elements (W, Au) were derived deep in the schist pile, probably also from metamorphic reactions.

The oxygen isotope alteration aureole is probably too narrow to be of any practical use in exploration for similar lode deposits, at least in the Glenorchy area. (From the author's abstract)

PATERSON, M.S., 1982, The determination of hydroxyl by infrared absorption in quartz, silicate glasses and similar materials: *Bull. Minéral.*, v. 105, p. 20-29. Author at Res. Sch. of Earth Sci., Australian Nat'l. Univ., Canberra 2600, Australia.

A survey of calibrations available for various substances supports the view that the strength of absorption of hydroxyl in the $3\ \mu\text{m}$ infrared region is frequency dependent. When proper account is taken of the anisotropy factor γ , it appears that a single calibration line for the integral molar absorption coefficient I can be applied, as a first approximation, to a variety of substances, including silicate and other glasses, quartz and the various forms of water. This relation is $I/\gamma = 150(3780 \nu)$ where ν is the wave number in cm^{-1} and I is given in cm^{-2} per mol H/l. Its acceptance allows the hydroxyl content associated with the broad-band or gel-type absorption in quartz and similar substances to be estimated to a first approximation and has the implication that the distribution of hydroxyl bond strengths is much more biased to high wave numbers than is at first suggested by the shape of the spectrum. (Author's abstract)

PATIL, R.R., 1982a Fluid inclusion study, a tool to solve geological problems (abst.): [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies, 22-23 March, 1982 Indian Inst. Tech., Bombay, p. 43 (unpaginated).

PATIL, R.R., 1982b Fluid inclusion research in Himalaya - a review (abst.) [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies, 22-23 March, 1982, Indian Inst. Tech., Bombay, p. 37 (unpaginated).

PATRICK, R.A.D., 1982, Mineralizing fluids at Tyndrum, Scotland (abst.): *J. Geol. Soc. London*, v. 139, part 1, p. 97.

The Tyndrum lead-zinc deposits occur as veins and vein breccias in Moinian quartzites. The veins occupy fractures associated with the Tyndrum-Glen Fyne fault. Fluid inclusion studies revealed the mineralizing fluids carried 18 wt% equivalent NaCl, had a Na/K ratio of 3:1 and entered the veins at c. 300°C . The inclusions also revealed evidence for "boiling," and secondary inclusions containing fresh water and displaying homogenization temperatures of $\sim 125^\circ\text{C}$ may represent trapping of the resulting condensate. Electron microscope studies of the sphalerite revealed that the secondary inclusions developed along deformation twins, zones of intense dislocation, as well as fractures.

The mineralogy of the deposits indicates the temperature of the solutions increased with time. K-feldspar is a wall rock alteration product and its formation was the result of boiling, a high SiO_2 concentration and the low Na/K ratio of the mineralizing solutions. This low Na/K ratio is explained by the fluids reacting with the K-rich metamorphic source rocks. Sulphur isotope studies indicate a different source of sulphur for the baryte and the sulphides. (Author's abstract)

PATTERSON, C.S., SLOCUM, G.H., BUSEY, R.H. and MESMER, R.E., 1982, Carbonate equilibria in hydrothermal systems: first ionization of carbonic acid in NaCl media to 300°C: *Geochimica Cosmo. Acta*, v. 46, p. 1653-1663. Authors at Chem. Div., Oak Ridge Nat'l. Lab., Oak Ridge, TN 37830.

The ionization quotients of aqueous carbon dioxide (carbonic acid) have been precisely determined in NaCl media to 5 m and 50° to 300°C using potentiometric apparatus previously developed at Oak Ridge National Laboratory. The pressure coefficient was also determined to 250°C in the same media. These results have been combined with selected information in the literature and modeled in two ways to arrive at the best fits and to derive the thermodynamic parameters for the ionization reaction, including the equilibrium constant, activity coefficient quotients, and pressure coefficients. The variation with temperature of the two fundamental quantities ΔV° and ΔC_p° were examined along the saturation vapor pressure curve and at constant density. The results demonstrated again that for reactions with minimal electrostriction changes the magnitudes and variations of ΔC_p° and ΔV° with temperature are small and, in addition, ΔC_p and ΔV are approximately independent of salt concentration.

The results have also been applied to an examination of the solubility of calcite as a function of pH (in a given NaCl medium) for the neutral to acidic region both for systems with fixed CO₂ pressure and systems where the calcium ion concentration equals the concentration of carbon. The pH of saturated solutions of calcite with P(CO₂) of 12 bars increases from 5.1 to 5.5 between 100° and 300°C. (Authors' abstract)

PAVLOV, A.L., 1982, Possible role of element-organic compounds in formation of quartz-ore deposits: *Geologiya i Geofizika*, no. 7, p. 37-43 (in Russian). Author at Inst. Geol. Geophys. of Siberian Branch of Acad. Sci. USSR, Novosibirsk.

The author discusses the role of compounds like C₂H₅Cl, (C₂H₅O)₄Si, AlC, (C₂H₅)₄Sn etc., hypothetically existing in various stages of post-magmatic processes and possibly producing minerals and gases (CO, CO₂, CH₄) detectable in fluid inclusions. (A.K.)

PAVLUN', N.N., 1982, Crystallogenic sequence and certain typomorphic features of pyrites from the deposit Akchatau: *Mineralog. Sbornik*, v. 36, no. 1, p. 31-36 (in Russian; English abstract). Author at L'vov Univ., L'vov, Ukrainian SSR.

Th of inclusions in quartz paragenetic with cubic pyrite are 405-320°C (Td of this pyrite 420-360°C); with pyrite of habit being combination of cube and pentagonal dodecahedron {210} - 350-290°C (Td of pyrite 380-320°C); with pyrite of pyritohedron habit - 350-240°C (Td of pyrite 340-280°C). (Abstract by A.K.)

PAVLUN', N.N. and SIMKIV, Zh.A., 1982, Evolution of chemical composition of mineral-forming solutions of rare-metal ores in the deposit Akchatau (central Kazakhstan): *Zapiski Vses. Min. Obshch.*, v. 111, no. 1, p. 67-74 (in Russian).

The deposit Akchatau (rare metal-W-Mo) consists of greisens and quartz veins. Four horizontal zones were found there from the bottom up: 1) under ore, 2) main ore, 3) above-ore, and 4) "secondary" ore zones. Two stages of mineral formation were distinguished: I pneumatolytic-hydrothermal, including substages molybdenite-quartz, Th* 440-340°C, P 1200-1000 bars, and commercial rare-metal-molybdenite-wolframite-quartz plus pyrite-wolframite-quartz, Th >480-260°C, P 1600-500 bars; II hydrothermal, including galena-sphalerite-quartz, Th 310-150°C, P 550-350

bars, and fluorite quartz plus zeolite-calcite, Th 180-60°C. Early hydrotherms were of F-Cl-K-Na type, total salts up to 65% (NaCl+KCl). Later hydrothermal solutions had Cl-K-Na composition with increasing CO₂ amount, total salts from 41 to 32 wt. %. Special attention was paid to a) rare-metal-molybdenite-wolframite-quartz and b) pyrite-wolframite-quartz substages; 6000 Th measurements in quartz and fluorite and 17 water leachates from quartz were made. Th increases with the depth increment; average paleotemperature vertical gradient is 25°C per 100 m, horizontal - from 8 to 10°C per 100 m, displaying essentially concentric pattern of paleoisotherms. The ions: Cl (0.61-5.65 here and later ⁿmg/250 ml), HSiO₂ (this ionic form accepted conditionally) 2.56-8.06, Na 0.62-3.63, F 0.56-0.61, K 0.20-1.71, Ca 0-0.27, HCO₃ 0-0.44, pH of water leachates ranges from 6.4 to 5.3. (Abstract by A.K.)

*All Th without P corrections. (A.K.)

PEARCE J.A. and BALDWIN, J.A., 1982, Geochemical tracers for identifying the pathlines of mineralizing fluids: examples from the El Salvador porphyry copper deposit, Chile (abst.): J. Geol. Soc. London, v. 139, p. 98.

PECHERKIN, A.I., 1982, Saturation of water by calcium sulfate during filtration into riverside gypsum massif: Sovetskaya Geologiya, no. 1, p. 54-47 (in Russian). Author at the Perm State Univ., Perm, USSR.

The paper bears plots of CaSO₄ concentration vs time for filtration rates 0-100 cm/sec at 25°C, CaSO₄ solubility in water at T 0-100°C and time of gypsum solubility vs velocity of filtration at T 0-50°C during the forced flow; applicable to fluid inclusion studies in sedimentary and diagenetic minerals. (A.K.)

PECK, C.W., 1982, A geochemical and fluid inclusion study of the mineral deposits of the Platoro fault zone, Platoro Caldera, San Juan Mountains, Colorado: MS thesis, Colorado Sch. Mines, Golden, Colorado.

Indexed under Fluid Inclusions. (E.R.)

PECK, J.H., 1982, Fluid inclusion studies for dating fault movement, in O.C. Farquhar, ed., Geotechnology in Massachusetts, Proc. of a Conference in March 1980, Graduate Sch. Univ. Massachusetts, p. 443-446. Author at Stone & Webster Engrg. Corp.

Faulting is pervasive in New England and records tectonic movements which have occurred in the geologic past. No presently active faults are known. Determination of the age of last movement on old faults is difficult but is required when faulting is found on or near nuclear reactor sites or other facilities licensed by the Nuclear Regulatory Commission. Analyses of fluids trapped within minerals which have crystallized from aqueous solutions circulating in fault planes give specific data on the geologic conditions present at the time of crystallization. Fluid inclusions reveal ranges of temperature, pressure, salinity, composition, and oxidation state of the solutions.

The studies of fluid inclusions in quartz, calcite, sphalerite, and other less common transparent crystalline minerals in fault zones provide clues as to depth of overburden, geothermal conditions, and anomalous fluid sources after initial fault movement. The minerals themselves act as sensitive strain indicators for the detection of movement after various stages of mineral crystallization.

Determination of the temperature range of crystal formation, the approximate formation pressure, and the composition of the fluids has enabled the geologist to put limiting values on the depth and other geologic

conditions of formation. Assuming reasonable values for hydrostatic and lithostatic pressures and geothermal gradients, one can calculate qualitatively a depth range for crystallization. Minimum age of last fault movement is approximated by assuming conservative denudation rates and calculating the time necessary to exhume the mineralized fault. (Author's abstract)

PENG, Ligui, 1982, The study of mineral inclusions on the pyritic Cu-bearing deposit of Baiyinchang in Gansu Province, China: Bull. of Xi'an Inst. Geol. & Min. Resources, Chinese Acad. Geol. Sci., no. 4, p. 114-123 (in Chinese, English abstract).

Based on the study of the mineral inclusions mineralized rocks and ore minerals in quartz-keratophyre series of this area, some conclusions are drawn as follows:

1. On the basis of the uniform temperature of the solid inclusions in the quartz-keratophyre series (1050°C to 1150°C) and of melting of quartz-keratophyre matrix, and the appearance of a large number of gas bubbles at 1100-1150°C, [we suggest] that various quartz-keratophyres originated from magma at a temperature of 1050-1150°C and that the rocks formed from rapidly cooling magma with a great deal of volatile flux, not far from the volcanic orifice.

2. Two [stages of] gas inclusions [were recognized]. The early period belongs to the uncolored gas-liquid inclusions with a uniform temperature (Th?) of 207-405°C (not corrected for pressure). The later period formed colored gas-liquid inclusions (coexisting with polyphase inclusions containing liquid CO₂ and daughter minerals) with a uniform T of 153-469°C. The metallogenesis is related to the later hydrothermal action.

According to the data obtained, the metal-bearing solutions are characterized by pH>8, salinity = 20.0%±, density = 1.02, and in part containing immiscible hydrothermal [fluids] of high salinity (30-60%), rich in Si, Fe, Na, Cu, S, P, CO₂, and the presence of Mg, Ca, K, Pb, Ti, Ag et al. which are the major source of mineralization. The T of hydrothermal fluid ranged from 153-469°C and the T of metallogenesis is calculated at 200-374°C [indicating a] middle-high temperature hydrothermal deposit.

3. The enriched zone of colored gas-liquid inclusions is a promising area of mineralization, and ore deposits of large scale are apt to be found in a district rich in solid inclusions. (Modified by E.R. from the author's abstract)

PERCHUK, L.L. and LINDSLEY, D.H., 1982, Fluid-magma interaction at high pressure-temperature conditions, in S. Akimoto and M.H. Manghnani, eds., High-Pressure Research in Geophysics: Advances in Earth and Planet. Sci., v. 12, p. 237-250. First author at Inst. Exp. Min., the U.S.S.R. Acad. Sci., 142432, Chernogolovka, Moscow, USSR.

The chemical fluid-magma interaction has been studied involving two kinds of systems: "basalt-fluid" and "peridotite-fluid" at 1 to 4 GPa and 1,200 to 1,500°C. The plagioclase melt has been used as a starting material to investigate the first system. The alkali fluid has been introduced in the capsule to produce the alkali melt and carbonatite from the plagioclase melt: $Ca_{1-x}Na_xAl_{2-x}Si_{2+x}O_8 + (1-x)(Na_nK_{1-n})_2CO_3 + H_2O = Na_x(Na_nK_{1-n})_{1-x}Al_{2-x}Si_{2+x}O_{18} \cdot zH_2O + (1-x)CaCO_3 \cdot (1-z)H_2O$.

The K-Na exchange between silica-rich magma and (K, Na)Cl fluid has been also carried out over the wide Na/(Na + K) range at 1,100°C and 6 bars: $0.44NaAlSi_3O_8 \cdot 0.56SiO_2 + KCl = NaCl + 0.44KAlSi_3O_8 \cdot 0.56SiO_2$.

The reaction $CaMgSi_2O_6 \cdot Mg_2SiO_4 \cdot Mg_3Al_2Si_3O_{12} + (1+n)(K_2O \cdot 2H_2O \cdot CO_2) =$

$K_2Mg_6Al_2Si_6O_{22} \cdot 2H_2O + CaCO_3 + n(K_2CO_3 \cdot 2H_2O)$ can explain the origin of carbonate and phlogopite material in kimberlite magma in the depth more than 150 km beneath the platforms in Eastern Siberia and South Africa. (Authors' abstract)

PERRY, E.C., Jr. and MONTGOMERY, C.W., eds., 1982, Isotope studies of hydrologic processes: Northern Illinois Univ. Press, 118 pp.

A selection of 12 papers from a 1980 AGU meeting, covering a variety of subjects of potential interest to fluid inclusion studies: stable isotopes of O and H in water, C in HCO_3^- , S in SO_4^{2-} and S^{2-} , and radioisotopes of U, H, and Ra, as well as various aspects of rock-water interaction in geothermal systems and sediments. (E.R.)

PERSIKOV, E.S. and KALINICHEVA, T.V., 1982, Concentration and temperature dependence of viscosity of magmatic melts (method of calculation and prediction): Akad. Nauk SSSR Doklady, v. 266, no. 6, p. 1467-1471 (in Russian). Authors at Inst. Exper. Mineralogy of Acad. Sci. USSR, Chernogolovka near Moscow, USSR.

The paper bears data on viscosity of the melts: SiO_2 , albite and albite- H_2O , binary and pseudobinary systems like granite- H_2O , basalt- H_2O , andesite- H_2O , Na_2O-SiO_2 , $MgO-SiO_2$ etc.; pertinent to formation of melt inclusions. (A.K.)

PESQUERA, A., FORTUNE, J.P., HERRERO, J.M. and VELASCO, F., 1982, Pb-Zn-Ba vein deposits related to the granite of Penas de Haya (western Pyrenees-Spain) (abst.): Bull. BRGM, sec. II, v. 2, no. 3, p. 287. First author at Dept. Cristal. Mineral., Univ. del Pais Vasco, App. 644, Bilbao, Spain.

The Basque Paleozoic massif of Cinco-Villas (Navarre-Guipuzcoa) includes numerous Pb-Zn-F-Ba deposits and rather fewer iron deposits.

All the deposits display roughly the same paragenesis: sphalerite, galena, fluorite, quartz, siderite, pyrite, arsenopyrite, chalcopyrite, pyrrhotite, antimony sulfosalts, silver sulfosalts, cassiterite, etc. The sphalerite-pyrite-pyrrhotite association and measurements on the fluid inclusions in the fluorite indicate an emplacement temperature of between 250°C and 350°C. (From the authors' abstract)

PETROV, P., 1982^a Primary sectorial fluid inclusions in quartz (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 212. Author at Sofia Univ., Sofia, Bulgaria.

Primary sectorial inclusions, the orders of their distribution and relations with other types have been observed in the quartz of lead-zinc lodes of Southern Bulgaria (Madan ore district, Majar Ore field). The sectorial inclusions possess one common peculiarity consisting in their normal orientation towards rhombohedral facets. The vacuoles of the inclusions are rather complex in shape. Simple negative crystals are extremely scarce. As proved by optical examinations, low-temperature conditions enable recrystallization and splitting of some inclusions. This results in anomalous inclusions with different phase filling. Sectorial inclusions impart milky-white color to the aggregates of gangue quartz and to individual crystals in which they are present. Since the degree of saturation with inclusions is rhythmical, quartz acquires zonal structure.

It has been proved that ore minerals occur only in those parts of ore lodes where quartz is only slightly defective and poor in sectorial fluid inclusions. (Author's abstract)

PETROV, P.P., 1982^b Primary sectorial fluid inclusions in milk-white

quartz: Comptes rendus de l'Académie bulgare des Sci., v. 35, no. 4, p. 487-490 (in English).

Dense masses of subparallel primary inclusions, elongated in the direction of growth, and arranged in white zones representing growth stages, are described from various Bulgarian ore and non-ore quartz veins. (E.R.)

PETROVSKAYA, N.V. and NOVGORODOVA, M.I., 1982, Changes of acidity-alkalinity of solutions during formation of gold ore deposits, p. 141-154, in Acid-basic properties of chemical elements, minerals, rocks and natural solutions: "Nauka," Moscow, 216 pp., 1100 copies printed, price 2 rubs 50 kopecks (in Russian).

Changes of pH of mineral-forming solutions (Th 50-450°C) during origin of gold ore deposits are polycyclic in agreement with the idea of the separation of ore process into stages. Commercial stage of hydrothermal ore process is characterized by alkaline solutions. Important role is displayed by acid and alkaline dissolving of rocks and ores. Under shallow conditions the colloid masses precipitate from solutions, next significantly or completely recrystallized. (Authors' abstract, translated by A.K.)

PETROVSKAYA, S.G., 1982, Geochemical peculiarities of mineral associations and conditions of their formation in the molybdenum deposit (Western Transbaikalia): Geologiya i Geofizika, no. 7, p. 81-87 (in Russian). Author at Inst. Geochem., Irkutsk, USSR.

The Mo deposit Khorzhertuy (Dzhida ore region) formed due to late Paleozoic-early Mesozoic tectonic-magmatic activation, in connection with intrusion of porphyry-like, fine grained leucocratic granites. Two stages of deposit formation are distinguished: greisen and hydrothermal. Greisen minerals bear inclusions homogenizing in G phase at 480-365°C and in L phase at 350-310°C; quartz of the hydrothermal stage yielded Th 510-280°C. Quartz veinlets with coarse-flaky molybdenite are characterized by inclusions with Th 510-460°C in G and 370-300°C in L, the inclusions commonly bear CO_2 , KCl, NaCl and MoO_2 (sic, a misprint for MoS_2 ?-A.K.), indicating heterogeneous fluid during mineral growth. (Abstract by A.K.)

PHILPOTTS, A.R., 1982^a Compositions of immiscible liquids in volcanic rocks: Contrib. Mineral. Petrol., v. 80, p. 201-218. Author at Dept. Geol. & Geoph., and Inst. Materials Sci., Univ. Connecticut, Storrs, CT 06268, USA.

Immiscible liquids, preserved as chemically distinct, glassy globules (Si-rich and Fe-rich) occur in many tholeiitic basalts and some alkaline and calcalkaline lavas. The glasses typically form part of a dark mesostasis containing skeletal magnetite crystals. In thick flows, the Si-rich liquid may crystallize to granophyric patches, and the Fe-rich one to aggregates of hedenbergite, magnetite, and accessory phases. The mesostases containing these immiscible phases constitute from 20% of a primitive olivine tholeiite ($\text{MgO} = 7.5\%$) to 50% of a highly fractionated quartz tholeiite ($\text{MgO} = 2.8\%$), but may be less if the rock is oxidized. Abundant ferric iron promotes early crystallization of magnetite and prevents the iron enrichment necessary to reach the immiscibility field; thus, aa flows rarely exhibit immiscibility, whereas the more reduced pahoehoe ones do.

Alumina and alkalis are concentrated in the Si-rich liquid, whereas the remainder of the major elements are concentrated in the Fe-rich melt; but the partitioning of Fe, Mg, Ca, and P is less pronounced in alkaline rocks than in tholeiites. Conjugate liquids have compositions of granite

and Fe-rich pyroxenite, though the Si-rich melt in alkaline rocks is more syenitic and the Fe-rich one contains considerable normative alkali feldspar. The liquids coexist with plagioclase and augite of, respectively, An_{50} and $Ca_{34}Mg_{19}Fe_{47}$ compositions in tholeiites, and An_{40} and $Ca_{42}Mg_{29}Fe_{29}$ in alkaline rocks. Immiscibility is not restricted to K-rich residual liquids, but the miscibility gap is narrower for Na-rich compositions. In tholeiitic basalts with 52% SiO_2 , the Na_2O/K_2O ratios in conjugate liquids are equal, but at lower silica contents the Si-rich liquid is relatively more sodic, whereas at higher silica contents it is relatively more potassic. This may explain the association of sodic granites with mid ocean ridge basalts.

Immiscible liquids are present in sufficient amounts in so many volcanic rocks that magma unmixing should be considered a viable means of differentiation during the late stages of fractionation of common magmas, at least at low pressures. (Author's abstract)

PHILPOTTS, A.R., 1982, Silicate liquid immiscibility in alkaline lavas (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 587.

PICHAVANT, M., 1982, Potash metasomatism induced by circulation of boron-bearing fluids: experimental evidence (abst.): J. Geol. Soc. London, v. 138, part 1, p. 97-98.

PICHAVANT, M. and MANNING, D.A.C., 1982, The role of volatile elements, particularly boron and fluorine, on the petrology of granites: Coll. Intern. CNRS "Géochimie et Pétrologie des Granitoïdes", Clermont-Ferrand, p. (in French).

Boron and fluorine are generally found concentrated in different ways in certain particular granites, tourmaline leucogranites (enriched in B) and albitic granites with topaz and Li-mica (enriched in F). These granites are a characteristic sign of magmatic activity in the lithosphere. They share common characteristics: level of emplacement in the crust; petrographic and textural characteristics indicate that the majority of these granites have crystallized under fluid-saturated conditions (this is not the case for the majority of granites). These are peraluminous granites, composed of white micas, alumino-silicates, minerals rich in aluminum such as garnet, cordierite, oxides and characteristic accessory minerals. B and F are found in tourmaline, topaz, fluorite and micas, respectively. Geochemical data for major elements show low values of Ca, Mg and Fe, which makes these granites particularly suited to apply available experimental data in the reference system Qz-Or-Ab. Available data for REE, $^{160}/^{180}$, Rb/Sr are limited. Sn-W mineralizations are frequently spatially associated with these granites.

Recent experimental results provide new insights on their petrology. A fractional crystallization mechanism for fluorine-bearing granitic magmas can produce melts enriched in albite as well as define the position of the limit of the quartz-feldspar phase and the liquidus surface temperature in the system Qz-Ab-Or- H_2O with addition of F at $P = 1$ kbar. This possibly applies directly to certain granitic massifs with compositions abnormally rich in albite (Cornwall, England; Central Massif, France). Solidus temperatures for boron- or fluorine-bearing systems can be lowered to under $600^{\circ}C$ at $P = 1$ kbar. Under these conditions, muscovite can crystallize directly and separate from the magma at lower pressures (more compatible with the geologic setting) than in systems with only H_2O . The presence of andalusite at magmatic temperatures as well as the crystallization of two alkali feldspars at relatively low pressures are also possibilities. In consideration of the presence of a fluid phase during crys-

tallization, data for the partitioning between fluid and magma are used to discuss the behavior of REE and elements such as Sn and W. Starting with values of K_D (fluid/magma) for B and F and models of fractional crystallization, one can place restrictions on the origin of the volatiles. Natural abundances of B and F indicate that the experimental concentrations used are geologically reasonable. In conclusion, we discuss the mechanism of generation of these evolved granites starting with the following models: 1) differentiation by fractional crystallization, and 2) metasomatic melting. (Abstract translated courtesy R. Bodnar)

PICHAVANT, Michel, RAMBOZ, Claire and WEISBROD, Alain, 1982, Fluid immiscibility in natural processes: use and misuse of fluid inclusion data - I. Phase equilibria analysis - a theoretical and geometrical approach, in R. Kreulen and J. Touret (guest eds.), Current Research on Fluid Inclusions: Chem. Geol., v. 37, p. 1 - 27. First author at Centre de Rech. Pétrograph. et Géochim., 54501 Vandoeuvre-les-Nancy Cedex, France.

Many occurrences of fluid immiscibility in natural geologic systems have been reported recently, most often from fluid inclusion studies. However, the interpretation of fluid inclusion data in terms of immiscibility sometimes suffers from ambiguity of the vocabulary, insufficient knowledge of the immiscibility constraints and insufficient knowledge of the topology (in the TPX space) of natural fluid systems. For such reasons some authors have been misled to erroneous interpretations.

The term "chemical immiscibility" is unambiguously redefined as a multiphase multicomponent equilibrium. The consequences of this definition are directly derived from the phase rule and concern the possible equations that relate the various parameters (temperature, pressure, volumes, compositions) to each other. These equations already put constraints on the topology of the phase equilibria in fluid systems.

A particular expression of the phase rule is proposed, which takes into account the multiphase-constant bulk volume-constant bulk composition constraints in fluid inclusions. The consequences of such an expression are of major importance in fluid inclusion studies.

The phase relations of some simple systems that approximate quite efficiently the natural complex fluids are then detailed: $H_2O-NaCl$, CO_2-CH_4 , H_2O-CO_2 , H_2O-CO_2-NaCl . The effects of these topologies and of the supplementary constraints (constant bulk composition and constant bulk volume) assumed for fluid inclusions (isopleth-isochoric systems) are discussed. (Authors' abstract)

PICKTHORN, W.J., 1982, Stable isotope and fluid inclusion study of the Port Valdez gold district, southern Alaska: MS thesis, Univ. California, Los Angeles, California, 66 pp.

Indexed under Fluid Inclusions. (E.R.)

PIGAGE, L.C., 1982, Linear regression analysis of sillimanite-forming reactions at Azure Lake, British Columbia: Can. Mineral., v. 20, p. 349-378. Author at Cyprus Anvil Mining Corp., 300-355 Burrard St., Vancouver, British Columbia V6C 2G8.

Late replacement of fibrolite by muscovite is proposed as the K^+/H^+ ratio keeps changing in the fluid phase. (E.R.)

PIGFORD, T.H., 1982, Migration of brine inclusions in salt: Nucl. Technology, v. 56, p. 93.

A theoretical discussion indicating that there is a threshold thermal gradient below which no movement can occur, so the problem of migration of fluid inclusions in the thermal gradients around nuclear waste packages

is not as severe as originally thought by some. (E.R.)

PIPEROV, N.B. and PENCHEV, N.P., 1982, Deuterium content of the inclusion water from hydrothermal galenas, Madan, Bulgaria: preliminary investigation: *Econ. Geol.*, v. 77, p. 195-197. Authors at Inst. General & Inorganic Chem., Bulgarian Acad. Sci., 1040 Sofia, Bulgaria.

Water was extracted from large fluid inclusions in galena (Bonev, 1977, *Fluid Inclusion Research--Proc. of COFFI*, v. 10, 1977, p. 30), converted to hydrogen by hot zinc in a novel procedure, and analyzed for δD . A meteoric source seems likely, but deep-seated waters may also be involved. (E.R.)

PIPEROV, N.B., PENCHEV, N.P. and ZIDAROVA, B.P., 1982, Evidence for the chemical nature of fluorite-depositing solutions based on the fluid inclusion studies (Palat, Bulgaria) (abst.): *IAGOD Sixth Symp.*, Tbilisi, USSR, Sept. 6-12, 1982, *Collected Abstracts*, p. 230. First author at Inst. General & Inorganic Chem., Sofia, Bulgaria.

The fluorite mineralization in Palat deposit (Bulgaria) is probably related to a postvolcanic (Pleistocene) hydrothermal activity. The mineral paragenesis, except fluorite, includes also quartz, calcite and some clay minerals. The fluorite crystals contain gas-liquid inclusions with Th in the 150-180°C range.

The decrepitation was studied by decreptobarometry. A Penning-gauge and a fast recorder were used to record the decrepitation of the single inclusions. The volatiles were also released on progressive heating in vacuum (EGA) and they were determined using a Pirani-gauge as a detector of the total pressure (H_2O) and a mass spectrometer for CO_2 . Microcryometry was used to evaluate the salt concentration.

The mineral-forming solutions were found to be of low salinity (<1%), probably of the hydrogencarbonate type, and CO_2 -saturated. (Authors' abstract)

PISUTHA-ARNOND, V., 1982, Thermal history, chemical and isotopic compositions of the ore-forming fluids responsible for the Kuroko massive sulfide deposits in the Hokuroku district of Japan: PhD dissertation, Pennsylvania State Univ., University Park, Pennsylvania, 168 pp.

Indexed under Fluid Inclusions. (E.R.)

PITZER, K.S. and MURDZEK, J.S., 1982, Thermodynamics of aqueous sodium sulfate: *J. Solution Chem.*, v. 11, no. 6, p. 409-413. Authors at Dept. Chem. & Lawrence Berkeley Lab., Univ. California, Berkeley, CA 94720.

The activity coefficient of saturated aqueous Na_2SO_4 is calculated from the properties of the solid and the infinitely dilute solution as well as the solubility. These values are compared with those given by the equation of Rogers and Pitzer which is based on the measured dependence of heat capacity upon molality together with other solution properties at low temperature. Excellent agreement is found from 30 to 280°C. Consequently the equation of Rogers and Pitzer is given an extended range of validity to saturated molality and to 280°C. The trend of solubility with temperature is discussed in relation to the ΔC_p of solution. (Authors' abstract)

PLANETARY SCIENCES UNIT, UNIVERSITY OF CAMBRIDGE, 1982, Mantle methane - fool's gold?: *Nature*, v. 300, p. 312-313.

A review, the title to which is a play on words, referring to T. Gold's controversial hypothesis that methane is outgassing from the mantle in large amounts. The review cites much evidence against the hypothesis. (E.R.)

PLUMMER, L.N. and BUSENBERG, Eurybiades, 1982, The solubilities of calcite, aragonite and vaterite in CO₂-H₂O solutions between 0 and 90°C, and an evaluation of the aqueous model for the system CaCO₃-CO₂-H₂O: *Geochimica Cosmo. Acta*, v. 46, p. 1011-1040.

POKROVSKAYA, I.V., 1982, Mineralogy and formation conditions of polymetal deposits - Rudnyi Altay: Kazakh Branch of "Nauka" Publ. House, Alma-Ata, 128 pp. plus 23 photo plates, 1000 copies printed, price 2 rubls. 40 kopecks (in Russian).

The book contains reference Th and Td for the deposits: Strezhan, Tishin and Ridder-Sokol'noe, on p. 94-97. (A.K.)

POKROVSKII, V.A., 1982, Experimental investigation of the equilibrium of 1.5 albite - 0.5 KCl - HCl - 0.5 muscovite - 3 quartz - 1.5 NaCl at 300-500°C and under pressure of 1 kbar: *Dokl. Akad. Nauk SSSR*, v. 262, no. 2, p. 438-441 (in Russian).

POLAND, E.L., 1982, Stretching of fluid inclusions in fluorite at confining pressures up to 1 kilobar: Master's thesis, Univ. of California, Berkeley, 76 pp.

Stretching of inclusions in fluorite was investigated experimentally, and yielded an equation for Ps, the threshold internal pressure (in bars) above which stretching will take place in inclusions larger than a given volume: $Ps = -178.0 \log V + 0.7 P_{ex} + 1018.9$, where V = volume in cubic micrometers and P_{ex} = external pressure. Two apparently distinct types of inclusion wall failure have been observed, first stretching, believed to be a plastic failure, in a few cases followed by "superstretching," which is almost certainly a brittle failure. Finally, the fluid inclusions represent a new approach to determination of the strength of fluorite. The results of this study may ultimately contribute to the understanding of the relationship between elastic parameters, mechanisms of failure, and internal stresses necessary to initiate various levels of deformation in fluorite and other crystals. (Modified from the author's conclusions)

POLIAK, B.G., PRASOLOV, E.M. and CERMAK, V., 1982, Mantle helium in "juvenile" fluid and the nature of the geothermal anomaly of Krasne Hory (Czechoslovakia): *Dokl. Akad. Nauk SSSR*, v. 263, no. 3, p. 701-705 (in Russian).

(See also Polak, B.G., Kononov, V.I., Tolstikhin, I.M. and Khabarin, L.V., 1975, The helium isotopes in thermal fluids, in *Proc. Int. Assoc. Hydrol. Sci., Symp.*, 1975, Grenoble.) (E.R.)

POLYKOVSKY, V.S., 1982, Thermobarogeochemical properties of fluorite deposit formation in the Tien Shan (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 230-231. Author at "Tashkentgeologia," Tashkent, USSR.

Fluorite mineralization was classified into pegmatite, skarn, pneumatolite-hydrothermal and hydrothermal genetic types. That in pegmatites occurred at the highest temperatures, with a wide Th range from 380 to 120°C, and at pressures 350-150 atm. A Th range of 330-90°C and pressure 500-400 atm. are typical of the fluorite-bearing rare-metallic greisens. Fluorite manifestations in contact-metasomatic and skarn deposits are characterized by Th 300-130°C and pressures 350-200 atm. Hydrothermal fluorite deposits were formed at temperatures ranging from 300 to 85°C and pressures from 500 to 90 atm. Temperatures from 280 to 150°C and pressures from 300 to 120 atm. are the most favorable for fluorite deposit

formation. Low-temperature hydrothermal fluorite deposits of Middle Asia with Th from 220 to 80° and pressures from 250 to 60 atm. are of particular interest as sources of fluor spar ores relatively free of trace elements.

Salt concentration is 3.00 mg/100 g of sample; Na and Cl are the most abundant.

Investigations of gas composition of the solutions from fluorite deposits showed, for early quartz (Th 280-200°C) $H_2 > N_2 > CO_2$; fluorite and barite (Th 230-100°C) $N_2 >> H_2$ and CO_2 ; late fluorite (Th 110-90°C) $H_2 > CO_2 > N_2$. (From the author's abstract)

POMĂRLEANU, Vasile and POMĂRLEANU, E.-A., 1982, Fluid inclusions in calcite of some ore deposits in Roumania, in R. Kreulen and J. Touret (guest eds.), Current Research on Fluid Inclusions: Chem. Geol., v. 37, p. 165-172. Authors at Inst. Geol. & Geoph., Lab. Geochem., Iassy and Res. Inst. of Anorganic Industry & Nefarious Metals, Bucharest, Roumania.

Calcites from hydrothermal, porphyry copper and skarn ore deposits from Roumania contain two-phase fluid inclusions (liquid + vapor) with a vapor phase of 2-90% of the inclusion volume. Calcite from pyroxene hornfels, associated with phlogopite, pyrrhotite, diopside and other minerals, contains inclusions with aqueous solution + vapor + halite.

Th of fluid inclusions in calcites from the first three groups of ore deposits lie in the range from 60° to 480°C and the salinities vary from 5 to 23 wt.% NaCl. In calcite from pyroxene hornfels, Th vary from 290° to 340°C and salinities range from 30 to 33 wt.% NaCl.

The relationship between the crystal habit of calcite and Th shows the possibility of using fluid inclusions in the study of crystallogenesis. (Authors' abstract)

PONOMAREVA, N.I., 1980, Comparison of the composition of gas-liquid inclusions in quartz of pegmatites of northern Karelia: Geol. Rudnykh Mestor., v. 22, no. 2, p. 18-26 (in Russian; translated in Int'l. Geol. Review, v. 24, no. 1, p. 135-142, 1982).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 194, 1980. (E.R.)

POPIELAK, R.S., BLACK, S.R., OLSEN, R.L. and ELLINGSON, C.T., 1982, Investigation of pressurized brine pockets, WIPP site, Carlsbad, New Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 591.

POPIVNYAK, I.V., MYAZ, N.I., SIMKIV, Zh.A., KONDRAKHIN, S.I., DEMIN, B.G., LEVITSKY, V.V. and KLUFAS, M.O., 1982, Some uses of thermobarogeochemistry in the evaluation and exploration of kimberlite bodies (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 212-213. First author at L'vov State Univ., L'vov, USSR.

There are two trends in the study of kimberlites using the methods of thermobarogeochemistry: (1) investigation of the mantle mineralizing media in the inclusions and (2) detection of the heating aureoles in the host rocks of the kimberlite bodies.

A great variety of melt inclusions have been found in the colored garnets and olivines of deep-seated xenoliths and xenocrysts from Yakutian kimberlite pipes. They contain sparingly soluble (glass, silicates), and readily soluble components (various salts) and volatiles. The investigation data on the inclusions, their phase composition, aggregate state and filling temperature evidence a complex polygenic nature of the kimberlite bodies. Repeatedly alternating phenomena which induced creation of microfissures in early minerals and melting in intergranular spaces occurred during a single stage in the kimberlite magma moving from the lower to

the upper levels of the Earth.

The method of multiple water extraction has been used to find the chemical composition of readily soluble components of the melt inclusions in the red garnet. The following ionic composition was observed (in %-equiv.): Li^+ -0.2; Na^+ 16.8; K^+ 5.3; Ca^{2+} 3.3; Mg^{2+} 72.5; Sr^{2+} 0.2; Ba^{2+} 0.9; $\text{Fe}(\text{tot.})$ 0.8; HCO_2^- 87.8; Cl^- 4.0; SO_4^{2-} 1.0; HSiO_3^- 7.2.

Chromatography was used to estimate the chemical composition of the volatiles from the orange and red garnets and the olive-green olivine. The obtained compositions agree with the earlier published results of gas extractions from the violet pyrope, and with the mass-spectrometrically established composition of gaseous traces in diamonds. The close relations of C:N:O:H speak for a similarity of the fluid regime of crystallization of some pyropes, olivine and diamond. A whole gamut of hydrocarbons (HC) has been observed in the studied minerals in addition to N_2 , H_2 , O_2 , CO_2 , CH_4 , N_2 , which is highly prevalent among the volatiles, is supposed to be a catalyst, while HC the carbon source. The relations of C:N:O:H, the most important volatile elements, are proposed as a criterion to be used in exploration and evaluation of kimberlite bodies. The method of sectional decrepitation across contact strike used in the study of the host rocks of kimberlite bodies has revealed the "heating" zone. The decrepitation activity of the host rocks first increases away from the kimberlite pipes, then decreases varying from 200 to 4000 impulses. It drops noticeably and varies close around the background value (200 imp.) beyond a distance equal to the pipe diameter. Owing to the observed regularity, the proposed method can be applied in the exploration of kimberlite bodies. (From the authors' abstract)

POPIVNYAK, I.V. and SIMKIV, Zh.A., 1981, Soluble components of mantle-derived mineral-forming media: Dokl. Akad. Nauk SSSR, v. 256, no. 4, p. 966-969 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 256, p. 181-184, 1982).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 163-164. (E.R.)

POPOV, V.S., 1982, Liquation in magmas - illusion and reality (review of the foreign literature): Zapiski Vses. Min. Obshch., v. 111, no. 5, p. 614-621 (in Russian). Author at Inst. Min., Geochem. and Crystallochem. of Rare Elements (IMGRE), Moscow, USSR.

Analysis of the present foreign literature shows that extensive occurrence of textures of emulsion habit stimulates the enthusiasm of scientists intending the foundation of ideas about immiscibility in silicate magmas as important petrogenetic process. However, data of experimental and theoretical petrology make the limits for undoubted phenomena of immiscibility in iron-rich melts, and even in such melts immiscibility develops only in microscale. Macrot textures "liquid in liquid" and coeval formation of large volumes of magmas of various composition may be explained by a more probable mechanism proposed by an alternative hypothesis, which suggests the contemporaneous intrusion of magmas connected with different magmatic chambers, and the coexistence of two liquid phases during some time is explained by the slow mixing and dissolving. (Author's conclusions translated by A.K.)

POPOV, V.V., 1982, Geological conditions of formation of stratiform zinc-lead and pyrite deposits: Sovetskaya Geologiya, no. 8, p. 21-36 (in Russian).

The reported T of formation of metasomatic ore parageneses are in ranges 100-140°C, sometimes more. (A.K.)

PORTER, E.W. and RIPLEY, E.M., 1982, Golden Sunlight Au-Ag deposit, Montana: origin of mineralizing fluids (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 591.

PORTNOV, A.M., 1982, Self-oxidation of mantle fluid and the genesis of diamond of kimberlites: Dokl. Akad. Nauk SSSR, v. 267, no. 2, p. 942-945 (in Russian).

POWELL, R., 1982, Fluids and melting under upper amphibolite facies conditions (abst.): Geol. Soc. Newsletter (London), v. 11, no. 4, p. 17. Author at Univ. Leeds.

The formation of migmatites by partial melting is discussed in terms of internal buffering paths on temperature - $a(\text{H}_2\text{O})$ diagrams. Internal buffering along melting reactions causes lowering of $a(\text{H}_2\text{O})$ because of the considerable solubility of H_2O in silicate melts. There is a temperature interval between the temperature at which the time path of a rock intersects the solidus and the temperature at which substantial melting first occurs (where a dehydration reaction runs into the solidus). Over this temperature interval, $a\text{H}_2\text{O}$ can be lowered substantially with little melt produced prior to more substantial melting and the production of obvious migmatites. Neosome/melanosome-palaeosome relations in migmatites are accounted for by melt segregation combined with H_2O -diffusion (driven by $a(\text{H}_2\text{O})$ gradients set up by localized partial melting). These ideas are illustrated using a model pelitic system and literature studies of upper amphibolite facies pelitic rocks. (Author's abstract)

PRASOLOV, E.M., VERKHOVSKIY, A.B. and POLYAK, B.G., 1982, Atmospheric noble gases of the present-day active hydrotherms (theoretical calculations and experimental data): Geokhimiya, no. 12, p. 1691-1704 (in Russian; English abstract). First author at All-Union Petro. Sci.-Res. Geol.-Prosp. Inst., Leningrad, USSR.

Pertinent to studies of G in fluid inclusions. (A.K.)

PREECE, R.K., III and BEANE, R.E., 1982, Contrasting evolutions of hydrothermal alteration in quartz monzonite and quartz diorite wall rocks at the Sierrita porphyry copper deposit, Arizona: Econ. Geol., v. 77, p. 1621-1641. First author at Geol. Dept., Phelps Dodge Corp., Morenci, AZ 85540.

Two wall-rock types of contrasting chemical composition host the causative Ruby Star quartz monzonite porphyry intrusion and hypogene mineralization at the Sierrita porphyry copper deposit. Vein-related hydrothermal alteration in the Harris Ranch quartz monzonite and biotite quartz diorite wall rocks consists of several mineralogically discrete assemblages. Temporal evolution of different alteration assemblages was established, in part, using petrographic relations within, and crosscutting relations among, individual veins. Temperature and salinity characteristics of hydrothermal fluids responsible for filling of individual veins were determined using primary fluid inclusions in vein-filling quartz. Each generation of primary vein filling introduced characteristic secondary fluid inclusions into earlier developed veins as well. Histograms of homogenization temperatures of primary and secondary fluid inclusions from different veins, and accompanying salinity data, permitted temporal correlations to be drawn between veins which either did not exhibit crosscutting relations in individual samples or which formed in different wall rocks and thus exhibited different alteration mineralogies.

Evolution of hydrothermal activity in the area sampled commenced with

potassic alteration in both quartz monzonite and quartz diorite wall rocks from 10 to 12 molal (37-41 wt %) NaCl equivalent fluids, inclusions of which homogenize by halite dissolution in the approximate temperature range 300° to 370°C. Salinities of later fluids were in the range 2 to 3 molal (10-15 wt %) NaCl equivalent with only minor salinity variations for the remaining time span monitored by this study. Homogenization temperatures of primary fluid inclusions in veins formed from these lower salinity fluids began near 400°C and increased initially to approximately 430°C where boiling occurred. The pressure defined by boiling of these fluids is about 330 bars. A continuous decrease in fluid inclusion homogenization temperatures followed down to about 300°C, during which time deposition of quartz and K-feldspar with accessory biotite and/or hematite occurred in new and reopened veins in the quartz monzonite wall rock. Simultaneously in the quartz diorite, a sequence of veins and adjacent alteration halos formed, each consisting of an early assemblage of potassic affinity (quartz + biotite + K-feldspar + albite) which evolved to a propylitic assemblage (quartz + epidote + chlorite) as vein filling proceeded. With continued cooling of the solution below about 300°C, muscovite took the place of K-feldspar as the stable potassium-bearing mineral in the quartz monzonite. An analogue to this late-stage quartz + muscovite veining in the quartz monzonite could not be established in the quartz diorite but may consist of zeolite (stilbite) + anhydrite.

The bulk of hypogene copper mineralization in both wall-rock types was associated with approximately 2 molal (10 wt %) NaCl equivalent solutions. In the quartz diorite, significant chalcopyrite deposition is associated with fluid inclusions homogenizing from 370° down to about 320°C and always occurs with the later stage propylitic minerals in each vein. In the quartz monzonite wall rock, chalcopyrite was deposited during the transition from potassic and into phyllic alteration. Fluid inclusion homogenization temperatures for this mineralization range from about 330° down to 200°C. No primary chalcopyrite was seen to occur with earlier potassic veining formed from either high- or low-salinity fluids in the quartz monzonite. A very late stage of deposition of chalcopyrite, pyrite, and minor bornite filled the center of late phyllic veins in the quartz monzonite; correlated fluid inclusions have salinities from 1 to 5 molal (5-23 wt %) NaCl equivalent and homogenization temperatures in the range of 140° to 160°C. The different alteration and sulfide mineral assemblages interpreted to have formed simultaneously in the two wall rocks of contrasting chemical character can be reasonably assigned to different chemical interactions of each rock type with similar, or equivalent, hydrothermal fluids. (Authors' abstract)

PRICE, L.C., 1982^a Organic geochemistry of core samples from an ultra-deep hot well (300°C, 7 km): Chem. Geol., v. 37, p. 215-228.

PRICE, L.C., 1982^b, [Importance of high-temperature solubility of crude oil in methane to petroleum generation and maturation](abst.): Geol. Survey Research 1981, U.S. Geol. Sur. Prof. Paper 1275, p. 40.

See 1982a and b items above. (E.R.)

PRICE, R.C., SNEERINGER, M.R. and FREY, F.A., 1982, Geochemistry of basalts from the West Indian triple junction (25°S, 70°E) (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 473. First author at La Trobe Univ., Bundoora, Victoria 3083, Australia.

The boundaries of three major plates (Africa, India and Antarctica) meet in a triple junction near 25°S, 70°E in the Indian Ocean. Fresh basalts from the vicinity of this triple junction have major and trace

element abundances of "normal" MORBs; e.g., K (762-925 ppm), Rb (1.07-1.30 ppm), Cs (0.015-0.22 ppm), Ba (13-15 ppm) and LREE/HREE abundance ratios less than chondritic ratios. Plume-type basalts which are common in the vicinity of the South Atlantic triple junction (near Bouvet Island) have not been dredged from the West Indian Ocean triple junction which lacks a bathymetric high. However, basalts from the West Indian Ocean triple junction have $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (0.70317-0.70329) higher than "normal" MORBs and this feature is also characteristic of basalts from the Central Indian Ridge (Hedge et al., 1979).

The principal phenocryst phases in these glassy basalts are plagioclase and olivine and many of the plagioclase phenocrysts show resorption and reverse zoning. Glass inclusions within reverse-zoned plagioclase phenocrysts vary systematically in composition from core to rim of the host and glass inclusion compositions correlate with host plagioclase compositions. Glass inclusions in the rims of reverse zoned plagioclase phenocrysts have higher Mg numbers (0.66) than inclusions in the cores (Mg number = 0.55) and this suggests that disequilibrium features such as reverse zoning are a consequence of mixing between a relatively fractionated magma (Mg number <0.55) and a less evolved magma (Mg number >0.66). (Authors abstract)

PUGIN, V.A. and KHITAROV, N.I., 1982, Geochemistry of several elements during liquation in basaltic magmas: *Geokhimiya*, no. 1, p. 35-46 (in Russian). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The paper describes partitioning of Co, Ni, V, Cr, Cu, Sr and Ba between varioles and matrix in variolites; pertinent to melt immiscibility in inclusions. (A.K.)

PURTOV, V.K. and YATLUK, G.M., 1982a, Behavior of silica during action of HCl and NaCl solutions with rocks and rock-forming minerals at temperature 600-800°C and pressure 1000 kg/cm³ (101.9 MPa): *Akad. Nauk SSSR Doklady*, v. 263, no. 2, p. 448-450 (in Russian). Authors at Inst. Geol. Geochem. of Ural Sci. Center of Acad. Sci. USSR, Sverdlovsk.

The investigations were made with HCl solutions of pH 1 to 6 and NaCl solutions of concentration 0.01-5 n and substances: liparite, basalt, hornblende, biotite, gabbro-norite and dunite. SiO₂ concentration in solutions after runs was in ranges 0.3-3 g/l. (A.K.)

PURTOV, V.K. and YATLUK, G.M., 1982b, Mobilization of iron and magnesium from rocks and rock-forming minerals by solutions HCl and NaCl at temperature 600°C and pressure 1000 kg/cm² (101.9 MPa): *Akad. Nauk SSSR Doklady*, v. 262, no. 5, p. 1242-1245 (in Russian). Authors at Inst. Geol. Geochem. of the Ural Sci. Center of Acad. Sci. USSR, Sverdlovsk.

The experiments were made with gabbro-norite, dunite, basalt, liparite, hornblende and biotite. (A.K.)

PUZANOV, L.S., 1982a, Origin of magnetite ores of the Korshunovskoe deposit (data of studies of inclusions of mineral-forming media): *Akad. Nauk SSSR Doklady*, v. 266, no. 1, p. 209-211 (in Russian). Author at All-Union Sci.-Res. Inst. of Mineral Raw Materials, Moscow, USSR.

The deposit Korshunovskoe belongs to the Angara-Ilim region. Pyroxene-magnetite and carbonate-magnetite ores were studied. Diopside bears four types of inclusions: I. P melt-pneumatolytic (G 50-70 vol.%); II. P inclusions of melt-intrusive stage (glass, xls+G, polyphase); III. S pneumatolytic (G, G>>L); IV. S hydrothermal (L>G, L). They were obtained for polyphase type II inclusions containing solids (65-80 vol.%), L (5-20 vol.%)

and G (10-20 vol.%). Five measurements gave 900°C. Td measurements were as follows: 800°C (six), 850°C (seven) and 880°C (nine). Also Th in ranges 760-840°C (twenty-six) were obtained. For inclusions with solids occupying 30-55 vol.%, Th 600-630°C. Pneumatolytic and hydrothermal inclusions yield Th 480-100°C. For the other Siberian deposits Th of inclusions in fassaite, diopside and spinel are 500-900°C, and in garnet, amphibole and scapolite 550-740°C. (Abstract by A.K.)

PUZANOV, L.S., 1982, On the polygenic nature of the fluorspar mineralization (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 231-233. Author at All-Union Research Inst. of Min. Resources, Moscow, USSR.

In central Aldan and Buryatia, P inclusions in fluorite and quartz have Th 650-870°C; later crystallization at 450-520°C from brines. [The compositions appear to be various ratios of salts, silicates, and volatiles - E.R.] Hydrothermal [later?] mineralization occurred at 350-100°C. (From the author's abstract)

PUZANOV, L.S., 1982, Origin of the apatite deposit Seligdar (Central Aldan), in N.P. Ermakov, ed., Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 108-111 (in Russian).

For abstract, see entry Puzanov and Partsevskiy in Fluid Inclusion Research--Proceedings of COFFI, vol. 11, 1978, p. 173; abstract of this paper was not published in the Abstract Volumes of the Vladivostok Symposium. (A.K.)

RAFALSKY, R.P., 1982, Solubility of sulfides of zinc, lead, and silver in hydrothermal solutions: Geokhimiya, no. 12, p. 1780-1797.

RAFAL'SKIY, R.P. and MASALOVICH, A.P., 1981, Determination of the instability constants of lead chloride complexes at elevated temperatures: Geokhimiya, no. 12, p. 1868-1885 (in Russian; translated in Geochem. Int'l., v. 18, no. 6, p. 158-174, 1982).

RAKCHEEV, A.D., 1982, Thermoelectroosmotic filtration of ascending metamorphosing fluids and solutions in the Earth's crust: Akad. Nauk SSSR, Dokl., v. 265, no. 2, p. 450-453 (in Russian).

RAKHMANOV, A.M., 1982, Evolution of state and composition of mineralizing solutions in the course of skarn rare-metal deposit formation in central Tajikistan (abst): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 250-251. Author at Tajik State Univ., Dushanbe, USSR.

Skarn-rare-metal deposits are widespread over the territory of Central Tajikistan. The great majority of the deposits occur at contact of the Upper Paleozoic moderately acidic granites with the Silurian, Devonian and Carboniferous carbonate complexes. According to the nature of ore mineralization the deposits can be classified into skarn-scheelite-cassiteritic (Maikhura), skarn-scheelitic (Kanjaz, Sarymat) and skarn-cassiterite-stannitic (Mushiston), etc. The ore-forming stages are realized here as a successive development of skarn, quartz-rare-metal, quartz-sulphide and quartz-carbonatic mineralization stages.

Homogenization and additional decrepitation of fluid inclusions on the deposits under study have provided estimation of the mineralization temperature ranges. They are: 660-150°C for Maikhura; 620-160°C for

Kanjaz; 660-160°C for Sarymat; 640-160°C for Mushistan; 620-170°C for Takfon; 660-180°C for Jilau. The most typical ranges of 660-390°C were found for the skarn stages; 480-220°C for the quartz-rare-metallic; 420-160°C for the quartz-sulphide; and 200-160°C for the quartz-carbonatic ones.

Pressures in the mineral-forming medium were calculated (using inclusions with carbon dioxide) to be 750-650 atm. in most cases.

Water leachates showed Na, K, Ca, HCO₃, F and Cl, plus minor Mg and Al. Later fluids were higher in F. Gas chromatography showed CO₂, CH₄, N₂, H₂ and O₂. (From the author's abstract)

RAMASAMY, R., 1982, Fluid inclusion geochemistry for rapid methods of mineral prospecting (abst.): [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies, 22-23 March, 1982, Indian Inst. Tech., Bombay, p. 40-41 (unpaginated). Author at Tamilnadu State Geol. Br., Madras-32.

The major Karur (N 10°57' - E 78°05') Gem tract of Tamilnadu is spread over 50 km to the north and south of Cauvery river and extending about 100 km length along the river. Ruby (pigeon blood), sapphire, magnesian spinel, cordierite, bronzite and garnet occur in anorthosites and ultrabasics while emerald, aquamarine, beryl, topaz, moonstone and piezoelectric quartz occur in granites and pegmatites. Sporadic occurrences of gem pockets are seen in many places and abandoned old workings are numerous. Fluid inclusion studies can be applied in order to develop mines in the most promising areas and to trace out migration of gem-forming fluids towards nests of mineralization. For prospecting of gem minerals the following procedure is outlined: (i) detailed geological mapping of the area, (ii) collection of pegmatite samples, (iii) crushing of pegmatites and hand sorting of quartz minerals, (iv) examination of quartz grains for fluid inclusions, (v) selection of pegmatites having fluid inclusions in quartz and regular sampling along their trends, (vi) petrographic observations under heating and freezing stages by using doubly polished thin sections, (vii) determination of loss on ignition of 2 gms of finely ground quartz, (viii) 2 gms of 60-80 mesh quartz may be subjected to decrepitation, (ix) 1 gm of 60-80 mesh quartz may be analyzed by gas chromatography, (x) 100 gms of 60-80 mesh quartz may be subjected to water and then weak acid leaching processes. Extracts may be made up to 100 ml and the soluble contents may be estimated by using the methods of routine water analysis, (xi) analytical data may be interpreted by using thermodynamic constants, geothermobarometers, chemical variation and model diagrams. The same procedure may be followed for the exploration of blind ore bodies of gold, polymetallic sulphides, micas and barites in Tamilnadu and elsewhere. Specific decrease in the ratios of H₂O/CO₂, SiO₂/CO₂, SiO₂/total volatiles in quartz serve as good indicators for the location of gem pockets, gold, piezoelectric quartz and contact metasomatic deposits. Increasing ratios of Cl/OH, K₂O/Na₂O and HF/HCl in quartz are indicative of apatite, fluorite, muscovite, beryl, topaz, Mo-W mineral deposits. Increasing tendencies of decrepitation activity, temperature of maximum decrepitation, Th, abundance of dms, increasing of salinity of fluid phases and pressure of fluids are marked features of the fluid inclusions found in quartz towards the approach of ore deposits. Geochemistry of ore-forming fluids is described in detail. (Author's abstract)

RAMBALDI, E.R. and WASSON, J.T., 1982, Fine, nickel-poor Fe-Ni grains in the olivine of unequilibrated ordinary chondrites: *Geochimica Cosmo. Acta*, v. 46, p. 929-939. Authors at Inst. Geoph. & Planetary Physics,

Univ. California, Los Angeles, CA 90024, USA.

Fine ($\leq 2 \mu\text{m}$), Ni-poor ($\leq 10 \text{ mg/g}$) Fe-Ni grains are common inclusions in the olivine in porphyritic chondrules in unequilibrated ordinary chondrites. The olivine grains appear to be relicts that survived chondrule formation without melting. The most common occurrence of this "dusty" metal is in the core of olivine grains having clear Fe-poor rims and surrounded either by small euhedral clear olivine grains zoned with FeO increasing toward the border of the grains or by large elongated Fe-poor orthopyroxenes oriented parallel to the chondrule surface and enclosing small round olivine grains. Various amounts of Ca, Al-rich glass are always present. The dusty metal is occasionally found in the rims of olivine grains either isolated in the matrix or included in chondrules. A rare occurrence is as bands in highly deformed olivines.

This dusty metal appears to be the product of in situ reduction of FeO from the host olivine. Among the possible reductants H_2 or carbonaceous matter $(\text{CH}_2)_n$ seem the most likely. Hydrogen may have been implanted by solar-wind or solar-flare irradiation, but this requires that dissipation of nebular gas occurred before the end of the chondrule formation process. Carbonaceous matter may have been implanted by shock. Less likely reductants are nebular CO or C dissolved in the olivine lattice. The large relict olivine grains may be nebular condensates or, more likely, fragments broken off earlier generations of chondrules. (Authors' abstract)

RAMBOZ, Claire, PICHAVANT, Michel and WEISBROD, Alain, 1982, Fluid immiscibility in natural processes: use and misuse of fluid inclusion data - II. Interpretation of fluid inclusion data in terms of immiscibility, in R. Kreulen and J. Touret (guest eds.), Current Research on Fluid Inclusions: Chem. Geol., v. 37, p. 29-48.

Phase equilibrium analysis of the relevant systems together with the application of the principles of chemical equilibrium put severe constraints on the interpretation of fluid inclusion data in terms of immiscibility. [See Pichavant et al., 1982, this volume.]

Following from that point, the major limits on the accuracy, and even the validity, of fluid inclusion quantitative data and their interpretation in terms of fluid composition and density are briefly discussed.

The practical implications of the general constraints (temperature, pressure, topology of the fluid systems) are envisaged. Emphasis is laid on some important consequences such as: the use of isochore intercepts (and the possible resulting interpretation of fluid mixing rather than unmixing), the case of highly saline inclusions, the identification and interpretation of heterogeneous trapping.

The composition and density constraints on coexisting fluids are presented, and illustrated by natural examples.

Taking into account all the measurable parameters in fluid inclusions (volume, temperature and nature of phase transitions, more or less complete individual spectroscopic analyses), all the available experimental data, and all the theoretical constraints, may be long and difficult. However, it is most generally very informative and productive although part of these data is often sufficient to deny unmixing. Nevertheless, a final example on metamorphic fluids demonstrates how such an approach can "prove," and also characterize a fluid unmixing during a geologic process. (Authors' abstract)

RAMSAY, J.G., 1980, The crack-seal mechanism of rock deformation: Nature, v. 284, p. 135-139. Author at Geologisches Inst.,-ETH, Zentrum, CH 8092 Zurich, Switzerland.

Many naturally deformed crustal rocks contain mineral-filled extension veins. The crystals making up the vein filling often show a fibrous habit and seem to be built up by a succession of "crack-seal" increments: the elastically deforming rock fails by fracture, and the walls of the open micro-crack are sealed together by crystalline material derived by pressure solution in the rock matrix. (Author's abstract)

Bands of inclusions parallel with the crack mark previous openings. (E.R.)

RANAWAT, P.S., 1982, Environment of fluorspar mineralization in Rajasthan - as indicated by fluid inclusion studies (abst.): [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies, 22-23 March 1982, Indian Inst. Tech., Bombay, p. 33-34 (unpaginated). Author at Dept. Geol., Univ. Rajasthan, Udaipur, India.

Fluorspar mineralization in Rajasthan occurs at five localities, viz. Mando-ki-Pal (Dungarpur Dist., South Rajasthan), Jhalara (Udaipur Dist., South Rajasthan), Asind (Bhilwara Dist., Central Rajasthan), Chowkri-Chhapoli (Sikar-Jhunjhunu Dist., North Rajasthan), and Karara (Jhalore Dist., South West Rajasthan). Of these, the first four are located along a nearly NNE-SSW axis running across the state. Based on fluid inclusion studies, it is concluded that these deposits formed independently under varied physico-chemical environment of mineralization, and that they are not located along a major lineament having common source, as one would be inclined to believe because of their single linear trend (cf. Van Alstine, 1976).

At Mando-ki-Pal two-phase fluid inclusions with high degree of fill are found in fluorites and associated minerals occurring in cataclastic and granitic gneiss host rocks. The stratabound fluorspar veins in quartzite (Nawagaon) have inclusions of liquid CO₂ occasionally with halite daughter mineral. Liquid CO₂ has not been found in fluid inclusions in fluorite from Jhalara area. They are biphasic inclusions with small vapor bubble. At Asind, the fluorite contains multiphase fluid inclusions with more than one daughter mineral. Dissolved CO₂ in the aqueous phase is suspected at Jhalara. At Chowkri-Chhapoli, the fluid inclusions are of lower degree of fill and have a halite daughter mineral. The associated first generation quartz has inclusions with halite daughter mineral while the inclusions in younger quartz contain a fibrous anisotropic daughter mineral.

Thus, a varied chemistry of mineralizing solutions depositing fluorspar in these areas is indicative of different sources and or different phases of fluorite mineralization. (Author's abstract)

RANAWAT, P.S. and DASHORA, R.S., 1982, Fluid inclusion study of the Karara fluorspar deposit, Rajasthan (abst.): [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies 22-23 March 1982, Indian Inst. Tech., Bombay, p. 35 (unpaginated). First author at Dept. Geol., Univ. Rajasthan, Udaipur, India.

The paper deals with petrography and temperature of homogenization of fluid inclusions in fluorite, barite and quartz from Karara area. The fluorspar mineralization occurs in Malani Volcanic (flow and pyroclastic) rocks.

Fluid inclusions in fluorites from different veins and of different paragenesis show two-phase inclusions with a high degree of fill and low salt content. A wide range in temperature of formation of different generations of fluorite is recorded (60°-197.5°C). Quartz (I), which formed earlier than fluorite (I), gave the highest temperature (240°). Barite formed at 160°-210°C is columnar and acicular and low temperature

barite, formed at 50°-90°C, is crystalline. Freezing data indicate that the mineralizing solutions were very low in dissolved salts. (From the authors' abstract)

RANKIN, A.H. and ALDERTON, D.H.M., 1982, Fluid inclusion evidence for the evolution of hydrothermal fluids in SW England (abst.): J. Geol. Soc. London, v. 139, part 1, p. 96.

Quartz from the granites of SW England contain a complex and varied assemblage of fluid inclusions. Several generations, each recording a particular hydrothermal event, are usually present, though it is difficult to establish an unequivocal paragenesis. Vapor-rich inclusions are common and homogenization temperatures range from less than 70°C up to about 600°C with salinities varying from 0 to greater than 50 equiv. wt% NaCl. Periodic boiling and influx of more dilute fluids of meteoric origin are invoked to explain these variations.

Marked differences in the distribution and abundance of different inclusion types occur on a regional scale. In particular, the Dartmoor granite contains a dominance of highly saline fluids characterized by high levels of Na, K, Ca and Fe chlorides (from SEM studies). Minor elements in these fluids (from ICP analysis of decrepitates) include B, S and traces of Sn, Cu, Pb, An and W. These inclusions are believed to represent the earliest fluids evolved from the cooling granite magma. The paucity of low salinity fluids indicate that later influx of meteoric fluids was restricted in this pluton. In other plutons, particularly in those parts where Sn-W-Cu mineralization is intense (e.g. N Carnmenellis), the inclusion population is often characterized by abundant low to moderate salinity fluids (Th ~150-450°C) believed to be dominantly meteoric in origin. The final phase of hydrothermal activity is represented in the granites of SW England by low temperature inclusions (less than about 150°C) which cross-cut all other generations. These fluids are particularly abundant in the kaolinized granites of St. Austell. (Authors' abstract)

RANKIN, A.H., ALDERTON, D.H.M., THOMPSON, M. and GOULTER, J.E., 1982, Determination of uranium: carbon ratios in fluid inclusion decrepitates by inductively coupled plasma emission spectroscopy: Min. Mag., v. 46, p. 179-186. First author at Dept. Geol., Imperial College, London SW7 2BP, England.

Uranium has been detected in fluid inclusion decrepitates from quartz of several granites of the British Isles and from vein quartz associated with the Hercynian granites of SW England using ICP. Material, ejected from the inclusions during decrepitation on heating the sample, is transferred into the plasma for qualitative analysis via a stream of argon. Several other elements have been detected in the decrepitate, of which carbon is of particular interest. It shows a strong positive correlation with U and indicates the importance of C (presumably as carbonate complexes) in the transport of U in hydrothermal systems. Approximate order of magnitude estimates of the average U contents of fluid inclusions from SW England samples, based on the assumption that U in the decrepitates is principally derived from the fluid inclusions, range from less than one to over a thousand ppm. Fluid inclusions may therefore be important in contributing to the levels of U reported in quartz (0.1 to 10 ppm). (Authors' abstract)

RASMUSSEN, D.H., 1982a, Energetics of homogeneous nucleation - approach to a physical spinodal: J. Crys. Growth, v. 56, p. 45-55.

RASMUSSEN, D.H., 1982, Thermodynamics and nucleation phenomena - a set of experimental observations: *J. Cryst. Growth*, v. 56, p. 56-66. Author at Dept. Chem. Engrg., Clarkson College of Tech., Potsdam, NY 13676, USA.

Classical nucleation theory assumes that the nucleus of a phase transformation is of the equilibrium composition and structure and that the undercooling to formation of this nucleus is a kinetically determined quantity. No relationship between the nucleation temperature and the corresponding equilibrium temperature is expected. Nonclassical theories of nucleation, notably the theory of a physical spinodal by the author, predict the nucleus is not necessarily of the equilibrium composition and structure and that there must be a relationship between maximum undercooling of a parent phase and the equilibrium temperature at the corresponding composition. These predictions are compared with experimental results on vapor to liquid condensation, liquid-liquid demixing, and nucleation of crystals from the melt and from solution. The experimental results support the view that a thermodynamic limit to undercooling exists and that nucleation at maximum undercooling in these three transitions corresponds to nucleation near this thermodynamic limit. (Author's abstract)

RASMUSSEN, R.A., KHALIL, M.A.K., DALLUGE, R.W., PENKETT, S.A. and JONES, B., 1982, Carbonyl sulfide and carbon disulfide from the eruptions of Mount St. Helens: *Science*, v. 215, p. 665-667.

Ash from the massive 18 May 1980 eruption of Mount St. Helens readily gave off large amounts of carbonyl sulfide and carbon disulfide gases at room temperature. These findings suggest that the sulfur that enhances the Junge sulfate layer in the stratosphere after volcanic eruptions could be carried directly to the upper atmosphere as carbonyl sulfide and carbon disulfide absorbed on ash particles from major volcanic eruptions. (Authors' abstract)

READ, A.J., 1982, Ionization constants of aqueous ammonia from 25 to 250°C and to 2000 bar: *J. Solution Chem.*, v. 11, no. 9, p. 649-664.

REGISTER, J.K., 1981, Brine pocket occurrences in the Castile formation, southeastern New Mexico, March 1981: U.S. Dept. of Energy, Waste Isolation Pilot Plant Project Ofc., Report TME 3080, 27 pp.

The brine pockets (here renamed "brine reservoirs"), which are, in effect, huge intergranular fluid inclusions in halite beds, are described in detail. Flow rates from them have ranged up to 20,000 barrels/day. One analysis of gases with fluid shows 55 mole % CO₂, 32 H₂S, 5 N₂, 7 CH₄, and lesser amounts of 5 higher hydrocarbons. Four chemical analyses show very high NaCl, but low Ca, Mg and K. SO₄ = ~0.1xCl, and represent redissolved evaporitic rocks, not Permian brines. (E.R.)

REICHMAN, F., 1982, Vertical zoning of fluorite deposits in Czechoslovakia (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 233. Author at Central Geol. Inst., Prague, Czechoslovakia.

Polyascendent lenticular fluorite veins in the Cesky Massif formed at 150-130°C; barite increases upward and quartz downward. (E.R.)

REKHARSKIY, V.I., PASHKOV, Yu.N., KAPSAMUN, V.P., KANTSEL', A.V., BOGUSHEVSKIY, E.M., DIKOV, Yu.P., KUDRIN, A.V., VAR'YASH, L.N., LANGE, Ye.K., DEDY, V.Yu. and GOLOVIN, A.F., 1982, Molybdenum and copper, p. 38-101, in *Geochemistry of ore-formation processes*: "Nauka," Moscow, 272 pp., 900 copies printed, price 3 rubls 50 kopecks (in Russian).

Quartz of the feldspar-quartz hydrothermal-metasomatic formation of the Cu-Mo deposit Kal'makyr bears inclusions of the following types: $\text{LH}_2\text{O} + \text{LCO}_2 + \text{G}$, $\text{LH}_2\text{O} + \text{G} \pm$ trapped feldspars + dm sylvite, Th 290-360°C and 250-280°C, respectively. By G chromatography also H_2 and N_2 were found in inclusions. Quartz of the quartz-sericite formation bears inclusions filled with $\text{LH}_2\text{O} + \text{G} + \text{dms}$ (halite and sylvite), Th 220-280°C, total salt content 400-430 g/l, gases consist of CO_2 and N_2 . (Abstract by A.K.)

REYF, F.G. and BAZHEEV, Ye.D., 1982, Magmatic process and tungsten ore mineralization: Siberian Branch of "Nauka" Publ. House, Novosibirsk, 160 pp., 1000 copies printed, price 1 rubl. 70 kopecks (in Russian). Authors at Geol. Inst. of Buryat Div. of Siberian Branch of Acad. Sci. USSR, Ulan-Ude, USSR.

The authors studied the most important W deposits of Transbaikalia and associated granitoid intrusions by thermobarogeochemical methods. Spokoynoe ore field granite quartz (Spokoynoe massif) yielded Th (°C) of melt inclusions 1020-985 (88, number of determinations), $\text{G} + \text{LH}_2\text{O} + \text{dms} + \text{LCO}_2 > 835$ (55), melt inclusions (late) 1025-875 (21), $\text{G} + \text{LCO}_2 + \text{LH}_2\text{O} \sim 300$ (20); same (Khangilay massif), melt inclusions 950 (24), $\text{G} + \text{LH}_2\text{O} + \text{dms}$ 480 (8), same location, greisen commercial ores $\text{LH}_2\text{O} + \text{LCO}_2 + \text{G}$ 295-315, dissolution of salt dms +6.8 to 10.4°C, P 550-570 atm, quartz-vein commercial ores $\text{LH}_2\text{O} + \text{LCO}_2 + \text{G}$ 300-290, dissolution of salt dms $\sim +10^\circ\text{C}$, P 550-570 atm., post-ore stage, S inclusions G/L 125-270, in all above cases Te -26.5 to -21.8°C. Dzhida ore field, quartz in granitoids of Gudzhir intrusion, melt inclusion in phenocrysts 730-1220, water content in inclusion melt, wt.% 3.6-5.0, melt inclusions in quartz of matrix 800-1000, water content in inclusion melt, wt.% 3.3-6.1, Dzhida Mo-W-rare metal deposit, inclusions in quartz, fluorite, huebnerite, beryl, types dms + L + G, G/L, $\text{G} + \text{LH}_2\text{O} + \text{LCO}_2$, Th 180-310 and more (decrepitation before homogenization), Te -31.6 to -27.1, Tm dms, -7.9 to +8.5, P 310 to 2200 atm. Mariktika ore mineralized point, quartz from granitoids bears melt inclusions that on heating (at $\sim 980^\circ\text{C}$) separate silicate melt and H_2O -salt \pm gas phase condensing on cooling to LH_2O salt melt and G bubble, Th 1050-1120 and in outer zones of quartz crystals from miaroles Th 915-930. Hydrothermal ore parageneses bear salt-dm-rich + $\text{LH}_2\text{O} + \text{G}$ inclusions, Th 490-550, and if ore mineral is present in inclusion, it dissolves at 690-900°C. Soktuy ore junction granitoids also bear inclusions consisting of silicate melt + salt melt, Th 1090-1235, hydrothermal ore parageneses Th 142-683, Te -60.7 to -20.5, P 2200-2900 atm. The book presents discussion of the petrological aspects of the features described for magmatic rocks, including H_2O and salt solubility in silicate melts and inclusion features that may help in prospecting for various types of tungsten mineralization. (Abstract by A.K.)

REYF, F.G. and ISHKOV, Yu.M., 1982, Possibilities of use of the laser microanalyzer for studies of composition of liquid phase of individual inclusions, in Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 14-31 (in Russian).

The Nd-glass laser was used for inclusion opening, working in the regime of free generation; spectra were recorded photographically in the spectrograph PGS-2. Standard solutions were prepared from chemical reagents (3 to 220 g of element per liter), drop of solution was put on the fresh epoxy, mixed with it and this way artificial inclusions were formed and used as standards after epoxy polymerization. Five compounds were tested and accepted for standards: Na_2WO_4 , Na_2MoO_4 , MnSO_4 , $\text{K}_3\text{Fe}(\text{CN})_6$ and H_3BO_3 .

Hence, in L phase in inclusions W, Mo, Fe, Mn and B were determined quantitatively (6 to 185 g/l) and Mg, Ca, Al, Sn, Be, Cu, Ti, Zn qualitatively. (Abstract by A.K.)

RICE, C.M., HARMON, R.S. and SHEPHERD, T.J., 1982, Porphyry molybdenum-style mineralization near Central City, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 598. First author at Univ. Aberdeen, Aberdeen AB9 1AS, Scotland.

A Laramide alkaline intrusive complex (c.63Ma) lies within concentric zones of molybdenite and fluorite mineralization. The intrusive sequence is: small plugs of quartz monzonite and syenite porphyry, early breccia pipe (explosion breccia followed by high Si ash flow tuff), monzodiorite dikes, trachyte dikes, late breccia pipe. The mineralization sequence is: early quartz-pyrite-MoS₂ veins, classic Au-Ag veins (c.59Ma), late fluorite and MoS₂ as veins and as matrix in the late breccia pipe. A Mo-W sediment anomaly extends for 8 km downstream.

Inclusion homogenization temperatures are: early Mo veins, CO₂-rich and rare halite-bearing giving 340-420°C and 240-340°C respectively; Au-Ag veins, aqueous 2-phase giving 220-380°C; late F veins, aqueous 2-phase giving 200-280°C. Salinities (as ≡ wt.% NaCl) are 34-42 for halite-bearing and 2-12 for other types. Trapping pressures of CO₂-rich are 1.3-1.8 kb.

Quartz δ¹⁸O values for early Mo and Au-Ag veins are 10.2-13.1‰ and 8.1-15.9‰ respectively. Quartz fluid inclusion δD values for early Mo and Au-Ag veins are -98 to -51‰ and -90 to -45‰ respectively, whereas δD values for fluorite and quartz fluid inclusions in late F veins are -79 to -57‰. Sericite associated with Au-Ag mineralization has respective ranges in δ¹⁸O and δD of 4.5 to 12.2‰ and -111 to -62‰. Country rock δ¹⁸O values range from 6.0 to 16.0‰.

These data suggest that (1) early Mo mineralization was deposited from magmatic CO₂-rich fluids expelled from a differentiated quartz monzonite stock, (2) Au-Ag mineralization was deposited from mixed magmatic-meteoric fluids marking the collapse of the hydrothermal system as the pluton cooled, (3) F mineralization was deposited from late magmatic fluids and (4) Au-Ag mineralization represents a high structural level in a porphyry Mo-style system that existed for ~4 Ma. (Authors' abstract)

RICH, R.A. and BARABAS, A.H., 1982, Genetic implications of preliminary mineralogical, paragenetic and fluid inclusion data for the Schwartzwalder uranium mine, Colorado, in *Vein-Type and Similar Uranium Deposits in Rocks Younger than Proterozoic*, Panel Proc. Series: Vienna, Int'l. Atomic Energy Agency, IAEA-TC-295/19, p. 181-193. First author at Yankee Atomic Electric Co., Westborough, MA.

Epigenetic uranium mineralization at the Schwartzwalder mine occurs in veins and breccia zones associated with Laramide faulting and fracturing in Precambrian metasedimentary rocks. Vein paragenesis consists of three major stages separated by fracturing events: (1) adularia-pitchblende-jordisite-carbonaceous matter; (2) ankerite-marcasite/pyrite-base metal sulphides; and (3) calcite-pyrite. Adularia and possibly jordisite were in part co-deposited with pitchblende. The precise paragenetic position of the epigenetic carbonaceous matter is unclear, but the occurrence of this material is restricted to stage 1 structures. Haematitic alteration haloes are spatially and probably genetically related to stage 1 structures. Fluid inclusions in stage 2 sphalerite and stage 3 calcite are characterized by low filling temperatures (75-165°C) and low to intermediate salinity (19 to less than 3 equivalent wt.% NaCl) aqueous solutions. Fluid inclusions in stage 1 adularia and stage 2 ankerite, however, exhibit

microthermometry characteristics atypical of aqueous inclusions; crushing-stage work indicates the absence of CO₂ or other gases under pressure in these inclusions. The above observations suggest the following genetic implications: (1) The presence of haematitic alteration haloes about stage 1 structures and the sequence of deposition of vein minerals indicate a trend with time from a relatively oxidizing to a relatively reducing mineralizing fluid and suggest a possible redox mechanism for uranium precipitation; (2) the presence of epigenetic carbonaceous matter in stage 1 structures and fluid inclusion data for minerals deposited before, during and after pitchblende suggest that uranium may have been transported to the site of deposition in a condensed organic or organo-aqueous fluid; (3) the mineralogy, paragenesis and uranium/carbonaceous matter association suggests a striking geochemical similarity between the Schwartzwalder deposit and certain sandstone-type uranium deposits. (Authors' abstract)

ROBINSON, Andrew and SPOONER, E.T.C., 1982, Source of the detrital components of uraniferous conglomerates, Quirke ore zone, Elliot Lake, Ontario, Canada: *Nature*, v. 299, p. 622-624. First author at Billiton Int'l. Metals, BV, 19 Louis Couperusplein, Box 190, The Hague, The Netherlands.

Large volumes of pyritic quartz-pebble conglomerate in the Elliot Lake district of Ontario contain at least 300,000 tonnes U₃O₈ recoverable at a grade of 0.1% (ref. 1), with much greater tonnages available at lower recovery grades. The Quirke zone alone contains in excess of 224,000 tonnes U₃O₈ at ~0.1% (refs 2-4) and is, accordingly, one of the world's largest known uranium deposits. Situated 40 km north of the North Channel of Lake Huron, 400 km north-west of Toronto, ore conglomerates occur in the Matinenda Formation, locally the basal unit of the Huronian Supergroup, and, although their age is not well constrained, they are probably close to 2,350 Myr old. Uraninite, the most important primary ore mineral, occurs as poorly rounded to euhedral grains 0.05-0.2 mm across within the matrix between quartz pebbles. While its chemical and morphological characteristics have led most workers to consider that the uraninite is detrital, there has hitherto been no attempt to characterize its source lithology, a matter of considerable significance as regards mineral exploration. This was the aim of the present study. We have examined the mineral and fluid inclusions observed in the quartz pebbles in the conglomerate and conclude that they are derived from a pegmatitic, potassic (alaskitic) granite. We have also demonstrated that in this source lithology, pebble-sized quartz was spatially associated with radioactive minerals, by inference, uraninite. The postulated characteristics of such a source are remarkably similar in several respects to the uraniferous alaskites of the Rössing deposit in Namibia. (Authors' abstract)

The inclusions are small and generally consist of L+V, ± a prismatic dm. Others contain many solid minerals, and some contain liquid CO₂.(E.R.)

ROBINSON, A.G. and SPOONER, E.T.C., 1982, Petrological evidence for the detrital uraninite in the uraniferous conglomerate ore horizons of the Quirke zone, Elliot Lake, Ontario (abst.): *Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts*, v. 7, p. 76. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario, M5S 1A1, Canada.

The uraninite grains in the Quirke ore zone, Elliot Lake, are thought to be detrital because of shape (sub-angular with crystal faces), a restricted size range (~0.1 mm), chemistry (~6.5% ThO₂, ~2.5% Y₂O₃ and <~0.9% Ce₂O₃) and clear relationships to sedimentary features (e.g. 0.5-1 cm "uraninite sandstone" layers). Detrital minerals which may have been associated with uraninite in the primary source include coarse, smoky quartz (~0.5-6 cm), microcline/orthoclase, magnetite with ilmenite exsolu-

tion lamellae on {111}, monazite and zircon. Plagioclase feldspar is rare. Smoky quartz occurs in minor amounts with milky quartz in barren quartzite between reefs, and vice versa. Hence, the smokiness of the quartz, which is a product of irradiation, is a pre-depositional feature and is consistent with a uraninite/smoky quartz association in the source. Observed mineral inclusions in ore horizon quartz include K-feldspar, zircon, biotite and rutile needles. This suite is similar to the detrital suite, and suggests that the ore horizon quartz is not "vein quartz," but "granitic;" a deduction which is consistent with the occurrence of (?) primary fluid inclusions in ore horizon quartz which are (i) CO₂-rich and (ii) H₂O rich with high salinities (daughter crystals present including halite). Hence, the source is inferred to have been a variably pegmatitic, potassic alkali feldspar granite, or alaskite, containing a significant uraninite concentration. The Rössing U deposit in Namibia/S.W. Africa is a striking analogue in petrology (smoky quartz, microcline, biotite, minor plagioclase and muscovite, zircon, monazite and uraninite), grain size (~0.5-5 cm), uraninite characteristics (e.g. g.s. = ~0.05-0.1 mm; ThO₂ = ~7%), and fluid inclusions. It is also comparable in size and grade (~200 x 10⁶ tons/0.05% U₃O₈) to the Quirke zone (~200 x 10⁶ tons/0.1% U₃O₈, minimum). (Authors' abstract)

ROBINSON, B.W. and FARRAND, M.G., 1982, Sulfur isotopes and the origin of stibnite mineralization in New England, Australia: *Mineral. Deposita*, v. 17, p. 161-174. First author at Geol. Dept., Kuwait Univ., P.O. Box 5969, Kuwait.

Stibnite mineralization in the antimony province of New England can be divided into Central type ores (veins of stibnite + quartz ± berthierite) and Peripheral type ores of stibnite + quartz + native antimony ± berthierite. The 'Central' stibnites have $\delta^{34}\text{S}(\text{CDT})$ values of $-5 \pm 2\%$ (1σ) which may represent equilibrium precipitation from mantle sulfur at about 200°C. 'Peripheral' stibnites have $\delta^{34}\text{S}$ values between 0 and -25%, with a large group at $0 \pm 2\%$. They represent precipitation from a limited supply of mantle sulfur and the acquisition of sedimentary sulfur. We consider that the different ore types were produced from distinct ore solutions derived from two immiscible melts. These originated in the deep mantle, were mobilized by tectonic activity and supplied the antimony and most of the sulfur to the ores. (Authors' abstract)

ROBINSON, M.S., SMITH, T.E., BUNDTZEN, T.K. and METZ, P.A., 1982, Cleary sequence of the Fairbanks mining district; primary stratigraphic control of lode gold/antimony mineralization (abst.): *Geol. Soc. Am. Program with Abstracts*, v. 14, p. 228. First author at Alaska State Div. Geol. & Geophys. Surveys, P.O. Box 80007, College, AK 99708.

Bedrock exposed in the Fairbanks Mining District comprise three poly-metamorphosed stratigraphic packages which appear to be in thrust contact. The lowest sequence, known as the Fairbanks schist, is mainly brown to gray quartzite and muscovite-quartz schist. Mineral assemblages in this 4,000-ft thick unit are indicative of greenschist-facies metamorphism. Above this is the Goldstream sequence, a unit dominated by garnet-muscovite schist, amphibolite, micaceous quartzite and impure marble, mineral assemblages indicate lower amphibolite-facies metamorphism. The Chatanika terrane, in the northern part of the district, is also in thrust contact with the Fairbanks schist. This unit is composed of garnet-clinopyroxene rocks, garnet amphibolite black quartzite and impure marble; mineral assemblages indicate upper amphibolite and possibly eclogite-facies metamorphism. Interstratified near the center of the Fairbanks schist is a 400-ft thick sequence of interlensing felsic schist, laminated white micaceous quartzite,

actinolitic greenschist, graphitic schist, metabasite, metarhyolite, and calcsilicate beds and quartzite and muscovite-quartz schist indistinguishable from the Fairbanks-schist host rocks. This group of rocks, the Cleary sequence, appears to be largely of distal volcanogenic origin and hosts many of the gold and antimony occurrences in the district. The Fairbanks District has produced 7,500,000 oz gold and 4,200,000 lb antimony. Lead isotopes, fluid inclusion data and field evidence suggest that most of the gold and antimony mineralization is the result of remobilization of metals in the Cleary sequence and redeposition of the metals in dilatant zones and fractures associated with structural arching and the emplacement of Mesozoic synkinematic plutons. (Authors' abstract)

ROBINSON, R.W., 1981a, Ore mineralogy and fluid inclusion study of the southern Amethyst vein system, Creede Mining District, Colorado: M.S. thesis, New Mexico Inst. Mining & Technol., Socorro, NM, 85 pp.

See Robinson and Norman, 1981, in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 172-173. (E.R.)

ROBINSON, R., 1981b, Mineralization along the southern Amethyst vein, Creede district, Colorado, in Field Trip Notes; Creede Mining District, San Juan Volcanic Province, Colorado, J.W. Lindemann, J.W. Babcock and J.R. King, eds.: Pub., Denver Reg. Explor. Geol. Soc., p. 43-50. Author at Rocky Mountain Energy, USA.

See Robinson and Norman, 1981, in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 172-173. (E.R.)

ROBUL, V.M., 1982, Typomorphic generations of accessory minerals: Mineralog. Sbornik, v. 36, no. 2, p. 44-48 (in Russian; English abstract). Author at Odessa Univ., Odesa, Ukrainian SSR.

In granitoid massifs of the Ukrainian shield, Kirovograd block, in pegmatites most of zircon, monazite, apatite, cyrtolite, garnet and xenotime has Th about 350°C; pneumatolytic-hydrothermal zircon, apatite, monazite, anatase, cyrtolite, fluorite, topaz, cassiterite, tourmaline and molybdenite(sic, A.K.) - 200-250°C. (Abstract by A.K.)

ROEDDER, E., 1982a, Igneous fluid inclusion geothermometry (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 471. Author at 959 USGS, Reston, VA 22092.

Inclusions (I) of trapped fluids (gas, liquid, or melt) can provide temperature (T) data on the history of many igneous rocks. This paper reviews the types of data available and their major limitations.

T of trapping (Tt) can be obtained from the homogenization T (Th) of silicate melt I with shrinkage vapor bubbles. Melt compressibilities are so low that Tt-Th (i.e. the "pressure correction") is only ~20°C/kb. T of phase changes on cooling, such as precipitation of daughter crystals or saturation with sulfide melt can be obtained from I already having such phases. The phase assemblage can provide constraints on maximum and minimum cooling rates.

T of more compressible fluids (H₂O or CO₂), plus the limited physical strength of the host crystal provide constraints on the P-T history after trapping. If the P-T path for the rock is far below the isochore for the trapped fluid, recognizable natural decrepitation will occur. If an independent geothermometer is available, I of compressible fluids provide a reliable geobarometer (e.g., CO₂ in nodules).

The obvious major limitation on such thermometry needs reiteration: usable I must be present. Many deep-seated rocks have few or none. All

phase equilibria are limited to those phases present, as metastability is common in these small systems. High viscosities and hence sluggish equilibria, plus possible leakage of H₂ during long runs and other experimental problems, make some determinations difficult or impossible. However, carefully selected *I* can provide excellent data. Comparison with other igneous geothermometers is seldom possible, as these several other methods generally measure different events in the history of the rock. (Author's abstract)

ROEDDER, E., 1982a, [Melt inclusions in Murchison chondrite meteorite not solar nebula condensates] (abst.): Geol. Survey Research 1981, U.S. Geol. Sur. Prof. Paper 1275, p. 164.

See Roedder, 1980b, Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 209-210. (E.R.)

ROEDDER, Edwin, 1982c, Fluid-inclusion evidence bearing on the environments of gold deposition (abst.): Abstracts and Information, Gold '82 Symp., 24-28 May, 1982, Zimbabwe: Harare, Zimbabwe, Geol. Soc. Zimbabwe, p. 23. Author at 959 U.S. Geol. Survey, Reston, VA 22092, USA.

The gold in most primary gold deposits in the world was dissolved, transported, and deposited in its present location by hot aqueous solutions under pressure. Any data on the temperature, pressure, density, and composition of these fluids can aid in understanding the processes of formation and hence may help in exploration.

With few possible exceptions, the only samples of these fluids are the fluid inclusions within minerals of the deposits. This paper 1) reviews briefly the general nature of inclusions and the data they can provide; 2) details some caveats particularly applicable to inclusion studies of gold deposits; 3) summarizes the extensive literature on fluid inclusions from gold deposits; and 4) considers briefly the uses of such inclusion data in exploration and mining. Many gold ores have not yet been examined for fluid inclusions, and some of the very fine grained materials may simply not have inclusions of suitable size (i.e. $> \sim 5 \mu\text{m}$). A literature survey of 151 pre-1978 fluid-inclusion studies of the major gold stage in a wide variety of deposits other than porphyry coppers, mainly in the USSR, showed homogenization temperatures ranging generally from 100 to 400°C. In some of these deposits, major gold deposition took place over a wide temperature range, but the average range was only 100 degrees. Inclusions in earlier and later gangue and ore-metal stages typically cover much broader ranges. When given, the salinities were generally < 10 wt% NaCl equivalent. The gold-depositing fluids were frequently rich in CO₂, particularly those from metamorphic and sediment-hosted (Carlin-type) deposits. A second, gas-rich fluid phase (i.e. "boiling") was common in many of the epithermal deposits. Precipitation of only a few parts per billion from the ore-forming fluid may be adequate to form major gold deposits; the specific cause of precipitation is obscure, however, and probably differs from one deposit type to another. (Author's abstract)

ROEDDER, Edwin, 1982d, Application of studies of fluid inclusions in salt samples to the problems of nuclear waste storage: Acta Geol. Polonica, v. 32, no. 1-2, p. 109-133.

The fluids present as fluid inclusions in salt samples from various bedded and domal salt deposits provide a surprising amount of information on the saline environment throughout the geological history of the deposit. Such information is valuable in considerations of the possible future

history of these deposits, should they be used for long-term nuclear waste storage sites. In addition, however, the fluid inclusions (and other varieties of water) present in the salt are of considerable importance to the safe design and operation of such sites, and most analyses of salt for water are erroneously low. Fluid inclusions will generally migrate up the thermal gradients, toward the waste canisters, and contain highly corrosive fluids. (Author's abstract)

This review paper summarizes material from 6 earlier publications. (E.R.)

ROEDDER, Edwin, 1982e, Fluid inclusions in gemstones: valuable defects, in International Gemological Symp. Proc. 1982, D.M. Eash, ed.: Gemological Inst. of Am., p. 479-502. Author at U.S. Geol. Survey, Reston, VA.

Fluid inclusions are small volumes of ancient fluids found within many gems. They occupy various types of defects or imperfections that have formed in the crystal during the otherwise more perfect crystal growth that is the prime characteristic of gems. Inclusions may be trapped during the growth of the host crystal (primary inclusions) or during the healing of fractures in the crystals at some later time (secondary inclusions). Both types of inclusions provide data on the environment of formation and history of gemstones that can be useful to gemology.

This paper summarizes: 1) the formation of fluid inclusions, 2) changes that take place after trapping, 3) types of data that can be obtained from the inclusions, 4) available published data on fluid inclusions in peridot, quartz, topaz, emerald (including some unpublished data), and diamond, and 5) some of the possible uses of such data. (Author's abstract)

ROEDDER, Edwin, 1982f, Fluid inclusion studies, in U.S. Geological Survey Research in Radioactive Waste Disposal--Fiscal Year 1979: U.S. Geol. Survey Circular 847, p. 16-17.

A review of past work on inclusions in salt, mostly referenced in previous COFFI volumes. (E.R.)

ROEDDER, E. and BASSETT, R.L., 1982, [Water content of rock salt] (abst.): Geol. Survey Research 1981, U.S. Geol. Sur. Prof. Paper 1275, p. 234.

See same authors, 1981, Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 175-176, 1981. (E.R.)

ROEDDER, E. and BELKIN, H.E., 1982, [Brine migration in salt in radioactive waste repositories] (abst.): Geol. Survey Research 1981, U.S. Geol. Sur. Prof. Paper 1275, p. 233.

See same authors, 1980a, Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 210 (1980). (E.R.)

ROEDDER, E. and BIGGAR, G.M., 1982, Experimental and analytical problems in the system $K_2O-FeO-Al_2O_3-SiO_2$ (abst.): Geol. Survey Research 1981, U.S. Geol. Surv. Prof. Paper 1275, p. 146.

A series of published and unpublished studies of phase equilibria in the low-temperature immiscible liquid field in the system leucite-fayalite-silica within the general system $K_2O-FeO-Al_2O_3-SiO_2$ has yielded in part discordant data on the composition of the two liquids and on the temperature and extent of the field of immiscibility. From a reexamination of the various studies and some interlaboratory comparisons, the authors concluded that there are four major causes of these discrepancies: (1) severe alkali loss in small-volume samples exposed to the furnace atmosphere, particularly in those starting as gels; (2) state of oxidation and local variations in the total iron content within the sample, due to

several experimental problems; (3) limited ranges of compositions and temperatures of the quench runs used to delineate the field of immiscibility; and (4) difficulty in obtaining accurate, quantitative, electron microprobe analyses of the glasses, particularly for light and (or) volatile elements in the presence of large and grossly variable amounts of iron.

Almost all electron microprobe analyses of pairs of immiscible liquids made from starting compositions in the system leucite-fayalite-silica (that is, with a 1:1 K/Al molar ratio) have ratios less than 1.0 for both melts, and the ratio for the high-iron melt is much lower than that for the conjugate high-silica melt. It is concluded that these differences stem from a combination of three effects: (1) loss of potassium in the experimental work, (2) low-potassium values in the electron microprobe analysis, particularly on the high-iron melts, and (3) real differences in the partitioning of potassium and aluminum between the two liquids. In support of this last effect, analyses of several examples of natural immiscibility, including some made by classical wet chemistry rather than electron microprobe, show considerably lower values for $(K+Na)/(Al)$ in the high-iron parts of the pairs. (From the authors' abstract)

ROEDDER, E. and BODNAR, R.J., 1982, [Errors in geologic pressure determinations from fluid inclusion studies] (abst.): Geol. Survey Research 1981, U.S. Geol. Sur. Prof. Paper 1275, p. 148.

See Roedder and Bodnar, 1980a, Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 210-211 (1980). (E.R.)

ROEDDER, Edwin and CHOU, I-Ming, 1982, A critique of "Brine migration in salt and its implications in the geologic disposal of nuclear waste," Oak Ridge Nat'l. Lab. Rept. 5818, by G.H. Jenks and H.C. Claiborne: U.S. Geol. Survey Open File Rept. 82-1131, 31 pp. Authors at U.S. Geol. Survey, 959 Nat'l. Center, Reston, VA 22092.

Jenks and Claiborne in 1981 published a 164 page "...comprehensive review and analysis of available information relating to brine migration in salt surrounding radioactive waste in a salt repository." Calculations are presented in that publication, that are called "reasonably conservative," to show that the rates and total volumes of brine expected to migrate into a given emplacement hole in bedded salt over the first 100 years are sufficiently low (e.g., <250 ml/year) that they are of relatively minor concern in the engineering design of a nuclear waste repository. We believe that because the values used for the major input parameters are either nonconservative, selected numbers, or are based on inadequate data, the results of these calculations are invalid. Neither we nor others are able to make a truly valid calculation at this time as there are too many uncertainties, but we show that conservative estimates should be larger, and perhaps two orders of magnitude larger, than those made by Jenks and Claiborne. (Authors' abstract)

ROGERS, P.S.Z. and PITZER, K.S., 1982, Volumetric properties of aqueous sodium chloride solutions: J. Phys. Chem. Ref. Data, v. 11, no. 1, p. 15-80. Authors at Dept. Chem. and Lawrence Berkeley Lab., Univ. California, Berkeley, CA 94720.

Literature data for the volumetric properties of sodium chloride solutions to concentrations of 5.5 molal have been compiled and critically evaluated. A semi-empirical equation of the same type found to be effective in describing the thermal properties of NaCl solutions has been used to reproduce the volumetric data from 0°C to 300°C and 1 bar to 1000 bar. Tables of values are given for the specific volume, expansivity, and

compressibility. Equations also are given for calculating the pressure dependence of the free energy, enthalpy, and heat capacity. These equations can be combined with a treatment of thermal properties to form a complete equation of state for sodium chloride solutions. (Authors' abstract)

ROMANCHEV, B.P. and KUZNETSOVA, S.Ya., 1982, Condition of crystallization of nosean in alkaline melts: *Izvestiya Akad. Nauk SSSR - Ser. Geol.*, no. 1, p. 134-137 (in Russian). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The studied sodalite trachytes were collected in the St. Helen Island, ordanshites - in the Gran Canaria Island. In the minerals of ordanshite Th of melt inclusions are 1030-1100°C (in pyroxene), 1030-1060°C (in apatite), 980-1000°C (in nosean), 1040-1080 (in plagioclase). Inclusions in plagioclase are large (up to 150 μm) and they bear glass and dms: glass melts at 840°C, dm nosean at ~1000°C with formation of two immiscible melts, at 1040°C apatite and magnetite melt; during dms melting process the amount of immiscible salt melt decreases and immiscibility gap was closed at 1060°C, further T increase caused melting of pyroxene dm and homogenization of G bubble. Dms were identified by optical properties. Melt immiscibility was found also in minerals from phonolites and trachytes from St. Helen Island, suggesting the liquation origin of the mineral group nosean-hauyne. Inclusions in these minerals bear dms: halite and nosean. The paper characterizes briefly the immiscibility in feldspathoid syenites in the Lovozero Massif (USSR) and role of the gases of the H₂O-CO₂-SO₂ system during formation of the nosean group minerals from magmatic melts. (Abstract by A.K.)

ROMBERGER, S.B., 1982, Transport and deposition of gold hydrothermal systems at temperatures up to 300°C (abst.): *Geol. Soc. Am. Abstracts with Programs*, v. 14, p. 602.

RONA, P.A., BOSTROM, K., WIDENFALK, L., CRONAN, D.S., JENKINS, W.J. and MALLETT, M., 1982, Hydrothermal mineralization of Mid-Atlantic Ridge 0-27°N (abst.): *Geol. Soc. Am. Abstracts with Programs*, v. 14, p. 602.

ROSE, W.I., Jr., STOIBER, R.E. and MALINCONICO, L.L., 1982, Eruptive gas compositions and fluxes of explosive volcanoes: budget of S and Cl emitted from Fuego volcano, Guatemala, in R.S. Thorpe, ed., *Andesites*, John Wiley & Sons, New York, p. 669-676. First author at Dept. Geol. & Geological Engrg., Michigan Tech. Univ., Houghton, MI 49931, USA.

Because of the force of such eruptions, direct eruptive gas determinations in major explosive eruptions have not been obtained. Nevertheless, the S and Cl budget of explosive eruptions can be constrained by several measurements including: (1) microprobe analyses of glass inclusions in phenocrysts; (2) analyses of scavenged acids on fresh ash; (3) analyses of residual S and Cl trapped in tephra; (4) remote correlation spectrometry of gases emitted by volcanoes in quiet intervals between eruptions; (5) determination of gas/particle ratios of S and Cl by airborne sampling inside small eruption clouds; and (6) direct measurements of Cl/S in passive emissions from craters.

Data determined by all the above methods, some of which were obtained at a low level of activity, are available for the recent activity at Fuego volcano, Guatemala. The large eruption of October 1974 released 2.2×10^{14} g of ash. Constrained extrapolation allows us to estimate that it also released 1.6×10^{12} g of S and 6.2×10^{10} of Cl. The flux of S and

Cl for 3 years of passive emission following October 1974, when added to the eruptive gases, make the emission totals equal 2.0×10^{12} g S and 4.7×10^{11} - 11×10^{11} g Cl. Based on the pre-eruption S and Cl content of Fuego magma, estimated from glass inclusions, the mass of magma required is 1×10^{15} g, about five times the amount erupted. Most of the S released and only a small fraction of the Cl was in the short-lived 1974 eruption. S is thus preferentially emitted during explosive eruptions and Cl during low level activity. The data suggest that rates of S emission during major eruptions are more than 100 times the largest measured rates during low level emissions. (Authors' abstract)

ROVETTA, M.R. and MATHEZ, E.A., 1982, Magnesite and other minerals in fluid inclusions in a lherzolite xenolith from an alkali basalt (abst.): *Terra Cognita*, v. 2, p. 229. First author at Los Alamos Nat'l. Lab., Los Alamos, NM 87545, USA.

Magnesite has been observed in CO₂-rich fluid inclusions in a typical Cr-diopside and spinel-bearing lherzolite recovered from the 1824 eruption of Lanzarote volcano, Canary Islands. The carbonate, which exists as 2-4 μ m diameter crystals on inclusion walls, was identified by its rhombohedral form and electron beam-generated EDS and WDS characteristic x-ray spectra in which C and Mg are major elements. The carbonate occurs as the sole phase in individual inclusions and has only been found in those inclusions enclosed in olivine. Phases present in other inclusions in olivine include Fe-oxide (probably pure magnetite), Fe- and Cu-Fe-sulfides, and silica. Although sulfides and magnetite may exist together in the same inclusion, most magnetite-bearing inclusions contain no other phases.

Regardless of the phases in them, mineral-bearing inclusions tend to possess irregular shapes, are relatively large (10-30 μ m) and exist together in arrays which define non-crystallographic surfaces. These features distinguish them as a group from all other inclusion populations in which daughter minerals are absent.

The production of carbonate by reaction of olivine and CO₂-rich fluid requires only that CO₂ fugacities be sufficiently high for any set of assumed conditions, i.e., the mere presence of magnesite yields no information on the T and P at which it formed. However, the apparent lack of phases more siliceous than olivine, e.g., enstatite or glass, in association with magnesite (or magnetite) means that either olivine in the immediate vicinity of the inclusion is non-stoichiometric, or the carbonate crystallized in a microfracture before annealing of olivine and formation of the inclusion, presumably at mantle P-T conditions. (Authors' abstract)

ROYZENMAN, F.M. and FORTUNATOV, S.P., 1982, Use of thermobarogeochemical methods in prospecting for phlogopite deposits in Aldan, in *Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits*, N.P. Laverov, ed.: Moscow, "Nedra" Publ. House, p. 220-225 (in Russian).

Commercial phlogopite bodies are zones of Mg skarns formed by metasomatism of diopside schists. The phlogopite bodies bear minerals that yield a specific peak on decrepigrams at $T < 320^\circ\text{C}$. For decrepitemetric mapping the following index was used: $D = \text{No. of impulses up to } 300^\circ\text{C} / \text{No. of impulses up to } 800^\circ\text{C} \times 100$. The decrepitemetric map of the ore field was made on the basis of Td measurements of 2000 samples. The distinct anomalies agree well with contours of ore bodies in 63% of cases, and 37% were "false" anomalies (i.e. barren rocks of high decrepitation activity). (Abstract by A.K.)

RUI, Zongyao, LI, Yingqing and CHANG, Hongtao, 1982, Discrimination between

ore-bearing porphyry and barren porphyry from fluid inclusions in the Yulong porphyry copper (molybdenum) deposit belt of the eastern Tibet Autonomous Region [China]: Zhongguo Dizhi Kexueyuan Kuangchan Dizhi Yanjiuso Sokan, no. 4, p. 65-78 (in Chinese). Authors at Inst. Miner. Deposits, Chin. Acad. Geol. Sci., Beijing, Peop. Rep. China.

Along the Yulong belt of porphyry Cu deposits, ore-bearing porphyries contain a diverse collection of gas, liq., and polyphase inclusions characterized by: (1) Th 180-600°, (2) Ph 240-1800 atm, (3) salinity <(10-18) m NaCl + KCl, (4) gas/liq. ratios 5-95%, and (5) daughter minerals halite, sylvite, hematite, anhydrite, and (probably) pyrite. The fluids included in the ore-bearing porphyries appear to have undergone repeated revival boiling and represent the derivs. of both magmatic fluids and meteoric groundwaters. In contrast, the liq. (predominant) and polyphase (scarce) inclusions in ore-barren porphyries yield (1) Th 100-350°, (2) Ph 240-747 atm; (3) salinity <10 m NaCl, (4) gas/liq. ratios 5-35%, and (5) halite as the only daughter mineral. These fluids have not undergone revival boiling and are predominantly intermediate- to low-temp. derivs. of meteoric groundwaters. (CA 98: 146837y)

RUMBLE, Douglas, III, 1982_a Polythermal, polybaric models of stable isotope fractionation during metamorphic devolatilization reactions: Carnegie Inst. Wash. Year Book 81, p. 377-380.

RUMBLE, D., III, 1982_b Oxygen isotope equilibration and permeability enhancement during metamorphism (abst.): Geol. Soc. Newsletter (London), v. 11, no. 4, p. 15. Author at Geophy. Lab., WA.

The degree to which oxygen isotope equilibrium has been achieved between the minerals of contiguous rock layers correlates with evidence of mechanisms of permeability enhancement in metamorphic rocks. Quartz separated from interbedded rocks such as calc-silicate, mica schist, amphibolite, quartzite, and metachert is homogeneous ($\pm 0.2\%$) where rocks either (1) have experienced devolatilization reactions producing 10 wt.%, or more, of fluid, or (2) have been intensely fractured and veined. Quartz from interlayered rocks lacking evidence of permeability enhancement differs by 1-2% in samples separated by only 1 cm. These results suggest intergranular diffusion through static pore fluid is not an efficacious process for exchanging oxygen isotopes between different rock types. Infiltrating pore fluid, however, can serve as a medium of isotope exchange over distances of meters where rocks are sufficiently permeable for fluid flow to occur. (Author's abstract)

RUMBLE, Douglas, III, 1982_c Stable isotope fractionation during metamorphic devolatilization reactions (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 448-449.

RUMBLE, D., III, FERRY, J.M., HOERING, T.C. and BOUCOT, A.J., 1982, Fluid flow during metamorphism at the Beaver Brook fossil locality, New Hampshire: Am. J. Sci., v. 282, p. 886-919. First author at Geoph. Lab., Carnegie Inst. of Washington, Washington, DC, 20008.

Rocks at the Beaver Brook fossil locality were regionally metamorphosed at 3.5 kb and 600°C. Metamorphic fluids were water-rich, $X_{H_2O} > 0.80$ (mole fraction), and contained variable amounts of CO_2 and CH_4 as controlled by the buffer capacity of different mineral assemblages in individual sedimentary beds. The minimum amount of fluid that flowed through the beds during metamorphism has been estimated using mineralogic and oxygen isotopic evidence. The mineralogic evidence is the extent to which decarbonation reactions have gone to completion as measured by petrographic

modal analysis. The isotopic evidence is the inferred metamorphic change in the oxygen isotopic composition of fossil brachiopods. Fluid-rock ratios of 1.5 to 4.0 (minimum estimate, by volume) are obtained from the mineralogic evidence, and ratios of 4.0 to 6.0 from the isotopic evidence. The large amounts of fluid flow observed at Beaver Brook are believed to be a consequence of metamorphic decarbonation reactions. These reactions, not in themselves capable of producing the computed amounts of fluid, nevertheless, are responsible for enhancing permeability sufficiently so that fluid flow could occur. (Authors' abstract)

RUMYANTSEV, V.N. and GANEEV, I.G., 1982, Spatial chemical differentiation as essential mechanism of evolution of acidity-alkalinity of hydrothermal solutions, p. 137-141 in Acid-basic properties of chemical elements, minerals, rocks and natural solutions: "Nauka," Moscow, 216 pp., 1100 copies printed, price 2 rubls 50 kopecks (in Russian).

KCl solution at T 150-350°C has acid reaction, but at 350°C it changes to alkaline. Spatial separation of hydrolysis products causes the acid-alkaline differentiation of the original electrolytes. The "wave" of acid solutions is caused by presence of high-volatile acid components (conclusions of isothermic-isobaric experiments). (A.K.)

RUSSELL, M.J. and SAMSON I.M., 1982. Solutions feeding Irish Zn+Pb (+Ba) and other "non-volcanogenic" exhalative deposits (abst.): J. geol. Soc. London, v. 139, p. 98

The properties of the hydrothermal solutions that fed the Irish exhalative Zn+Pb ore deposits have been estimated from fluid inclusion studies, geological and geochemical modelling [Russell et al., Mineral. Deposita (in press)] and experimental rock/water interactions at elevated temperatures and pressures [Bischoff et al., Econ. Geol. (in press)]. Salinities ranged from 10 to 25 equiv. NaCl wt.% and the solutions are considered to represent some ground water but the dominant fraction is probably modified highly saline early Carboniferous seawater. Metals mainly occurred in solution as chloride complexes. K/Na ratios were about 0.2. H₂S concentration was 10 ppm.

Saline seawater modification was by reaction with hot Lower Palaeozoic greywackes. The process was probably downward penetrating convection. Solutions were 1 pH unit on the acid side of neutral and were saturated with pyrite. Temperatures of the (boiling) solutions feeding Silvermines rose to at least 265°C and at Tynagh temperatures are assumed to have increased with time to perhaps >300°C to account for the later copper. Increase in temperature with time possibly reflects deepening of convection cells as the upper crust is cooled (Russell et al., op. cit.).

Non-volcanogenic exhalative deposits which formed in tensional environments elsewhere in the world (e.g. Mount Isa, Sullivan) probably had similar origins. Variations between deposits may be explained in terms of differences in fluid and source rock chemistry. Where source rock allows a modified seawater mineralizer of normal salinity (~3 wt.% NaCl), this may give rise to exhalative antimony deposits. Convection of solutions in a pile of mafic and felsic volcanics may result in some P₂O₃ (sic) and F accompanying Pb+Zn ore (e.g. Broken Hill, Australia). Where the upper crust contains anomalous B and Sn, exhalative tin deposits may occur.

The main causes of precipitation of sulphides in these deposits is boiling in the feeder zones (Finlow-Bates, T. & Large, D.E. 1978, Geol. Jb. D30, 27-39) and mixing with seawater just below and on exhalation onto the seafloor. Boiling in the feeder zones causes a rise in pH and a sudden drop in temperature which results in the precipitation of very fine-

grained sulphide which may be carried in the rising solutions to be rained onto the seafloor from the bottom-hugging fraction of a double diffusive plume. (Authors' abstract)

RUSSELL, Norman, SEAWARD, Michael RIVERA, José McCURDY, Karr, KESLER, S.E., CUMMING, G.L. and SUTTER, J.F., 1980, Geology and geochemistry of the Pueblo Viejo gold-silver deposit and its host Los Ranchos Formation, Dominican Republic: Conferencia Geol. Del Caribe v. 1, no. 9, p. 263-271. First author at Rosario Dominicana S.A., Apartado Postal 944, Santo Domingo, Dominican Republic.

See similar abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 178 (1981). (E.R.)

RYABCHIKOV, I.D., 1982^a Mantle sources of hydrothermal solutions (based on experimental data) (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 40-41.

RYABCHIKOV, I.D., 1982^b Solubility decrease of high-density crystalline phases in hydrothermal fluids during increase in pressure: Akad. Nauk SSSR Doklady, v. 262, no. 3, p. 698-700 (in Russian). Author at Oceanology Inst. of Acad. Sci. USSR, Moscow.

The problem is discussed with use of jadeite-diopside-water system at 900°C, $2-3 \times 10^9$ Pa and literature data on relations of albite, sanidine, phlogopite, forsterite, and clinopyroxene with water. Conclusions bear remark that mantle fractions producing Na- or K-rich magmas should be separate. (A.K.)

RYABCHIKOV, I.D., GREEN, D.H., WALL, W.J. and BREY, G.P., 1981, The oxidation state of carbon in the reduced-velocity zone: Geokhimiya, 1981, no. 2, p. 221-232 (in Russian; translated in Geochem. Int'l., v. 18, no. 1, p. 148-158, 1982).

RYABCHIKOV, I.D., REKHARSKIY, V.I. and KUDRIN, A.V., 1981, Mobilization of molybdenum by fluids during the crystallization of granite melts: Geokhimiya, no. 8, p. 1243-1246 (in Russian; translated in Geochem. Int'l., v. 18, no. 4, p. 183-186, 1982).

RYABCHIKOV, I.D., SCHREIER, W. and ABRAHAM, K., 1982^a Composition of fluids in the systems forsterite-silica-water and jadeite-diopside-water under conditions of the upper mantle: Izvestiya Akad. Nauk SSSR - Ser. Geol., no. 5, p. 13-21 (in Russian). First author at IGEM of Acad. Sci. USSR, Moscow.

The paper presents fluid composition in the above systems under P up to $3 \cdot 10^9$ Pa and T 990-1100°C. (A.K.)

RYABCHIKOV, I.D., SCHREYER, W. and ABRAHAM, K., 1982^b Compositions of aqueous fluids in equilibrium with pyroxenes and olivines at mantle pressures and temperatures: Contrib. Mineral. Petrol., v. 79, p. 80-84. First author at IGEM, 35 Staromonetny, Moscow 109017, USSR.

Solubility experiments were performed at 30 kbars in the system $Mg_2SiO_4-SiO_2-H_2O$, and at 20 and 30 kbars on omphacitic pyroxene-water mixtures. They confirm that the solubility of the forsterite component in aqueous fluids remains rather low (up to 5 wt.%), whereas the solubility of the SiO_2 component from solids of appropriate SiO_2 -rich compositions in the system $Mg_2SiO_4-SiO_2-H_2O$ increases with temperature up to some 75% at 1,100°C. At this temperature a simplified harzburgite consisting of

forsterite and enstatite coexists with a fluid containing about 35% (MgO + SiO₂). Hydrous fluids coexisting with omphacitic clinopyroxenes leach sodium silicate component from the solid leaving less jadeitic pyroxenes behind. Most interestingly, the amount of sodium leached at constant temperature increased with decreasing pressure.

Comparison of the results with previous solubility studies in the system K₂O-MgO-Al₂O₃-SiO₂-H₂O indicates that hydrous fluids in the mantle must be alkaline rather than silica-normative. Alkali metasomatism caused by such fluids would lead to postassium enrichment in deeper portions of the upper mantle and to sodium enrichment at shallower levels, where amphiboles become stable. This K/Na fractionation in the upper mantle may explain the generation of K-rich or of Na-rich magmas through partial melting at different depths. (Authors' abstract)

RYE, D.M. and BRADBURY, H.J., 1982, Migration of fluids through Pyrenean thrust sheets (abst.): EOS, Trans. Am. Geophys. Union, v. 63, p. 428.

RYE, R.O., HALL, W.E., CUNNINGHAM, C.G., CZAMANSKE, G.K., AFIFI, A.M. and STACEY, J.S., 1982, Preliminary mineralogic, fluid inclusion, and stable isotope study of the Mahd adh Dhahab gold mine, Kingdom of Saudi Arabia: USGS Open-File Report OF-03-4 (also listed as U.S.G.S. Open-File Report 83-291), 26 pp. First author at U.S. Geol. Survey, Denver, CO.

The Mahd adh Dhahab mine, located about 280 km northeast of Jiddah, Kingdom of Saudi Arabia, has yielded more than 2 million ounces of gold from periodic production during the past 3,000 years. A new orebody on the southern side of the ancient workings, known as the South orebody, is being developed by Gold Fields-Mahd adh Dhahab Limited. A suite of samples was collected from the newly exposed orebody for preliminary mineralogic, stable isotope, fluid inclusion, and geochemical studies.

The Mahd adh Dhahab deposit is in the carapace of a Proterozoic epizonal rhyolite stock that domed pyroclastic and metasedimentary rocks of the Proterozoic Halaban group. Ore of gold, silver, copper, zinc, tellurium, and lead is associated with north-trending, steeply dipping quartz veins in a zone 1,000 m long and 400 m wide. The veins include an assemblage of quartz-chlorite-pyrite-hematite-chalcopyrite-sphalerite-precious metals, which is similar to the mineral assemblage at the epithermal deposit at Creede, Colorado.

The primary ore contains abundant chalcopyrite, sphalerite, and pyrite in addition to a complex precious metal assemblage. Gold and silver occur principally as minute grains of telluride minerals disseminated in quartz-chlorite-hematite and as inclusions in chalcopyrite and sphalerite. Telluride minerals include petzite, hessite, and sylvanite. Free gold is present but not abundant.

All of the vein-quartz sample contained abundant, minute inclusions of both low-density, vapor-rich fluids and liquid-rich fluids. Primary fluid inclusions yielded Th of from 110° to 238°C. Preliminary light-stable isotope studies of the sulfide minerals and quartz showed that all of the $\delta^{34}\text{S}$ values are between 1.2 and 6.3 per mil, which is a typical range for hydrothermal sulfide minerals that derive their sulfur from an igneous source. The data suggest that the sulfide sulfur isotope geochemistry was controlled by exchange with a large sulfur isotope reservoir at depth.

The $\delta^{18}\text{O}$ values of all stages of vein quartz in the South orebody range between 8.5 and 11.1 per mil. This range is similar to that for quartz from the North orebody and indicates that the hydrothermal system consisted of dominantly exchanged meteoric water, which was uniform in

temperature and $\delta^{18}\text{O}$ content throughout the area during the entire period of mineralization.

Lead isotope analyses of two galena samples indicate that the lead in the South orebody is less radiogenic than that from the North orebody and confirm that the lead was derived from oceanic crust approximately 700 Ma ago. (Authors' abstract)

RYZHENKO, B.N., MEL'NIKOVA, G.L. and SHVAROV, Yu.V., 1981, Computer modeling of formation of the chemical composition of natural solutions during interaction in the water-rock system: *Geokhimiya*, no. 4, p. 481-495 (in Russian; translated in *Geochem. Int'l.*, v. 18, no. 2, p. 94-108, 1982).

Abstract in *Fluid Inclusion Research--Proceedings of COFFI*, v. 14, p. 180. (E.R.)

SAFRONOV, A.F. and NIKISHOV, K.N., 1982, Fluid regime of upper mantle and mineral associations in diamonds: *Akad. Nauk SSSR Doklady*, v. 262, no. 4, p. 961-964 (in Russian). Authors at Inst. Geol. Yakutian Div. of Siberian Branch of Acad. Sci. USSR, Yakutsk.

The paper presents results of calculation of composition of G mixture in equilibrium with lherzolite from basalt (CO_2 , CO, H_2 , O, H_2) for T 900 and 1400°C, P up to 20 kbars. (A.K.)

SAHU, K.C., 1982, Fluid inclusions indicative of multiple evolution of hydrothermal solutions: [Proceedings & Abstracts], National Workshop on Fluid Inclusion Studies, 22-23 March, 1982, Indian Inst. Tech., Bombay, p. 1-17 (unpaginated). Author at Indian Inst. Tech., Bombay-76, India.

A review which also presents data on Tm NaCl, Tm KCl, and Th L-V for inclusions in the Khetri Cu-Zn deposit from an unpublished Indian government report by K.C. Sahu and V. Panchapakesan (1981). The ranges are: Tm NaCl 175-365°C; Tm KCl 79-138°C; Th L-V 269-400°C. (E.R.)

SAKAI, Hitoshi, CASADEVALL T.J. and MOORE J.G., 1982. Chemistry and isotope ratios of sulfur in basalts and volcanic gases at Kilauea Volcano, Hawaii: *Geochimica Cosmo. Acta*, v. 46, p. 729-738. First author at Inst. for Therm. Spring Res., Okayama Univ., Misasa, Tottori-Ken, Japan 682-02.

Eighteen basalts and some volcanic gases from the submarine and sub-aerial parts of Kilauea volcano were analyzed for the concentration and isotope ratios of sulfur. By means of a newly developed technique, sulfide and sulfate sulfur in the basalts were separately but simultaneously determined. The submarine basalt has 700 ± 100 ppm total sulfur with $\delta^{34}\text{S}_{\Sigma\text{S}}$ of $0.7 \pm 0.1\%$. The sulfate/sulfide molar ratio ranges from 0.15 to 0.56 and the fractionation factor between sulfate and sulfide is $+7.5 \pm 1.5\%$. On the other hand, the concentration and $\delta^{34}\text{S}_{\Sigma\text{S}}$ values of the total sulfur in the subaerial basalt are reduced to 150 ± 50 ppm and $-0.8 \pm 0.2\%$, respectively. The sulfate to sulfide ratio and the fractionation factor between them are also smaller, 0.01 to 0.25 and $+3.0\%$, respectively. Chemical and isotopic evidence strongly suggests that sulfate and sulfide in the submarine basalt are in chemical and isotopic equilibria with each other at magmatic conditions. Their relative abundance and the isotope fractionation factors may be used to estimate the f- O_2 and temperature of these basalts at the time of their extrusion onto the sea floor. The observed change in sulfur chemistry and isotopic ratios from the submarine to subaerial basalts can be interpreted as degassing of the SO_2 from basalt thereby depleting sulfate and ^{34}S in basalt.

The volcanic sulfur gases, predominantly SO_2 , from the 1971 and 1974

fissures in Kilauea Crater have $\delta^{34}\text{S}$ values of 0.8 to 0.9‰, slightly heavier than the total sulfur in the submarine basalts and definitely heavier than the subaerial basalts in accord with the above model. However, the $\delta^{34}\text{S}$ value of sulfur gases (largely SO_2) from Sulfur Bank is 8.0‰, implying a secondary origin of the sulfur. The $\delta^{34}\text{S}$ values of native sulfur deposits at various sites of Kilauea and Mauna Loa volcanoes, sulfate ions of four deep wells and hydrogen sulfide from a geothermal well along the east rift zone are also reported. The high $\delta^{34}\text{S}$ values (+5 to +6‰) found for the hydrogen sulfide might be an indication of hot basalt-seawater reaction beneath the east rift zone. (Authors' abstract)

SAKHAROVA, M.S., BATRAKOVA, Yu.A. and RYAKHOVSKAYKA, S.K., 1981, The effects of pH on the deposition of gold and silver from aqueous solution: *Geokhimiya*, 1981, no. 3, p. 371-378 (in Russian; translated in *Geochem. Int'l.*, v. 18, no. 2, p. 28-34, 1982).

SAMORUKOVA, L.M. and KOZAKOV, I.K., 1982, Results of studies of melt inclusions in Precambrian granitoids of the Western Sangilen (Tuva ASSR), in N.P. Ermakov, ed., *Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House*, p. 66-69 (in Russian).

For abstract, see entry Samorukova in *Fluid Inclusion Research--Proceedings of COFFI*, vol. 11, 1978, p. 188. (A.K.)

SAMSONOV, A.Ya., 1982, Peculiarities of structure of the Irtysh sulfide-polymetal deposit: *Geol. Rudn. Mest.*, v. 24, no. 6, p. 85-93 (in Russian). Author at Moscow State Univ., Moscow, USSR.

Inclusions in ore-bearing quartz have Th 560-620°C, P 5-6 kbar; essential component is CO_2 . (A.K.)

SATO, T., 1982, Epithermal gold-silver mineralization at Kushikino, southern Kyushu, Japan - a fossil geothermal system (abst.): *IAGOD Sixth Symp.*, Tbilisi, USSR, Sept. 6-12, 1982, *Collected Abstracts*, p. 42. Author at Geol. Survey Japan, Yatabe Higashi, Ibaraki, Japan.

The gold-silver veins of the Kushikino mine are of typical epithermal type occurring in Miocene propylite and have produced seven million tons of ore averaging 6.2 g/t Au and 52 g/t Ag.

As the result of integrated studies of fluid inclusions, stable isotopes, wallrock alteration, gravimetric data and deep diamond drillings, the mineralizing system was reconstructed and interpreted as remnants of ancient geothermal system, of which the hydrothermal fluid is of local meteoric origin and the heat source is quartz diorite porphyry intrusions. The mass and heat transport processes, fluid dynamics and site of gold-silver precipitation of this fossil geothermal system are discussed in comparison with present-day volcanic geothermal areas in Japan. (Author's abstract)

SAWKINS, F.J., 1982a, The formation of Kuroko-type deposits viewed within the broader context of ore genesis theory: *Mining Geol.*, v. 32, no. 1, p. 25-33. Author at Dept. Geol. & Geophy., Univ. Minnesota, Minneapolis, MN 55455, USA.

Kuroko-type massive sulfide deposits exhibit similarities to certain epigenetic polymetallic Cordilleran deposits in base metal ratios, paragenesis and time-space association with felsic magmatism. In addition, the transport and deposition of Kuroko-type ores occurs within seawater-dominated convective systems.

Consideration of empirical data from the Taupo Volcanic Zone, New Zealand indicates strong similarities to the general setting of Kuroko ore deposition, and implies large volumes of intrusive magma to provide the necessary heatflux.

The metal content of certain postmagmatic fluids and δD constraints on Kuroko-type ore fluids suggest a model for Kuroko-type ore genesis in which host-rock leaching is not the major source of the metals involved. The preferred model envisages a magmatic source for the bulk of the metals in Kuroko-type ores, with the overlying convective systems acting as focussing mechanisms for ore fluid discharge and as contributors of reduced sulfur for metal sulfide deposition. (Author's abstract)

SAWKINS, F.J., 1982. A comprehensive model for the genesis of Kuroko-type massive sulfide deposits (abst.): IAGOD Sixth Symp., Tbilisi, USSR, Sept. 6-12, 1982, Collected Abstracts, p. 42-43. Author at Univ. Minnesota, Minneapolis, MN, USA.

There is virtually universal acceptance of the fact that Kuroko-type massive sulfide deposits form by exhalation of metalliferous fluids at the seawater interface. Concurrence on the source(s) of the metals involved and the reason why such deposits tend to be limited to specific stratigraphic horizons has not been achieved.

The empirical data indicate that Kuroko-type deposits exhibit a time-space relationship to felsic magmatism, form in the temperature range of ~ 250 - 300°C , and are associated with active seawater-dominated hydrothermal convection. Based on stratigraphic relationships a paragenesis from copper to lead plus zinc and barite is indicated.

A number of features of the deposits suggest that a simple model of leaching, transport and exhalation of metals by heated seawater is inadequate. For example, Kuroko-type deposits exhibit strong similarities to typical postmagmatic deposits (e.g., skarn deposits) in terms of both their metal ratios and paragenesis, and their time-space relationship to felsic magmatism.

Recent work on postmagmatic deposits has demonstrated that postmagmatic ore fluids can contain in excess of 10,000 ppm of base metals in solution. It is also apparent from studies of the Taupo Volcanic Zone in New Zealand that the widespread meteoric water-dominated hydrothermal activity present must be thermally driven by large intrusive bodies at depth. The structural setting of the Taupo Volcanic Zone exhibits strong similarities to that of the Miocene green tuff region of Japan in which the Kuroko deposits developed.

These observations, coupled with a considerable body of δD data on Kuroko fluid inclusions and alteration minerals that indicate δD values of the ore fluids as intermediate in composition between seawater ($\delta D = 0$) and typical magmatic water ($\delta D = -50$), support the concept of magmatic water involvement in the genesis of Kuroko-type deposits.

A genetic model involving relatively long-lived seawater convection cells combined with short term addition of metal-rich postmagmatic fluids is suggested. Such a model is capable of explaining all the geologic, geochemical and isotopic features of Kuroko-type deposits. Furthermore, the limitation of Kuroko-type deposits to specific stratigraphic horizons within volcanic sequences is mirrored by the chronology of magmatic events in certain postmagmatic deposits. For example, at Bingham in Utah a six million year sequence of magmatic activity has been chronicled by radiometric dating, but only a single ore-forming event occurred within that time.

An important aspect of the model is the effect of the seawater convection systems in focussing the discharge of deeper magmatic fluids

at specific points. It is at, and adjacent to, such discharge points that Kuroko-type deposits form. (Author's abstract)

SAWKINS, F.J., 1982, Overview of types of gold deposits in subaerial environments (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 608. Author at Dept. Geol. & Geoph., Univ. Minnesota, Minneapolis, MN 55455.

Gold deposits formed in subaerial environments occur primarily in subduction-related volcanics or volcanics related to back-arc extension. Disseminated deposits form at extremely shallow depth in situations where caprocks have undergone pervasive fracturing. Vein deposits generally exhibit well-defined favorable zones (200-500 vertical extent) within more extensive structures. Such zones typically form at shallow depth (<1 km). Base metal sulfides are generally a minor component, but in some instances they increase conspicuously downwards.

In ensimatic arcs Ag/Au ratios tend to be low (~1), whereas in continental arcs ratios are higher (>20), and tend to increase from the principal arc towards the inner arc. Ag/Au ratios within specific vein districts can provide interesting systematics, useful to further exploration. Gangue mineralogy is dominated by quartz (incl. chalcedony), but calcite, adularia and Mn silicates are important locally. Alteration phases developed are mainly chlorite, sericite, clays, and pyrite, and many districts occur within areas of regional propylitization.

Fluid inclusion and isotopic studies indicate vein mineralization occurs mainly in the range 240-280°C and disseminated mineralization at <200°C. The fluids involved were essentially of local meteoric origin. Despite the above generalities, variability in these deposits in zoning characteristics and alteration intensity is marked. Furthermore, the controls of favorable zone development and the ultimate source of gold remain problematic. Two factors important in exploration for such deposits in young volcanic terrains are recognition that vein structures can weaken markedly above favorable zones, and sets of veins exhibit spacings similar to geothermal convection cells (~5 km). (Author's abstract)

SCHERKENBACH, D.A., 1982, Geologic, mineralogic, fluid inclusion and geochemical studies of the mineralized breccias at Cumobabi, Sonora, Mexico: Ph.D. dissertation, Univ. Minnesota, Minneapolis, MN, 240 pp. Indexed under Fluid Inclusions. (See next item.)

SCHERKENBACH, D.A. and SAWKINS, F.J., 1982, The molybdenum deposit of Cumobabi, northern Sonora, Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 14, p. 609. Authors at Dept. Geol. & Geoph., Univ. Minnesota, Minneapolis, MN 55455.

At Cumobabi a series of Mo-Cu mineralized breccias are associated with 56 m.a. felsic intrusives. Of the 35 breccia bodies known only a few contain significant ore-grade mineralization. Detailed geologic, alteration, fluid inclusion, and geochemical studies indicate two distinctive stages of post-brecciation alteration and metallization. Stage I involved strong potassic (+ anhydrite) alteration of centrally located breccias and deposition of molybdenite-pyrite-quartz assemblages. Stage II involved development of crosscutting quartz-sericite alteration and deposition of chalcopyrite and lesser tetrahedrite, as replacements of pyrite.

Stage I quartz contains excellent primary fluid inclusions of three types: low-salinity, high-salinity, and vapor-dominated. Detailed studies of these indicate episodic boiling events within the temperature

range 440-350°C, related to repeated fluctuations from lithostatic to hydrostatic pressures at depths of 1.0-1.5 km. Relationships indicate an original low-salinity fluid (6-9 wt% alk. chl.) split into high salinity and vapor phases during episodes of pressure reduction. Daughter mineral suites in high-salinity fluid inclusions are spectacular, and at least 12 phases, including chalcopyrite, have been identified by S.E.M. techniques. The presence of chalcopyrite daughters in some vapor dominated inclusions is noteworthy. Both volumetric analysis of cpy daughters and quantitative chemical analyses of fluid inclusions indicate several thousand p.p.m. of iron and copper in the ore fluids as well as significant zinc (550 to 1,700 p.p.m.). Apparently base metal amounts were greater than those of reduced sulfur, suggesting availability of the latter may be a crucial factor in postmagmatic ore deposition. (Authors' abstract)

SCHIFFRIES, C.M., 1982, The petrogenesis of a platiniferous dunite pipe in the Bushveld Complex: infiltration metasomatism by a chloride solution: *Econ. Geol.*, v. 77, p. 1439-1453. Author at Dept. Geol. Sci., Harvard Univ., Cambridge, MA 02138.

It is proposed that a high-temperature chloride solution flowed through irregular channel-ways along a structural weakness near the axis of the pipe and reacted with the noritic host rocks, leading ultimately to the formation of dunite. Reaction fronts advanced at different rates outward from the channelways and produced a sequence of metasomatic zones.

Aqueous chloride complexes are also believed to have played an important role in the transport and precipitation of the platinum-group elements, the base metals, and other cations. Interdependent chemical reactions involving a chloride solution, olivine, magnetite, and the platinum-group elements can account for the preferential association of the ore with iron-rich olivine. Infiltration metasomatism by a high-temperature chloride solution may have an important bearing on the interpretation of other features of the Bushveld Complex. (From the author's abstract)

SEDOVA, I.S., 1982, Quartz-plagioclase metasomatites - a low-temperature rock analogous to ultrametamorphic granitoids, in N.P. Ermakov, ed., *Thermobarogeochemistry in Geology - Materials of the Sixth All-Union Symposium on Thermobarogeochemistry: Vladivostok, Far East Sci. Center, Acad. Sci. USSR Pub. House, p. 14-21 (in Russian).*

For the abstract, see *Fluid Inclusion Research--Proceedings of COFFI*, vol. 11, 1978, p. 190. (A.K.)

SEDOVA, I.S. and GLEBOVITSKIY, V.A., 1982, Migmatization and granitization during metamorphism of the andalusite-sillimanite type in the Ladoga series: *Dokl. Akad. Nauk SSSR*, v. 264, no. 2, p. 431-434 (in Russian).

SEDOVA, I.S., NGUY, T.N. and KAMENTSEV, I.Ye., 1982, Structural state of K-Na feldspars of migmatites and ultrametamorphic granitoids in connection with conditions of their formation: *Zapiski Vses. Min. Obshch.*, v. 111, no. 5, p. 514-528 (in Russian). First author at Inst. of Geol. and Geochronol. of Precambrium of Acad. Sci. USSR, Leningrad, USSR.

Rocks of granulite facies yielded Th of fluid inclusions: SW Pamirs 780°C, Belomor'ye 835-850°C; high-T amphibolite facies: SW Pamirs 790°C, 725°C, 620°C, Central Pamirs (Shatput) 700°C, region Vitim-Kalar 740°C, region Katugin 635°C, Tynda River 650°C, N. Priladozh'ye (=N. side of the Ladoga Lake) 700-715°C; parautochthonic and allochthonic granitoids: SW Pamirs 800°C, Central Pamirs 710, 740 and 765°C. The above Th values and fluid composition (H₂O, H₂, CO₂, CO, CH₄) determined by gas chromatography