COONS, W.E., MEYER, D., OLSEN, R.L. and REGISTER, J.K., 1984, The geochemistry of the Castile brines: implications for their origin and impact on the WIPP site: Mat. Res. Soc. Symp. Proc., v. 26, p. 49. Authors at D'Appolonia Consulting Engrs., 2340 Alamo SE, Suite 306, Albuquerque, NM 87106.

Pressurized brine reservoirs have been found in the Castile anhydrite which underlies the proposed Waste Isolation Pilot Plant. The major and minor component chemistry of the brines and the isotopic abundances of the brines and coexisting minerals have been determined and evaluated. Thermodynamic calculations indicate that the brines approach saturation with all major minerals in their host horizon. The brines, therefore, appear to be in equilibrium with their geologic environment and do not have the capacity for substantially degrading the integrity of the site. When analyzed through solute versus bromide plots, the data indicate that the most likely origin for the brines is Permian seawater. As a result, the reservoirs appear to have been derived from waters no longer being introduced into the rock (i.e., they have a finite source). (Authors' abstract)

CORREIA NEVES, J.M., MONTEIRO, R.L.B.B. and DUTRA, C.V., 1984, Chemical composition of pegmatitic beryl of Brazil and their petrologic and metallogenetic significance: Revista Brasileria de Geociencias, v. 14, no. 3, p. 137-146 (in Portuguese; English abstract). First author at Centro de Pesquisas Prof. Manoel Teixeira da Costa, CX. Postal 6208, CEP 30.000, Belo Horizonte, MG, Brazil.

Infrared [spectra] revealed H_2O, CO_2 and CH_4 occluded in channels of the beryl structure and/or present in fluid inclusions of the same mineral. The petrologic and metallogenetic implications of the chemical composition, mainly the variation in the alkali contents, of the studied beryls are discussed and interpreted. Above critical levels, the alkali contents can be used to disclose the potentiality of the pegmatite to become ore bodies for Li, Cs and Ta. (From the authors' abstract)

CORTI, H.R. and FERNANDEZ-PRINI, Roberto, 1984, Thermodynamics of solution of gypsum and anhydrite in water over a wide temperature range: Can. J. Chem., v. 62, p. 484-

COSTA, U.R., BARNETT, R.L. and KERRICH, R., 1984, the Mattagami Lake mine Archean Zn-Cu sulfide deposit, Quebec: Hydrothermal coprecipitation of talc and sulfides in a sea-floor brine pool -- evidence from geochemistry, $^{18}O/^{16}O$, and mineral chemistry -- a reply: Econ. Geol., v. 79, p. 1953-1955. First author at Programa de Pesquisa Pos-Graduacao em Geopfisica, Inst. Geosci. Univ. Federal Bahia, Federacao, Salvador, Bahia 40.000, Brazil.

A reply to a discussion by Zierenberg (this volume). (E.R.)

COX, D.P. and OHTA, Eijun, 1984, Maps showing rock types, hydrothermal alteration and distribution of fluid inclusions in the Cornelia Pluton, Ajo mining district, Pima County, Arizona: U.S. Geol. Survey Open-File Rpt. 84-388, 9 pp.

Tm NaCl 200-600+°C; Th L-V(L) 50-500°C; Th L-V(V) 300-600+°C. (E.R.)

CRAIG, H., KIM, K.-R. and RISON, W., 1984, Easter Island hotspot: I. Bathymetry, helium isotopes, and hydrothermal methane and helium (abst.): EOS, v. 65, no. 45, p. 1140. Authors at Scripps Inst. Oceanography, La Jolla, CA 92093. Continued next page.

Morgan (1972) proposed an Easter hotspot on the East Pacific Rise at 27°S, 114°W, to account for the Sala y Gomez chain and conjugate Tuamotu and Nazca Ridges. A number of authors: Pilger and Handschumacher (1981) and previously Chase, Hey et al., and Minster et al., have fixed the hotspot location on the East margin of the Easter microplate within a roughly 30 (N-S) by 60 (E-W) n-mile ellipse centered on 26°35'S, 111°40'W, based on plate-motion models and a 3-m.y. age for Easter Island. On Expedition PASCUA (1983) we used a Seabeam swath to sample basalts at two sites exactly on the East margin at the proposed hotspot latitude, as well as at 9 other sites on the EPR from 25°S to 34°S. At 26°26'S, the "East Ridge" of the microplate rises 750 meters above the seafloor to 2080 meters depth, with a width of 15 nm centered at 112°37'W. Basalts at the hotspot site have a very strong He-3/He-4 anomaly: the 3/4 ratio (R) = 10.5 to 11 x R(atm), similar to Society and Austral hotspot ratios. All other measured EPR, Juan de Fuca, and Galapagos basalts (44 samples) have normal MORB He: R = 9 R(atm) [range: 6.9-8.8]. Thus the Easter hotspot is a "High He-3" hotspot (R >8), in the class of the Austral, Society, Samoan, Hawaiian, Reunion, and Icelandic oceanic hotspots. The chemistry of these basalts is orthodox MORB, but Macdougall & Tanzer (next paper) find strong Sr & Nd anomalies vs. EPR basalts.

In addition to a mantle plume, a "hotspot" hydrothermal plume, 5 = 40 m above bottom was observed, with a 3/4 ratio anomaly of 317% (!) and a He-3 vs. He-4 slope showing R (added He) = 10.65 R(atm), as in the basalts. CH_4 was 55.6 µcc/kg in the plume. The CH_4/He-3 ratio is 0.19 E6, exactly similar to Loihi Seamount plumes (0.18 E6), but much lower than MORB hydrothermal plumes and vents at 21°N, 19-21°S, and Galapagos (range: 3-20 E6). Thus CH_4/He-3 in hotspot basalts is only 2% of the MORB ratio. (Authors' abstract)

CRAWFORD, M.L., STOUT, M.Z. and GHENT, E.D., 1984, P-T-X (fluid) evolution in Al_2SiO_5-bearing schist, Mica Creek B.C.: fluid inclusion evidence (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 478-479. First author at Dept. Geol., Bryn Mawr College, Bryn Mawr, PA 19010.

Metamorphosed pelitic rocks from Mica Creek, British Columbia contain kyanite with minor fibrolite and andalusite-bearing quartz pods. Mineral compositions were used to infer peak P-T conditions and fluid compositions in equilibrium with the solid phases. Fluid inclusions in three schist samples prove to be good indicators of conditions affecting those rocks during and after peak metamorphic conditions. In samples from two localities fluid inclusions from schist and quartz-rich segregations have densitites appropriate to the peak metamorphic conditions. The observed fluid compositions (low salinity aqueous with <12 mol% dissolved CO_2) agree well with calculated X H_2O values of .90-.98. The fluids unmixed as the schists were uplifted and cooled; fluid inclusions trapped during this stage outline a solvus in the CO_2-H_2O-NaCl system. A later influx of fluid (immiscible low salinity aqueous and mixed CO_2-CH_4) accompanied formation of andalusite-bearing plagioclase-rich segregations. The restricted association of andalusite-bearing pods and low density fluids suggest a localized but pervasive fluid influx during uplift. The P-T conditions and fluid compositions at this stage require that the andalusite-plagioclase-quartz pods form by segregation in the presence of aqueous fluids, rather than by anatexis. (Authors' abstract)

CRERAR, D.A., WOOD, S.A., BRANTLEY, S.L. and BOCARSLY, A.B., 1984, Chemical controls on solubility of minerals in hydrothermal solutions (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p.

55. First author at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544.

The transport, deposition and zoning of hydrothermal ores is controlled by three main factors: the crystal chemistry and stability of the mineral phase, the physicochemical properties of aqueous electrolyte solutions at high T and P, and the thermodynamic and molecular properties of aqueous metal species. Recent solubility and spectroscopic data from our own and other laboratories permit the following generalizations on the chemistry of transition metal complexes at elevated temperatures. Bonding changes from primarily ionic to covalent across each transition row. The d^{10} transition metals behave more as Pearson soft bases, preferentially complexing with soft acids (electron donors) such as HS^-, while metals to the left show increasing "hardness" bonding to moderately soft electron donors such as Cl^-. The Pearson rule successfully describes speciation to about 250°C, but breaks down at higher T as all metals become harder, and electrostatic interaction increases. Recently recognized relativistic effects predict increased tendency towards covalent bonding down each vertical group of elements; this in part explains the preference of Au and Hg for HS^- complexes and the anomalous behavior of Sb and Bi. It has become increasingly apparent that ligation numbers decrease with temperature such that neutral complexes like $FeCl_2^0$ may predominate above roughly 250°C. This can be attributed to some or all of the following changes observed at increasing temperatures: decreasing dielectric constant of water; descent from octahedral to tetrahedral complex symmetry; pronounced decrease in activity coefficients of anionic ligands; increasing importance of hydrolysis. Increased solubility of ore minerals at higher temperatures can be attributed to many of the above effects; a previously overlooked and equally important explanation is the rise in pH buffering capacity of the solvent which dramatically increases corrosive capability. (Authors' abstract)

CROCKET, J.H. and LAVIGNE, M.J., Jr., 1984, Sulphur sources in the Dickenson gold mine as suggested by sulphur isotopes, in Gold '82: the geology, geochemistry and genesis of gold deposits, ed., R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1), p. 417-433.

CUNNINGHAM, C.G. and BARTON, P.B., Jr., 1984, Recognition and use of paleothermal anomalies as a new exploration tool (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 481.

CUNNINGHAM, C.G., RYE, R.O., STEVEN, T.A. and MEHNERT, H.H., 1984, Origins and exploration significance of replacement and vein-type alunite deposits in the Marysvale volcanic field, west central Utah: Econ. Geol., v. 79, no. 1, p. 50-71. First author at U.S. Geol. Survey, Mail Stop 913, National Center, Reston, VA 22092.

Replacement and vein-type alunite deposits formed in two significantly different epithermal environments in the Marysvale volcanic field of Utah. Alunite deposits, replacing intermediate composition lava flows, formed 23 m.y. ago in near-surface, highly oxidizing conditions at the tops of hydrothermal plumes that were spaced at 3- to 4-km intervals around a monzonite stock. The deposits are horizontally zoned outward, from alunitic cores to kaolinitic and propylitic envelopes, and are vertically zoned from a lower pyrite-propylite assemblage upward through assemblages dominated by alunite, jarosite, and hematite to a flooded silica cap. The $\delta^{34}S$ values of 11.5 to 15.4 per mil for replacement alunite along with geologic constraints indicate that sulfate sulfur was derived from underlying Mesozoic evaporites. The $\delta^{34}S$ values of -15.3 to +5.1 per mil of underlying pyrite, however indicate that reduced sulfur, necessary to produce low pH during oxidation, either was produced by partial reduction of the evaporite sulfate or came from another source. The transition from the pyrite-propylite zone to the alunite zone probably marks the paleoground-water surface.

In some localities, deposits of natroalunite, the sodium-rich analog of alunite, are superimposed upon the alunite deposits. In each case, the $\delta^{34}S$ values of the natroalunite (-5.5 to 0.7‰) are distinctly lower than those of the alunites and indicate a nonevaporitic source of sulfur. Field relations and radiometric ages indicate that the natroalunite is significantly younger than the alunite and related to entirely separate thermal events. The source of high Na/K in solutions that is required to form natroalunite may have been halite-rich evaporites in the underlying Mesozoic sedimentary rocks.

Vein-type alunite deposits formed 14 m.y. ago as open-space fillings in extension fractures above a concealed stock. Crystals of alunite grew inward from the walls, forming veins of nearly pure alunite as much as 20 m thick. Fluid inclusions in the alunite contain low density vapor indicating crystallization in a wet-steam geothermal system. The $\delta^{34}S$ values near zero per mil indicate that the vein-type alunite sulfur probably had a magmatic source, and it appears that the sulfur may have been present as SO_2 shortly after degassing from the magma. Similar $\delta^{34}S$ values (near 0%) characterize sulfide minerals in base and precious metal deposits surrounding the alunite deposits.

The presence of sedimentary sulfur in the replacement alunite deposits indicates that the fluids involved in hydrothermal systems related to the 23-m.y.-old stock interacted with the sedimentary rocks beneath the volcanic field where they may have formed skarn and replacement deposits. Although they have a different sulfur source, deposits of a similar type may be related to the systems that formed the later natroalunite deposits. The probable magmatic orign for sulfur in the 14-m.y.-old vein-type alunite and its deposition from vapor-rich fluids, as well as the probable magmatic origin for sulfur in the surrounding base and precious metal deposits, suggest that the underlying stock may host porphyry-type deposits. (Authors' abstract)

CURRIE, K.L., 1984, A note on the solubility of quartz in supercritical water; in Current Research, Part B: Geol. Surv. Canada, Paper 84-1B, p. 369-372.

d'ANGELO, W.D., DORRZAPF, A.F., Jr. and DOUGHTEN, M.W., 1984, Analysis of fluid inclusions by inductively coupled plasma atomic-emission spectroscopy and ion chromatography (abst.): 26th Rocky Mountain Conf., Denver, Colorado, Aug. 5-9, 1984, Rocky Mountain Sec., Soc. for Applied Spectroscopy and the Rocky Mountain Chromatography Discussion Group, Progam and Abstracts, p. 144. Authors at U.S. Geol. Survey, 923 National Center, Reston, VA 22092.

Inductively coupled plasma atomic emission spectroscopy (ICP-AES) and ion chromatography (IC) were used to determine the cationic and anionic composition of 27 fluid inclusions from salt from the Palo Duro basin in Texas. Sample sizes ranged from 0.21 to 40 µl. Each sample was diluted to 1-ml with distilled water. Half of the 1-ml diluted sample was further diluted 1:1 with 10% (v /v) HCl and analyzed by ICP-AES for Na, K, Mg, and Ca. The remaining half of the 1-ml sample was diluted 1:1 with a mixture of 0.006 M $NaHCO_3$ and 0.0048 M Na_2CO_3 to give a final concentration of

HCO_3^- and CO_3^{2-} in the sample equal to that of the IC eluent, thus eliminating the water dip. This aliquot then was analyzed by IC for F^-, Cl^-, Br^-, and SO_4^{2-}. Because of the multi-element capabilities of ICP-AES and IC, a smaller amount of sample was used than is required for single-element determinations, and the dilution was kept to a minimum. For 14 of the samples, the average charge balance (anions/cations) was 1.06 ± 0.10, and the range was 0.86 to 1.19. (Authors' abstract)

DARDENNE, M.A. and SAVI, C.N., 1984, Geology and geochemistry of fluorite veins of Segunda Linha Torrens e Cocal-SC: Revista Brasileira de Geoci., v. 14, no. 2, p. 120-127 (in Portuguese). First author at Dept. Geoci., Univ. Brasilia. CEP 70910, Brasilia, DF, Brasil.

In the fluorite province of Southern Brazil (Santa Catarina State), the mineralized veins are positioned in open NS to N30E trending faults. Those faults are open fractures in the crystalline basement (granites and quartz-monzonites of the Upper Proterozoic), that form a paleogeographic high, limiting the eastern edge of Paraná Basin. The mineralized faults also cut across Eocambrian porphyry-quartz dikes, Upper Carboniferous sediments of Itararé Group and Upper Cretaceous diabase dikes. The fluorite veins show a symmetrical and/or assymmetrical simple zonation, characterized by banded fluorite, fine and coarse breccias, "cocardes" and associated geodes. Fluorite samples are green, light-yellow and white in color, and are found associated with chalcedony, quartz, barite, pyrite, kaolinite and more rarely galena. Precipitation of fluorite occurred in melange zone between rising hydrothermal fluids and connate water in sediments of the Itararé Group, that is underlain by crystalline basement. The formation of fluorite veins is linked to the evolution of the rifting event that separated the South American and African continents, probably from the end of Cretaceous to the beginning of Tertiary. The origin of fluids investigated by oxygen and sulphur isotope studies in barite, fluid inclusions in fluorite and rare earth distribution in various types of fluorite samples, is related to convective circulation of superficial waters percolating at depth, which are then heated, starting the leaching of fluorine from basement rocks and depositing fluorite during the ascending process towards the surface. (Authors' abstract)

DARIMONT, Anne, 1984, Fluid inclusion study of Ba, F(Zn, Pb) mineralizations from the metallogenic district in south Belgium: Bull. Minéral., v. 107, p. 227-232 (in French; English abstract). Author at Lab. Géol. Appliquée, 45, avenue des Tilleuls, B 4000 Liège, Belgique.

Vein-type mineralizations of Ba, F(Zn-Pb) in Devonian (Frasnian, Givetian) carbonate host rocks from the metallogenetic district of South Belgium, are studied by fluid inclusions. The paragenetic sequence determined by petrographic studies at Beauraing is listed as follows: sphalerite-fluorite I, calcite-fluorite II, barite-galena. Te values are lower than -50°C. Th and Tm ice are: sphalerite (110°C, -15°C), fluorite I (75°C, -23°C), calcite (140°C, -4°C), fluorite II (125°C, -2°C) and barite (<50°C, -6°C). $NaCl-CaCl_2-H_2O$ solutions represent fairly well the composition of the mineralizing brines; in sphalerite, the molality in Cl^- ions is around 4.4; and the salinity is comprised between 10 and 14% NaCl with 10 and 6% $CaCl_2$.

The observations on fluorite II, characterized by Th = 125°C and Tm = -2°C, in the whole district attests to the regional distribution of the fluid responsible for this episode. This study enables the reconstitution of thermobarometric evolution. The crystallization of sphalerite and fluorite I takes place around 1000 bars and 180°C, as shown by the intersection of their respective isochores in P-T diagram. Deposition of calcite and fluorite II, characterized by the highest filling temperatures is suggested as a consequence of later reopening of veins, with subsequent decrease in pressure. Barite and galena represent the low temperature final stage. (Author's abstract)

DAVIDSON, D.W., HANDA, Y.P., RATCLIFFE, C.I., TSE, J.S. and POWELL, B.M., 1984, The ability of small molecules to form clathrate hydrates of structure II: Nature, v. 311, p. 142-143. First author at Div. Chem., Nat'l. Res. Council of Canada, Ottawa, Canada K1A 0R9.

Since gas hydrates were shown in the mid-1950s to be water clathrates of two distinct crystallographic structures, it has been generally accepted that structure I hydrates are formed by molecules with maximum van der Waals diameters of up to about 5.8 A while structure II hydrates are formed by larger molecules, up to about 7.0 A in size. No exception to this general rule has been observed among more than 100 individual species of molecules known to form clathrate hydrates. From X-ray and neutron diffraction studies we now find, however, that the two smallest molecules which form clathrate hydrates - argon and krypton - do so in the structure II modification. This finding supports a suggestion of Holder and Manganiello. (Authors' abstract)

DAVINA, O.A., YEFIMOV, M.Ye., MEDVEDEV, V.A. and KHODAKOVSKIY, I.L., 1983, Thermochemical determination of the stability constant of $UO_2(CO_3)^{4-}_{3(sol)}$ at 25-200°C: Geokhimiya, no. 5, p. 677-684 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 3, p. 10- , 1984).

DAWSON, J.B., 1984a Contrasting types of upper-mantle metasomatism?, in Kimberlites, v. II: The mantle and crust-mantle relationships, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 289-294.

Metasomatism is now well-recognized in upper-mantle peridotite xenoliths in kimberlites and basalts. It is patent when petrographically recognizable by development of hydrous phases rich in incompatible elements, usually by replacement of anhydrous phases and sometimes associated with injection of fluids into channelways. The case is examined for a more subtle cryptic metasomatism causing incompatible-element enrichment in the absence of replacement and injection features. More chronological data are needed to assess whether the chemical and physical effects of metasomatism (enhanced heat production, lowering of the solidus, decreased gravitational stability) can be correlated with known magmatic and tectonic events. (Author's abstract)

DAWSON, J.B., 1984b Xenoliths in kimberlites: clues to the Earth's upper mantle: Sci. Prog., v. 69, no. 273, p. 65-81. Author at Dept. Geol., The Univ., Sheffield S1 3JD, England.

Blocks of the upper mantle, brought to the Earth's surface during kimberlite eruptions, indicate that this deep layer of the Earth is lithologically complex. Although olivine-rich peridotites predominate, there are many mineralogical and textural variants. Eclogites, although relatively rare, confirm the complexities observed in the peridotites. Some of the complexities have been caused by kinetic deformation, fluid migration and magma intrusion. Although these processes have largely obliterated old fabrics and isotopic ages, the xenolith suites include some ancient relicts from the early stages of the Earth's history. (Author's abstract)

DEICHA, G.A. and PROUVOST, J., 1984, Scanning electron microscopy applied to crystallogenetic disequilibrium in the evolution of veils of fluid inclusions: 27th Int'l. Geol. Congress, Abstracts, v. 5, p. 33 (in French). First author at Univ. P. & M. Curie, Lab. Géol. Appliquée, Paris, France.

Nonequilibrium processes typically apply to the trapping of fluids during the healing of fractures, leaving evidence of both corrosion and deposition in the fluid inclusions. Scanning electron microscopy is well suited to studying the factors which may control the number, dimensions, morphology and other characteristics of cavities formed by such dynamic processes. The case studies reported address the relationships between "pseudo-primary" and "pseudo-secondary" inclusions, with special reference to porphyry copper deposits. (From the authors' abstract, translation courtesy M.J. Logsdon)

DEINES, Peter, GURNEY, J.J. and HARRIS, J.W., 1984, Associated chemical and carbon isotopic composition variations in diamonds from Finsch and Premier kimberlite, South Africa: Geochimica Cosmo. Acta, v. 48, p. 325-342. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

The carbon isotopic composition of 66 inclusion-containing diamonds from the Premier kimberlite, South Africa, 93 inclusion-containing diamonds and four diamonds of two diamond-bearing peridotite xenoliths from the Finsch kimberlite, South Africa was measured. The data suggest a relationship between the carbon isotopic composition of the diamonds and the chemical composition of the associated silicates. For both kimberlites similar trends are noted for diamonds containing peridotite-suite inclusions (P-type) and for diamonds containing eclogite-suite inclusions (E-type): Higher $\delta^{13}C$ P-type diamonds tend to have inclusions lower in SiO_2 (ol), Al_2O_3 (opx, gt), Cr_2O_3, MgO, Mg/(Mg + Fe) (ol, opx, gt) and higher in FeO (ol, opx, gt) and CaO (gt). Higher $\delta^{13}C$ E-type diamonds tend to have inclusions lower in SiO_2, Al_2O_3 (gt, cpx), MgO, Mg/(Mg + Fe) (gt), Na_2O, K_2O, TiO_2 (cpx) and higher in CaO, Ca/(Ca + Mg) (gt, cpx).

Consideration of a number of different models that have been proposed for the genesis of kimberlites, their xenoliths and diamonds shows that they are all consistent with the conclusion that in the mantle, regions exist that are characterized by different mean carbon isotopic compositions. (Authors' abstract)

DE JONG, A.F.M. and SALEMINK, J., 1984, O-18/O-16 and fluid inclusion data from skarn and ore deposits at Seriphos, Greece (abst.): Terra Cognita, v. 4, no. 2, p. 216-217. Authors at Inst. Earth Sci., P.O. Box 80021, 3508 TA Utrecht, The Netherlands.

On the island of Seriphos, Cyclades, Greece, the intrusion of a granodiorite produced extensive skarn and (iron) ore deposits. The occurrence of bleached zones along fractures in the magmatic rocks indicates that the skarn and ore components were leached from the granodiorite and deposited in the adjacent country rocks. Oxygen isotopes and fluid inclusions were studied to unravel the chronological evolution in the metasomatic solutions during the progressive hydrothermal cooling of the intrusive systems.

Melting relations in primary fluid inclusions in quartz grains from unaltered hornblende-biotite-granodiorite indicate that the 'primary magmatic fluids' were hydrous $NaCl-KCl-CaCl_2-MgCl_2$ solutions with a total salt content of 45-40 eq.wt.% NaCl. Quartz grains from quartz-albite-sericite assemblages of the bleached granodiorite contain fluid inclusions with a very similar composition and a total salt content of 40-35 eq.wt.%

NaCl. In both rock types the homogenization temperatures of the fluid inclusions are T(h) = 250-300°C. The comparable whole rock $\delta^{18}O$-values of 9.3‰ for the unaltered granodiorite to 10.0% for the altered rocks suggests that the leaching occurred at a low water/rock ratio (fig. 2).

In early formed hedenbergite-andradite skarns primary fluid inclusions in coexisting quartzes contain 'magmatic' $NaCl-KCl-CaCl_2-MgCl_2$ solutions with a total salt content of about 35-30 eq.wt.% NaCl and T(h) = 300-350°C. Isotopic data indicate a formation of these skarns at temperatures around 550°C from hydrous solutions with $\delta^{18}O = 10-12‰$.

In medium temperature quartz-epidote assemblages fluid inclusions contain total salt concentrations of 25-23 eq.wt.% NaCl. Quartzes coexisting with actinolite-calcite-magnetite/hematite parageneses have primary fluid inclusions with 20-18 eq.wt.% NaCl and T(h) = 300°C. The $\delta^{18}O$-values of coexisting pairs of magnetite and quartz from these MT-skarns point to equilibrium formation temperatures of about 400°C and to an isotopic composition of the water phase between 9.0 and 6.0‰.

In late stage pyrite-quartz, fluorite and barite deposits the total salt content of the primary fluid inclusions further decreases from around 20 eq.wt.% NaCl to less than 15 eq.wt.% NaCl. The homogenization temperatures of the inclusions at the same time decrease from around 250°C to some 100°C. The isotopic composition of the coexisting water phase gradually decreases from $\delta^{18}O = 6‰$ to $\delta^{18}O$-values approaching 0‰.

The uniform homogenization temperatures of around T(h) = 300°C of the fluid inclusions in the magmatic rocks as well as in the HT- and MT-skarns evidence a formation process whereby the hydrothermal solutions remained largely along the same isochore ($\rho = 0.75$ gr/cm^3) as the formation temperatures dropped. The gradually decreasing total salt content and $\delta^{18}O$-values of the metasomatic solutions confirm that the metasomatic mass exchange system at Seriphos was a largely closed system; there was a continuous reequilibration of the fluids as metasomatism progressed.

We conclude that the skarn and ore deposits at Seriphos were formed from a limited amount of solutions that percolated along the cracks and fractures in the solid rocks. The fluids originated from degassing of the granodioritic magma. (Authors' abstract)

DELANO, J.W., 1984, Vesicles in four varieties of Apollo 15 volcanic glass (abst): Lunar and Planet. Sci. XV, p. 218-219.

DEMIN, Yu.I., 1984, Thermal regime of granitoids and their associated mineralization: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 281-287. Author at Moscow State Univ., Moscow, USSR.

Includes some discussion of Th for melt inclusions in quartz and feldspar (from the literature?).

See also Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 53. (E.R.)

DENNIS, P.F., 1984. Oxygen self-diffusion in quartz under hydrothermal conditions: J. Geophys. Research, v. 89, no. B6, p. 4047-4057. Author at Dept. Geol., Imperial College.

Oxygen self-diffusion, D_{OX}, has been monitored in single-crystal quartz in the temperature range 515°-850°C under hydrothermal conditions. In the beta field, between 700° and 850°C, the data are represented by two linear Arrhenius relations for transport parallel and perpendicular to c. Values for D_0 ($m^2\ s^{-1}$) are 2.09×10^{-11} parallel to c and 3.16×10^{-10} perpendicular to $(10\bar{1}0)$. Values for ΔH ($kJ\ mol^{-1}$) are 138.54 parallel to c and 203.72 perpendicular to $(10\bar{1}0)$. At 700°C, in the total presusre range 11.5-100 MPa, D_{ox} is independent of water ($f(H_2O)$) and oxygen ($f(O_2)$) fugacities between the Ni-NiO and Fe_3O_4-Fe_2O_3 buffers. The results are consistent with diffusion via a simple charged vacancy mechanism under an extrinsic point defect regime. Further experiments are required to confirm the nature of the mobile oxygen defect. A key aspect of the results is the observation that at the low water fugacities of the present experiments a hydrogen-containing defect appears to play no role in the oxygen transport mechanism. This is in contrast to other published sets of data and leads directly to the requirement for detailed interlaboratory comparisons. (Author's abstract)

DENNIS, P.F., 1984, Oxygen self diffusion in quartz: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 260-265. (See previous item.)

DES MARAIS, D.J., 1984, Isotopically light carbon in midocean ridge basalts - fact or artifact (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 486-487.

DES MARAIS, D.J. and MOORE, J.G., 1984, Carbon and its isotopes in mid-oceanic basaltic glasses: Earth & Planet. Sci. Letters, v. 69, p. 43-57. First author at NASA-Ames Res. Center, Moffett Field, CA 94035, USA.

Three carbon components are evident in eleven analyzed mid-oceanic basalts: carbon on sample surfaces (resembling adsorbed gases, organic matter, or other non-magmatic carbon species acquired by the glasses subsequent to their eruption), mantle carbon dioxide in vesicles, and mantle carbon dissolved in the glasses. The dissolved carbon concentration (measured in vesicle-free glass) increases with the eruption depth of the spreading ridge, and is consistent with earlier data which show that magma carbon solubility increases with pressure. The total glass carbon content (dissolved plus vesicular carbon) may be controlled by the depth of the shallowest ridge magma chamber. Carbon isotopic fractionation accompanies magma degassing; vesicle CO_2 is about 3.8‰ enriched in ^{13}C, relative to dissolved carbon. Despite this fractionation, $\delta^{13}C$(PDB) values for all spreading ridge glasses lie within the range -5.6 and -7.5, and the $\delta^{13}C$ (PDB) of mantle carbon likely lies between -5 and -7. The carbon abundances and $\delta^{13}C$(PDB) values of Kilauea East Rift glasses apparently are inflenced by the differentiation and movement of magma within that Hawaiian volcano. Using ^3He and carbon data for submarine hydrothermal fluids, the present-day mid-oceanic ridge mantle carbon flux is estimated very roughly to be about 1.0×10^{13} gC/yr. Such a flux requires 8 Gyr to accumulate the earth's present crustal carbon inventory. (Authors' abstract)

DEVINA, O.A., KUYUNKO, N.S., YEFIMOV, M.Ye., MEDVEDEV, V.A. and KHODAKOVSKIY, I.L., 1983, The thermodynamic parameters of BF_4^- and boron hydroxyfluoride complexes in aqueous solution at 25-300°C: Geokhimiya, no. 8, p. 1150-1159 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 4, p. 132-142, 1984). Authors at Vernadskiy Inst. Geochem. and Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Measurements have been made on the enthalpy of solution of $KBF_{4(c)}$ in NaF solutions up to μ =0.7 in an LKB-8700 solution calorimeter at 25, 35, 45, and 60°C. The measurements and published data have been used to calculate the thermodynamic parameters of $BF^-_{4(sol)}$ and of boron hydroxyfluoride complexes at 25-300°C. (Authors' abstract)

DE VIVO, Benedetto, 1984, Inclusion fluids in minerals: Le Scienze, No. 186, Feb. 1984, p. 30-40 (in Italian).

A review of fluid inclusion research. (E.R.)

DE VIVO, Benedetto and LATTANZI, Pierfranco, 1984, Applications of the study of fluid inclusions to the investigations of geothermal fields: Rendiconti della Societa Italiana di Mineral. & Petrol., v. 39, p. 393-400 (in Italian; English abstract). First author at Centro di Geocronologia e Geochim. della Formazioni recenti del C.N.R., Citta Univ., Piazza Aldo Moro, 00185, Rome.

The fluid inclusions in minerals are the most direct witness of the fluid phase with which the minerals interacted at the moment of their formation (primary inclusions) or in a subsequent age (secondary inclusions). Hence, fluid inclusion studies in minerals formed by interaction between hydrothermal fluids and wall rocks in geothermal fields make possible the reconstruction of the fluid characteristics present in the past in the geothermal field. By comparing such characteristics with those of present geothermal fluids, the past evolution of the geothermal fluids and the past evolution of the geothermal field can be traced and hypotheses about its future evolution formulated.

As examples, results obtained on the geothermal fields of Broadlands (New Zealand), Los Alamos (New Mexico) and Larderello (Tuscany) are reported. In particular, the data obtained on the fluid inclusions of Larderello show that the present fluid, in agreement with the generally accepted models, made up essentially of superheated steam, may derive from the boiling of a liquid phase initially dominant. (Authors' abstract)

DIDENKO, A.V., 1984, Formation conditions of carbonaceous matter and minerals in mercury deposits of Transcarpathia (based on results from study of inclusions): Deposited Doc. 1984, VINITI 4926-84, p. 119-125 (in Russian).

Th and pH of gas-liquid inclusions in elongate prismatic quartz from the Hg ore deposits are 170-160° and 7.0-7.1, respectively, in crystals with a hexagonal cross section and ~260° and 6.6-6.7, respectively, in crystals with a trigonal cross section. In the inclusions, liquid carbonaceous matter (CM) envelops gas bubbles or occurs as droplets in aqueous solutions. In UV light these droplets luminesce yellowish brown and are classified as heavy petroleum. Liquid CM filling voids in altered quartz diorite porphyries has the elemental composition C 85.2, H 8.35, O + N + S 6.45%. IR spectra of liquid CM indicate the presence of arom. compounds, carbonyl compounds, and aliph. compounds with CH_2- and CH_3-groups. Mass spectrometric studies of the gas phase in inclusions determined the range in composition. CO_2 49.5-94.01, N_2 2.83-33.45, CH_4 2.8-28.8, H_2 0.34-41.6, and $C_2H_6 \leqslant 1.81\%$. The CM and Hg ore mineralization are closely related and were transported together in fluids, possibly in organometallic complexes. The Hg ore-forming minerals were derived from neutral-slightly alkaline solutions, with cinnabar, marcasite, and calcite crystallizing at 160-120°. The CM, including parafins, idrialite, and karpatite, formed after the deposition of cinnabar, from slightly alkaline solutions at 120 to 60°. (C.A. 103: 56981h)

DILLES, J.H., 1984, The petrology and geochemistry of the Yerington batholith and the Ann-Mason porphyry copper deposit, western Nevada: Ph.D. thesis, Stanford Univ., Stanford, CA, 462 pp.

Field, petrologic, and geochemical data presented herein constrain the origin of porphyry copper mineralization in the Jurassic Yerington batholith. The batholith, with 58-68% SiO_2, Peacock index ~56, high K_2O (3.0 wt% at 60% SiO_2), high strontium (~1100 ppm), and low initial strontium isotopic composition (0.7040), is similar to high-K orogenic andesites. Three major units were emplaced, from oldest to youngest: granodiorite, quartz monzonite, and porphyritic quartz monzonite (PQM), including porphyry. They show progressive decrease in volume, increase in depth of roof emplacement (<1, 1-2, >3 km, respectively), increase in grain size, and increase in silica content (~60, ~66, ~68 wt% SiO_2, respectively). Two concordant U-Pb zircon dates of 169 m.y.b.p. on granodiorite and 168 m.y.b.p. on mineralized quartz monzonite porphyry (QMP) indicate the batholith was emplaced within one million years. Phase petrology, stable isotopes, and both iron-titanium oxide and biotite compositional data indicate each plutonic unit crystallized while water-saturated at relatively high oxygen fugacities to the solidus at 700 ± 25°C, and that minerals reequilibrated to 500 ± 50°C during cooling in the presence of a magmatic water phase.

Hydrothermal alteration affected ~25 km^3 of rock at the Ann-Mason porphyry copper deposit. Main stage biotite (potassic) alteration and copper mineralization was contemporaneous with a central QMP dike swarm and was accompanied by flanking/deeper oligoclase-actinolite (sodic-calcic) alteration. Both alterations contain high salinity fluid inclusions trapped at 300-480+°C, but field relations, petrology, and stable isotope data suggest that magmatic fluids caused potassic alteration, whereas largely non-magmatic fluids, flowing up a temperature gradient, caused sodic-calcic alteration. Late stage albite-chlorite and lesser sericitic alterations cut main stage alteration, have pyritic mineralization, and contain low salinity fluid inclusions that homogenize at 150-250+°C. Stable isotope data and phase petrology suggest that late stage fluids were either ocean water or isotopically heavy meteoric water. I propose that most of the copper in the deposit came from a high salinity, water-rich magmatic fluid that separated from the crystallizing PQM/QMP magma, but that up to 16% may have been derived from leaching during sodic-calcic alteration. (Author's abstract)

DING, T. and REES, C.E., 1984, The sulphur isotope systematics of the Taolin lead-zinc ore deposit, China: Geochimica Cosmo. Acta, v. 48, p. 2381-2392. First author at Inst. Geol. of Mineral Deposits, Chinese Acad. Geol. Sci., Baiwanchuan Fuchenmen Wai, Beijing, PRC.

See next item. (E.R.)

DING, T.P., REES, C.E., SCHWARCZ, H.P., YONGE, C. and McMASTER, D., 1984, Stable isotope studies of the Taolin Pb-Zn deposit China (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 490. First author at Inst. Geol. & Mineral Deposits, Chinese Acad. Sci., Beijing, China.

The Taolin deposit consists of a series of hydrothermal veins. Taken together with δD of fluid inclusions, the data show that hydrothermal fluid was initially of magmatic composition but, as it cooled, it mixed with meteoric waters. A post-ore calcite-quartz assemblage was precipitated from essentially pure meteoric water. (From the authors' abstract)

DING, T.P. and RYE, R.O., 1984, Stable isotope studies of the Xihuashan tungsten ore deposit, Jiangxi, China (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 250-251 (in English). First author at Inst. Mineral Deposits, Chinese Acad. Geol. Sci., Beijing, China.

The Xihuashan quartz-wolframite deposit in Jiangxi, China, consists of over 600 steeply dipping quartz veins in the upper part of a complex biotite granite stock that intrudes Cambrian pelitic rocks.

The granite has an isochron age of 157 ± 13 m.y. and initial $^{87}Sr/^{86}Sr$ ratio of 0.7199. The $\delta^{18}O$ data on the stock indicate post-crystallization exchange with $\delta^{18}O$-depleted meteoric water. Whole rock and quartz $\delta^{18}O$ values suggest that the biotite granite may have S-type characteristics. The $\delta^{18}O$ data on quartz, wolframite, sericitized potassium feldspar, and muscovite from the veins and associated greisen envelopes, indicate deposition from fluids displaying a remarkable narrow range of $\delta^{18}O$ H_2O and temperature throughout vein formation and greisenization. The $\delta^{18}O$ H_2O of the hydrothermal fluids can be calculated to have been 3.14 ± 1.6. It is likely that the fluids contained an observable component of highly exchanged meteoric water. Most of the δD-H_2O values of the fluids are in the range typical of magmatic fluids and therefore cannot be used to sort out magmatic and meteoric water components without a more detailed study. Sulfur isotope data on sulfides, however, indicate that sulfide sulfur was derived from a deep seated igneous source. (Authors' abstract)

DINGWELL, D.B., HARRIS, D.M. and SCARFE, C.M., 1984, The solubility of H_2O in melts in the system SiO_2-Al_2O_3-Na_2O-K_2O at 1 to 2 kbars: J. Geol., v. 92, no. 4, p. 387-395. First author at Exper. Petrol. Lab., Dept. Geol., Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada.

The solubilities of water in six melts in the system K_2O-Na_2O-Al_2O_3-SiO_2 were determined at 970-1630 bars and 800°C. Melts were synthesized hydrothermally in Pt capsules in cold-seal vessels and then quenched isobarically. The solubilities were determined by micromanometric measurement of H_2O evolved during vacuum fusion of vesicle-free glass wafers and are reproducible to ±2.8% (2 s.d.) of the concentration. The solubilities at 970 bars for the granitic and phonolitic minimum melts are 2.88 ± 0.10 wt % and 5.01 ± 0.14 wt %, respectively. Both peralkaline and peraluminous granitic melts have higher H_2O solubilities than the 1 kbar $P(H_2O)$ minimum melt and indicate the existence of minima in solubilities at molar (Na = K)/Al = 1 along joins of constant SiO_2. Two melts at constant SiO_2 and (Na + K)/Al ratio, but varying in Na/(Na + K) (0.57, 0.69 molar), have the same solubility (2.88 ± 0.10, 7.64 ± 0.10 wt %). The compositional dependence of solubilities for peralkaline and peraluminous melts is not predicted by the solubility mechanism and calculation method of Burnham (1975, 1979, 1981) that was developed for metaluminous melts. The pressure dependence of solubility was investigated for a peralkaline melt with six determinations at four pressures from 970 to 1620 bars. The mole fraction of dissolved water (based on 8 moles of O) for this melt is proportional to the square root of the fugacity of water; the root mean square deviation from linearity is 1.4% and is equal to the analytical precision (1 s.d.). Our data for the haplogranite minimum are lower than some other determinations; however, the limitations of the various methods for determining solubilities in melts make detailed comparisons with our data difficult. The solubility of water in a Bishop Tuff melt was estimated from our measurements and used with direct measurements of H_2O in rhyolitic melt inclusions (4.9 ± 0.5 wt %, Druitt et al. 1982) to obtain the minimum pressure of water (2100 ± 300 bars) and a minimum depth (8 ± 1 km) of crystallization. (Authors' abstract)

DOBRETSOV, N.L., LITVINOVSKY, B.A. and REYF, F.G., 1984, The model of the fluid syntexis and ore-bearing granitoidal magmas (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 294. Authors at Geol. Inst. Buryat Div. of Siberian Br. USSR Acad. Sci., Ulan-Ude, USSR. Continued next page.

The data of the thermobarometry, geology and mineralogy show that only those intrusions or their parts bear W-Mo mineralization, in which the distillation begins at an early magmatic stage. In such hypabyssal and mesoabyssal intrusions the magma contains not 2-3% of H_2O, as usually, but 4.5-5%, in the late phases the content of H_2O increases up to 7%. Th of the melt inclusions in the intratelluric phenocrysts is 700-800°C, that determines the lower temperature limit of the formation of the magma. (From the authors' abstract)

DOBSON, D.C., 1984, Geology and geochemical evolution of the Lost River, Alaska, tin deposit: Ph.D. thesis, Stanford Univ., Stanford, CA, 162 pp.

Sn-W-Be-F and base metal mineralization at Lost River occurs in stockwork vein skarn, greisen and breccia within and above the cupola of a late Cretaceous granite which intrudes Ordovician limestone. The stock was emplaced at a shallow level in a setting characterized by minor normal faulting, but without metamorphism or major deformation. Major and minor element analyses indicate that mineralized intrusions at Lost River, and elsewhere on the northern Seward Peninsula, were highly evolved granites derived from sialic crust. The earliest partial melts were apparently felsic plutons which fractionated, probably by volatile-related mechanisms, to yield volumetrically small tin-bearing stocks.

Alteration in the limestone commenced with "anhydrous" skarn assemblages characterized in sequence by: (1) andradite; (2) fluorite + idocrase + magnetite; and (3) idocrase + subcalcic garnet ± fluorite and hornblende. Quartz + topaz + tourmaline + cassiterite + sulfide greisen within the granite was contemporaneous with fluorite + biotite + hornblende + sulfide + cassiterite vein formation in skarn. Further evolution resulted in deposition of mica-rich greisens at the apex of the cupola and margarite + muscovite + plagioclase alteration in the carbonates and skarn. Two breccia types cut all earlier assemblages. The first barely post-dated mica greisen, and consists of fragments of skarn, limestone and igneous rocks in a muscovite + zinnwaldite matrix. Kaolinite-matrix breccias are the last hydrothermal event noted.

Fluid inclusion studies suggest that early skarns formed from fluids at 350-400°C with salinities declining from 15-18 wt % NaCl to 9-15 wt %. Approximately isothermal boiling of the fluids resulted in greisenization of the granite; concomitantly, residual fluids with enhanced salinity (18-21% NaCl) caused hydrous silicate (biotite or hornblende) deposition in skarn. Pressures indicatd by boiling inclusions are roughly 250-400 bars. Phase equilibria require that initial fluids were characterized by extremely low XCO_2, moderate to low fO_2 and fS_2 and relatively high fHF/fH_2O. Following greisen and hydrous skarn alteration, declining temperatures, and increases in XCO_2 and fO_2, resulted in the formation of margarite and plagioclase in veins in limestone and skarn. Late clay alteration probably occurred at $T \leq 250°C$.

Data from Lost River and other Sn-deposits suggests that sudden pressure variations, accompanied by fluid boiling, are a common prerequisite of Sn-mineralization. Thus, the search for Sn-deposits can probably be restricted largely to shallow environments, where rapid pressure fluctuation (with boiling) can occur via fracturing, and fluid communication with the surface. In the case of Sn-skarns, shallow levels are especially critical because early silicates (e.g., andradite and idocrase) may contain significant Sn. The deposition of recoverable Sn is therefore dependent on the destruction of those phases by later alteration which is best accomplished at shallow levels, as "deep" skarns seldom show significant retrograde alteration. (Author's abstract)

DOLGOV, Yu.A., BAKUMENKO, I.T., TOMILENKO, A.A. and CHUPIN, V.P., 1984, Metamorphic and magmatic mineral formation according to the thermobarogeochemical data: Geologiya i Geofizika, v. 25, no. 12, p. 41-54 (in Russian; translated in Soviet Geol. & Geophysics, v. 25, no. 12, p. 41-52, 1984).

This article synthesizes the results of thermobarogeochemical studies of inclusions in the minerals of metamorphic and igneous rocks. The compositions of the metamorphosing fluids and the PT-conditions of formation of the metamorphic rocks of different series of facies and of certain metamorphogenic ore deposits are established. In the case of the Kholodninskoe pyritic-polymetallic ore deposit, it was found that there is a regular change in composition of the fluid (from methane to carbon dioxide) along with a pressure drop from $(7.0\text{-}7.5)\cdot10^8$ Pa in the ore-free host rocks to $(3.0\text{-}3.5)\cdot10^8$ Pa in the ore bodies. Information is presented on the use of inclusions in impactites to study the processes and products of impact shock metamorphism. Examples of the use of solidified melt inclusions to ascertain the nature and conditions of formation of such genetically complex bodies as anatectites, granites, pegmatites, and alkalic rocks are cited. Cases of the liberation of gases from magmas of different compositions in various geologic situations have been established on the basis of the accompanying fluid inclusions. (Authors' abstract)

DOLGOV, Yu.A, TOMILENKO, A.A. and CHUPIN, V.P., 1984a Anatexis and metamorphism conditions according to inclusions in minerals (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 35-36 (in English). Authors at Inst. Geol. & Geophy. Siberian Br. USSR Acad. Sci., Novosibirsk, USSR.

1. Fluid composition and evolution in metamorphism and anatexis and P-T parameters of these processes during the formation of a number of migmatite-gneiss complexes of the Soviet Union, Mongolia, the GDR and India are determined by thermobarogeochemical methods. During granulite formation of the Aldan shield, Khan-Khukh-Ei ridge (Mongolia), and charnockites and gneisses of Kansk granulite complex (the Yenisei ridge), fluid pressure was 6-8 kbar. Higher fluid pressures (>15 kbar) are obtained for eclogite of Eastern Siberia and the GDR. Low-temperature generations and crystallization of anatectic melts under the conditions of amphibolite facies of Mama mica-bearing region in Trans-Baikal region (about 640°C), Mymchukur block in the Dzhungarsky Alatau and Gorny Altai series in the South Chuisky ridge (about 700°C), comparing to amphibolitic and granulitic facies of the Western part of the Aldan shield (for Upper Aldan suite accordingly 830-780 and 900-820°C) are obtained when studying inclusions of crystallized granitoid melts by the homogenization method. In the granulite facies melting low water content (about 2-3 weight %) and rather high CO_2 content (up to 0.6 weight %) are established. The data on the conditions of volatiles separation during anatectic melts crystallization are obtained. 2. Craters on the Moon, Venus, Mercury and Mars surfaces are of impact origin. On the Earth similar craters are mainly wiped out by exogenous processes. Several tens of young preserved craters have peculiar structure and minerals, characterizing the influence of high pressures and high temperatures. Target rocks undergo local impact metamorphism and transform into impact-metamorphic ones. Minerals develop jointing at impact. Higher pressure and temperature develop near joints, and that leads to the formation of melting inclusions in joints, having a ladder-like pattern and gas bubbles appearing at cooling. Such inclusions allow usual procedures for determining homogenization temperature. (Authors' abstract)

DOLGOV, Yu.A., TOMILENKO, A.A. and CHUPIN, V.P., 1984b Conditions of anatexis and metamorphism (according to the data on inclusions in minerals): Geologiya i Geofizika, v. 25, no. 8, p. 91-98 (in Russian; translated in Soviet Geol. & Geophysics, v. 25, no. 8, p. 82-88, 1984).

On the basis of a study of metamorphogenic inclusions (H_2O, CO_2, CH_4, N_2, and their mixtures) and of crystallized melt inclusions in the minerals of Precambrian migmatite-gneiss complexes, this article presents information on the PT-characteristics and evolution of the composition of fluids in metamorphism and anatexis in the deeper zones of the Earth's crust. The temperatures at which anatectic melts are generated and crystallized were found to be higher (900-810°C) in the granulite than in the amphibolite (830-640°C) facies. It is shown that in addition to essentially aqueous-saline and carbon-dioxide fluids, in certain geologic environments fluids of essentially hydrogen-hydrocarbon and nitrogen composition can be of independent significance in metamorphism. (Authors' abstract)

DONALDSON, C.H., 1984a Crystal dissolution rates in a basaltic melt: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 174-175.

DONALDSON, C.H., 1984b Textures resulting from partial crystal dissolution in basaltic melt: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 175-177.

DOROBEK, S.L., 1984, Evidence for post-cementation migration of high-temperture, high-pressure fluids--Siluro-Devonian Helderberg Group, central Appalachians (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). Author at Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.

Fluid inclusion data and fracture-filling cements in carbonate and siliciclastic rocks of the Siluro-Devonian Helderberg Group, central Appalachians, indicate post-cementation, late Paleozoic migration of high-pressure, high-temperature fluids.

Void-filling quartz and calcite cements contain secondary, 2-phase fluid inclusions that give freezing temperatures of -20 to -25°C (-4 to -13°F) (salinity >22 wt. % NaCl). Homogenization temperatures are 200 to 300+°C (392 to 572°F) (temperatures calibrated and pressure corrected) and greatly exceed maximum paleotemperatures (120 to 160°C; 248 to 320°F) given by conodont color-alteration index values or calculated from known sedimentary overburden. High homogenization temperatures suggest rapid movement of metamorphic fluids so that ambient burial temperature was not raised for long enough periods of time to affect conodont CAI values. These fluids probably came from Blue Ridge-Piedmont thrust sheets that were undergoing metamorphism during late Paleozoic deformation. These fluids migrated more than 75 km (47 mi) during thrusting.

Well-cemented sandstone and limestone have multiple crosscutting trains of secondary hydrocarbon inclusions. Some trains crosscut cement-filled fractures. Hydrocarbons also occur as thin films along cement crystal boundaries and as secondary inclusions trapped along calcite deformation twins. These inclusions indicate geopressured fluids moved along intercrystalline boundaries and along deformation twin planes in calcite under deep burial conditions either during or after deformation.

Rare fractures contain transported skeletal grains, "exotic" clasts, recemented clasts of fracture-filling cement, and mud. Cement clasts contain included mud and skeletal grains, and indicate several episodes of particle transport, cementation, and refracturing prior to final fracture filling. Primary(?) 2-phase fluid inclusions in vein-filling calcite give homogenization temperatures of 120 to 150°C (248 to 302°F). Coarse-grained "clastic" fracture fills indicate migration of rapidly moving fluids capable of transporting clasts through fracture conduits under deep burial conditions. (Author's abstract)

DOSTAL, J, DUPUY, C. and BOIVIN, P.A., 1984, Geochemistry and petrology of ultramafic xenoliths and their host basalts from Tallante, southern Spain (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 58. First author at Dept. Geol., St. Mary's Univ., Halifax, Nova Scotia, B3H 3C3, Canada.

Ultramafic xenoliths enclosed in Plio-Quaternary alkali basalts from the Tallante volcanic massif near Cartagne, southern Spain are composed mainly of spinel peridotites or pyroxenites, which typically show granular textures. In the abundant composite xenoliths, the spinel peridotite is cut by pyroxenite or diorite veinlets generally 0.2-0.3 cm thick. Spinel peridotites are made up of olivine (Fo 90-91), enstatite (En 90 Fs 9 Wo 1) with 3.5% Al_2O_3, diopside (En 48 Fs 4 Wo 48) with 5% Al_2O_3 and Cr-spinel. These rocks underwent subsolidus reequilibration at about 850°C. Spinel lherzolites are probably mantle residues modified to variable degrees by metasomatic fluid. Pyroxenites are composed of dominant clinopyroxene (En 43 Fs 10 Wo 47) and subordinate amounts of olivine, amphibole, phlogopite and plagioclase. Clinopyroxenites have both major and trace element compositions intermediate between spinel peridotites and hot basalts. Their origin involved crystal segregation from alkali basalt magmas formed earlier than the host basalts. Close to the contact with the veinlets, the spinel lherzolites are enriched in Ca, Fe and some incompatible elements including light REE. The concentrations of incompatible elements are generally decreasing with distance from the veinlets. Such variations probably resulted from the migration of a fluid from the veinlets into the surrounding lherzolites. The source for the host alkali basalts had a concentration of transition elements similar to those of the associated peridotite xenoliths but had significantly higher abundances of some incompatible elements particularly light REE. The alkali basalts were derived from a heterogeneous incompatible element-enriched upper mantle source probably similar in composition to the composite xenoliths. (Authors' abstract)

DREIBUS, G., JAGOUTZ, E. and WANKE, H., 1984, Halogen inventory in the Earth's mantle - crust system (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 254 (in English). Authors at Max-Planck-Inst. für Chemie, Mainz, FRG.

Analyses of primitive and unaltered spinel-lherzolites from different continental localities yielded very low concentrations of Cl, Br, and I. Spinel- and garnet-lherzolites as well as crustal composites contain Cl, Br, and I in chondritic (C 1) abundance ratios, which seem to be valid for the Earth as a whole. Today most of the Earth's inventory of Cl, Br and I resides in the crust; most of Cl and Br (in C 1 ratio) dissolved in seawater and I to 90% in sediments.

The very low I concentration in seawater makes the Cl/I and Br/I ratios to an indicator for rock/seawater interaction on a local and global scale. Halogens with the seawater pattern were found in alkali basalts, island basalts, kimberlites, ancient subaerial tholeiites and komatiites.

The corresponding I/La ratios in ancient subaerial basalts from Isua and modern submarine tholeiites indicate constant halogen concentrations in their source regions over geologic times. However, contrary to oceanic tholeiites the highly fractionated modern alkali basalts have about a factor 10 to 100 lower I/La ratios.

The extremely low concentrations of halogens observed in the mantle seems to support the proposition that after accretion the Earth's mantle acted as a sink and not as a source for volatiles. (Authors' abstract)

DREW, G.J. and BOTH, R.A., 1984, The carbonate-hosted silver-lead deposits of the Ediacara mineral field, South Australia: petrological, fluid inclusion and sulphur isotope studies: Australian J. Earth Sci., v. 31, p. 177-201. First author at Dept. Mines & Energy, 191 Greenhill Road, Parkside, SA 5063, Australia.

The Ediacara mineral field is situated 30 km W of Beltana on the western margins of the Flinders Ranges, South Australia, and consists of silver-lead and copper deposits in lower Cambrian carbonate rocks that contain anomalous base-metal contents throughout the Adelaide Geosyncline. The lower Cambrian rocks, which consist of the basal Parachilna Formation and overlying Ajax Limestone, rest disconformably on the Precambrian, and at Ediacara occupy a shallow N-S elongate syncline near the hinge zone of the Adelaide Geosyncline. The main primary ore minerals of the silver-lead mineralization are galena and pyrite, with very minor chalcopyrite and sphalerite, and rare tetrahedrite and pearceite. The gangue consists mainly of silica (both chalcedony and quartz), with minor dolomite and rare barite. The mineralization is stratabound and occurs in conformable zones, the lowest of which commences about 30-50 m above the base of the Cambrian sequence. The host to the silver-lead mineralization, the Ajax Limestone, can be subdivided into three units which represent a set of lithologies, structures and organic traces indicative of a shallow near-shore carbonate environment. The silver-lead mineralization is mainly present in sandy and laminated dolomites which are deposited in an environment ranging from sub-tidal to bar and channel and tidal flat, respectively. Four types of mineralization have been recognized: disseminated sulphides of syngenetic and/or diagenetic origin and epigenetic concentrations along stylolites, in veins and as breccia fillings. Post-depositional solution activity has affected a large proportion of the carbonate sequence. The effects of this activity range from stylolites through stylobreccias to solution collapse breccias. The epigenetic concentrations of mineralizations have apparently been formed by the remobilization of the disseminated sulphides during solution activity. The ore and gangue minerals of the epigenetic mineralization display both euhedral forms and distinct colloform banding, and framboidal textures have also been observed in both pyrite and galena. There is evidence of repeated episodic precipitation and no simple paragenetic sequence can be recognized. Fluid inclusions in silica and dolomite associated with the epigenetic mineralization have homogenization temperatures of 159 to 199°C and freezing temperatures that indicate the fluids to be saline brines containing NaCl with $CaCl_2$ and/or $MgCl_2$. Sulphur isotope analyses show a range of $\delta^{34}S$ values from -12.5 to -8.6 per mil, with no evidence of significant differences between the four types of mineralization. The data suggest deposition of the disseminated sulphides as a result of biological reduction of seawater sulphate in a system partially open with respect to sulphate supply. Subsequent remobilization of sulphides apparently involved little or no sulphur isotope fractionation. The Ediacara silver-lead deposits have many features in common with Mississippi Valley-type lead-zinc deposits and appear to have similarities in terms of genesis, in that the epigenetic mineralization has been formed as a result of post-depositional solution activity during diagenesis in a sedimentary basin. The scale of transport of the metals deposited as the epigenetic mineralization at Ediacara appears, however, to have been very much less than that of the metals in other Mississippi Valley-type deposits. (Authors' abstract)

DU, Shengbao, 1983, Distribution regularity and ore genesis of rock crystal deposits in Guangxi: Min. Deposits, v. 2, no. 1, p. 66-74 (in Chinese; English abstract). Author at Geol. Team No. 8, Geol. Bureau of Guangxi.

Apart from a few ores in the pegmatites within granites and in the contact zones of skarns, a substantial number of rock crystal deposits in Guangxi occur in various sedimentary rocks, especially in quartz veins and calcite veins in Upper Carboniferous carbonate rocks. The deposits are controlled by a combination of the latitudinal tectonic system, neocathaysian tectonic system and a NW trending structural zone, showing a distribution characterized by orientation, symmetry, equidistance and mosaic pattern. Of all inclusions, liquid inclusions are best developed, and a certain number of gaseous inclusions have also been recognized in some deposits. This implies that ores were formed mostly in an environment dominated by hydrothermal solutions and partly in the boiling state. Some inclusions contain a substantial amount of liquid carbonic acid, sometimes reaching as much as 30%; some have in them a lot of organisms of gas or liquid phase[sic]. Th are determined to be in the range of 107-420°C, salinities (NaCl wt%) 2.65-10.9, pressures 200-600 bar, and pH 7.04-7.16. Lead isotopes of certain deposits fall into anomalous limits, while δS^{34}, $\delta O^{18}_{H_2O}$ have the values of +18.18 - -10.37‰, 6.00 - 24.02‰ and 1.9 - 2.4‰ respectively. The above characteristics and data vary with regularity in keeping with the different geological settings of the deposits. The rock crystal deposits in Guangxi are thus divided genetically into three types: postmagmatic pneumato-hydrothermal deposits, deposits from underground hot waters, and transitional deposits formed by above two solutions mixed at various ratios. (Author's abstract)

DUBESSY, Jean, 1984, Simulation of chemical equilibria in the C-O-H system. Methodological consequences for fluid inclusions: Bull. Minéral., v. 107, p. 155-168 (in French; English abstract). Author at Centre de Recherches sur la Géol. de l'Uranium, B.P. 23, 54501 Vandoeuvre-lès-Nancy, France.

$\bar{V}$-X properties of fossil fluids trapped in fluid inclusions do not differ more than a few percent from the initial $\bar{V}$-X properties of the fluid at high pressure and temperature conditions of trapping. During cooling of a fluid inclusion containing graphite, the change of the $\bar{V}$-X properties of the fluid in equilibrium with graphite are related to the initial composition of the trapped fluid. No significant modification of the $\bar{V}$-X properties of the trapped fluid is observed if less than 30% of atomic hydrogen of the system is lost. (Author's abstract)

DUBESSY, Jean, GUILHAUMOU, Nicole, MULLIS, Joseph and PAGEL, Maurice, 1984, Identification, in fluid inclusions, of solid H_2S and CO_2 with similar melting temperature: Bull. Minéral., v. 107, p. 189-192 (in French; English abstract). First author at Centre de Recherches sur la Géol. de l'Uranium, B.P. 23, 54501 Vandoeuvre-lès-Nancy, France.

In fluid inclusions from Lastourville (Gabon), Col d'Allos (France), Perry County (USA) and Val d'Illiez (Switzerland), melting of a solid phase was observed between -92°C and -103°C. Identification by Raman microspectrometry shows these phases are solid CO_2 and H_2S. These spectroscopic determinations are necessary for interpretations of microthermometric measurements. (Authors' abstract)

DUJON, S.-C. and LAGACHE, Martine, 1984, Exchanges between plagioclases and aqueous Na-Ca chloride solutions at different pressures and temperatures (400° to 800°C, 1 to 3 kb): Bull. Minéral., v. 107, p. 553-569 (in French; English abstract).

DUNCAN, I.J., 1984, Is pressure solution a major creep mechanism in orogenic belts? (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 83.

DUNCAN, I.J. and GWINN, C.J., 1984, Isotopic evolution of deep basinal brines in the Gulf Coast: the role of shale compaction and diagenesis (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 83. Authors at Dept. Geol. Sci., Southern Methodist Univ., Dallas, TX 75275.

Mass balance constraints suggest that fluids from compaction and dewatering of shales should be an important and perhaps dominant component of deep basinal brines. Stable isotope data provide critical evidence for distinguishing brine origin. The D/H evolution of shale formation waters can be modeled as a mixture of detrital clays, with δD initially in the range -70 to -85‰ relative to SMOW, and pore water with δD initially 0‰. The observed change in clay D/H ratios with depth and the D/H of water in equilibrium with the finest-grained clay fractions allows estimation of the D/H ratio of water evolved from shale compaction. Modification of the D/H ratio during fluid migration in clastic and carbonate aquifers is probably small. These calculations are in striking agreement with measured D/H ratios of Gulf Coast brines. These D/H data are incompatible with evaporated seawater forming even a small component of Gulf Coast brines. As was originally shown by Clay et al., the $^{18}O/^{16}O$ ratios of the Gulf Coast brines appear to be rock-dominated. Our calculations suggest brines in lower carbonate cements. The oxygen, and presumably carbon, isotope ratios of these brines are dominated by recrystallization and reprecipitation of detrial and cement phases. If the D/H data preclude formation water evolving from an original evaporative brine (the "Louann brine"), an alternative explanation must be found for the high observed chloride molarities. A reverse chemical osmosis mechanism has been recently suggested but has not been documented by field data. An alternative model is the dissolution of evaporative halite, deep in the section, by water migrating updip from compacting deep basinal shales. However, only Edwards brines have Br/Cl ratios consistent with halite dissolution. Fractionation of halogens by equilibration with diagenetic chlorites and/or clays may affect Br/Cl ratios in other aquifers. (Authors' abstract)

DUNNING, G.R., 1984, A sulfur isotopic, ore textural, chemical, and experimental study on the formation of the Kuroko deposits, Hokuroku district, Japan: Ph.D. dissertation, Memorial Univ. Newfoundland, Canada.

DUNNING, J.D., PETROVSKI, D., SCHUYLER, J. and OWENS, A., 1984, The effects of aqueous chemical environments on crack propagation in quartz: J. Geophys. Research, v. 89, no. B6, p. 4115-4123. Authors at Dept. Geol., Indiana Univ.

The chemical role of water and other aqueous environments in crack propagation was examined in a series of crack propagation tests in natural and synthetic quartz. The potential roles of surface free energy reduction and zeta potential (surface electrostatic potential) in chemical weakening were specifically examined by running the crack propagation tests in the presence of six surface active aqueous environments which varied substantially in these parameters with respect to quartz. Calorimetric and electrophoresis tests were also undertaken in order to determine the degree of reduction of the surface energy of quartz produced by each chemical environment and the zeta potential between each environment and quartz. It was found that there was a moderate correlation between reduction of the crack propagation stress of quartz and the degree by which the surface energy was reduced in the presence of a particular environment. No such correlation was found with respect to zeta potential. It was also observed that some of the chemical environments appeared to produce highly branched cracks in quartz. This branching effect is probably related to the velocity of crack propagation. (Authors' abstract)

DURAK, Bernard, PAGEL, Maurice and POTY, Bernard, 1984, Temperatures and salinities of fluids related to diagenetic silicifications of a sandstone formation overlying a uranium deposit located in the basement: Examples from the Kombolgie Sandstone (Australia): C.R. Acad. Sc. Paris, Ser. II, v. 296, p. 571-574 (in French; translated in U.S. Geol. Open-File Rpt. 84-155, 6 pp.).

Microthermometric studies have been performed on fluid inclusions localized in quartz overgrowths and quartz veins of the Kombolgie Sandstone. Minimum temperatures of formation lie between +65 and +210°C. Salinities are variable, and melting temperatures range from -45 to -6.3°C. An inverse relationship exists between salinity and minimum temperature of formation, where salinity increases and minimum formation temperature decreases with progressive silicification. Quartz overgrowths are therefore characterized by higher salinity and lower formation temperature than related detrital quartz grains. Silicification began at a temperature higher than 150°C. Comparable results have been obtained from studies of gangue minerals from the Jabiluka deposit. These data are essential for the interpretation of uranium deposits spacially associated wtih Proterozoic unconformities. (Authors' abstract translated by L.M. Bithell)

ĎURIŠOVÁ, Jana, 1984a Origin of greisen assemblages in the western Krusné hory Mts.: Vestnik Ustredniho ústavu geologického, v. 59, no. 3, p. 141-152 (in Czech; English abstract). Author at Ustredni ústav geol., Malostranské nám. 19, 118 21 Praha 1, Czechoslovakia.

The origin of tin and tungsten-bearing greisens at Bozi Dar, Vykmanov and Prebuz was studied by fluid inclusion method. Topaz and quartz from the ore assemblages were examined. The beginning of the greisenization process is characterized by the temperature interval 470-500°C and high salinity of solutions. In the course of greisenization, the gaseous and liquid phases of ore-bearing solutions separated. The proper greisenization process took place at 400-300°C from chloride solutions of low salinity (less than 10 mass %). (Author's abstract)

ĎURIŠOVÁ, Jana, 1984b Thermobarogeochemical research - methods and possibilities of its application: Acta Mont., v. 68, p. 197-204 (in Czechoslovakian). Author at Ústřed. Ústav, Geol., Prague, Czechoslovakia.

A review of ČSSR work on fluid-inclusions in Sn-W deposits of Krushne Hory, ČSSR. (E.R.)

DYMKIN, A.M., PURTOV, V.K. and YATLUK, G.M., 1984a Solubility of iron in high-temperature hydrothermal solutions: Akad. Nauk SSSR Doklady, v. 274, no. 1, p. 179-182 (in Russian). Authors at Inst. Geol. & Geochem. of Urals Sci. Center, Sverdlovsk, USSR. Continued next page.

Experiments were performed with iron extraction by NaOH, Na_2CO_3, K_2CO_3 and HCl solutions from gabbro-norite, dunite, amphibole, biotite, liparite and basalt at 600-800°C and P 101 MPa. (A.K.)

DYMKIN, A.M., PURTOV, V.K. and YATLUK, G.M., 1984b, Transport of iron in high-temperature hydrothermal solutions: Dokl. AN SSSR, 1984, v. 274, no. 1, p. 179-182 (in Russian, English abstract; translated in Int'l. Geol. Rev., v. 26, p. 1180-1184, 1984).

Presents the results of experiments on the mobility of iron resulting from the action of solutions of HCl, NaOH, Na_2CO_3, and K_2CO_3 on rocks and minerals at 600°C and 800°C and pressure 101 MPa, and interpretation of the probable conditions of formation of magnetite skarn deposits. (Authors' abstract)

EADINGTON, P.J., 1984, Redox controls in the hydrothermal reactions of tin (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 255 (in English). Author at CSIRO Div. Mineralogy, North Ryde, Australia.

Tin may occur with high concentrations (to 5%) in some silicate minerals as well as in cassiterite or stannite. The behavior of tin in hydrothermal systems depends on the substitution schemes of tin in silicate minerals as much as the solubility of cassiterite and stannite. Each of these processes is sensitive to redox conditions (or oxygen fugacity).

The solubility of cassiterite as chloro and fluoro complexes of tin increases with decreasing oxygen fugacity. Diadochic substitution of tin in silicate minerals should decrease with decreasing oxygen fugacity (and Fe^{3+}/Fe^{2+} ratio), since a $2\ Fe^{3+}(oct) = Sn^{4+}(oct) + Fe^{2+}(oct)$ substitution scheme has been demonstrated for some minerals, and is suggested by compositional data for others.

In both granites and skarns, hydrothermal concentrations of cassiterite are favored by low oxygen fugacities. Less tin is immobilized by substitution in silicate minerals and there are larger temperature- and pH-dependent-coefficients of solubility for cassiterite. (Author's abstract)

EDGAR, A.D., 1984, Metasomatism in the mantle: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 22.

EDGAR, A.D. and ARIMA, Makoto, 1984, Experimental studies on K-metasomatism of a model pyrolite mantle and their bearing on the genesis of ultrapotassic magmas: Proc. 27th Int'l. Geol. Congr., v. 9, p. 509-541. Authors at Dept. Geol., Univ. Western Ontario, London, Canada N6A 5B7.

Experiments at 20 and 30 kb, and 850-950°C on pyrolite with various concentrations of K_2O in aqueous solution have been used to model K-metasomatism in the upper mantle. (From the authors' abstract)

EDMUNDS, W.M., ANDREWS, J.N., BURGESS, W.G., KAY, R.L.F. and LEE, D.J., 1984, The evolution of saline and thermal groundwaters in the Carnmenellis granite: Mineralogical Mag., v. 48, p. 407-424. First author at British Geol. Survey, Hydrogeology Unit, Wallingford, Oxon OX10 8BB, England.

The Carnmenellis granite and its aureole contain the only recorded thermal groundwaters (up to 52°C) in British granites. They occur as springs in tin mines at depths between 200 and 700 m and most are saline (maximum mineralization 19,310 mg l^{-1}). Mining activity has disturbed the groundwater circulation pattern developed over a geological time-scale and levels of bomb-produced tritium (>4 TU) indicate that a significant component (up to 65%) of the most saline waters are of recent origin. All components of all the mine waters are of meteoric origin. Radiogenic ^{4}He contents, ^{40}Ar/^{36}Ar ratios, and uranium series geochemistry suggest that the thermal component has a likely residence time of at least 5 x 10^4 years and probably of order 10^6 years.

The thermal waters have molar Na^+/Cl^- ratios considerably less than 1 but they are enriched relative to sea water in all major cations except Mg. The groundwater is also particularly enriched in Li with contents ranging up to 125 mg l^{-1}. The groundwater salinity, which may reach a maximum of 30,000 mg l^{-1}, is shown to result from weathering reactions of biotite (probably through a chloritization step) and plagioclase feldspar, to kaolinite. On volumetric considerations, fluid inclusions cannot contribute significantly to the groundwater salinity, and stable isotope ratios rule out any contribution from sea water.

Groundwater silica contents and molar Na^+/K^+ ratios suggest that the likely equilibration temperature is 54°C, which would imply a depth of circulation of about 1.2 km. (Authors' abstract)

EFIMOVA, M.I., MALAKHOV, V.V., CHERNYSHEV, A.V. and NOSENKO, N.A., 1984, Genetic features of the borosilicate deposit, Dalnegorsk (according to thermobarogeochemical data) (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 38-39 (in English). First author at Far East Geol. Inst. Far East Sci. Center USSR Acad. Sci., Vladivostok, USSR.

The skarn deposit was formed at the contact of Mesozoic terrigenous-carbonaceous rocks with an andesitic granitoid intrusion. We distinguish two phases: the first one - 50.5 to 56.5 my - diorites, quartz-diorites, Th of crystallized inclusions is 980 to 990°C; the second one - 32 to 56.5 my - adamellites, aplites, granites, Th of melt inclusions is 770 to 820°C. Salt inclusions in granitoid quartz originated at 290 to 550°C. Analysis of mineral gas phase supports the temperature value of the start of crystallization. The deposit is zoned: inner zones - wollastonite (Th 560 to 690°C), median ones - hedenbergite (Th 550 to 420°C), marginal ones - andradite (Th 460 to 420°C). Kidney-shaped and globe-shaped formations with concentric zonal structures characterize the deposit. Borosilicate mineralization superimposed on all zones is represented by datolite, danburite, axinite; datolite is of principal importance. We distinguish three generations: datolite I (Th 365 to 320°C) composes lines in skarns replacing wollastonite; datolite II (Th 280 to 260°C) develops along fractures in skarn together with quartz I replacing hedenbergite and datolite I; datolite [III] (Th 240 to 220°C) is drusy, associates with apophyllite and quartz II (Th 260 to 220°C). We relate the skarn formation to the action of highly concentrated and high temperature fluids during active tectonic movements. Considerable increase of fault channels and rapid loss of solvent favored the formation of colloidal systems. Irregular crystallization of these systems explains the skarn texture variation. Bicarbonate-sodic solutions deposited productive association; CH_4 and CO_2 prevailed in gas phase. Borosilicate mineralization associates through time with the formation of minor intrusions of contrast[ing] alkaline-potassium series (36 to 27 millions of years). Isotope analysis of carbonaceous minerals confirms the endogenous source of [carbon] dioxide during mineralization. (Authors' abstract)

EGGLER, D.H. and BURNHAM, C.W., 1984, Solution of H_2O in diopside melts: A thermodynamic model: Contrib. Mineral. Petrol., v. 85, p. 58-66.

EGGLESTON, T.L. and NORMAN, D.I., 1984, Geochemistry and origin of rhyolite-hosted tin deposits, southwestern New Mexico (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 499. Authors at Geosci. Dept., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Tertiary-age topaz-rhyolite domes in New Mexico host Sn mineralization. Total Cl plus F varies from 1.4 to 0.2% with Cl/F = 2 to 4 and as much as 1.2% Cl. The $\delta^{18}O$ is +8 permil. REE patterns are flat with slight enrichment of LREE and deep Eu anomalies.

Sn mineralization is restricted to the flanks of intensely vapor phase recrystallized zones (VPRZ) just below the carapace of the domes. The general paragenesis is: quartz-topaz; hematite-cassiterite; and quartz-calcite-fluorite-wood tin. Studies of 5-phase, hydrous fluid inclusions containing a glass-like phase that melts at 350°C in the VPRZ indicate fluids with temperatures >600°C, calculated $\delta^{18}O$ of +6 to +10 permil, and 70 eq. wt. % NaCl. Cassiterite was deposited at 150 to 200°C from boiling fluids with a calculated $\delta^{18}O$ of -6 to 0 permil.

These data suggest that both magmatic and meteoric fluid were important to Sn deposition. Quartz and topaz were deposited by magmatic fluids evolved during cooling of the rhyolite. Later, wood-tin was deposited from short-lived, meteoric water-dominated, epithermal systems. Cassiterite was deposited at intermediate temperatures and salinities, suggesting mixed magmatic and meteoric water. The source of the Sn was the host rhyolites. The Cl content of these rhyolites is significantly higher than reported topaz rhyolites which contain no tin mineralization, suggesting that Cl is important in the formation of these Sn deposits. In addition, these rhyolites are similar in age and geochemistry to the nearby Iron Mt. granite which generated W-Sn-F skarns suggesting that the rhyolites are surface expressions of deeper W-Sn systems. (From the authors' abstract)

ELDERS, W.A., 1984, Continental scientific drilling to 5.5 km in the Salton Sea geothermal field, California, USA (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 9, pt. 1, p. 123-124.

ELLIOT, W.P., 1984, The pre-1958 atmospheric concentration of carbon dioxide: EOS, v. 65, no. 26, p. 416-417.

ELPHICK, S., 1984, Oxygen isotope diffusion studies: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 141-143.

ELTHON, D., HANSON, R., ALLEN, R. and VERGARA, H., 1984, Unusual ocellar textures in diabases from the Sarmiento ophiolite complex, Chile: Can. J. Earth Sci., v. 21, p. 376-378. First author at Dept. Geosci., Univ. Houston, University Park, Houston, TX 77004, USA.

Unusual ocellar textures from the base of the sheeted dikes unit in the Sarmiento ophiolite are described. There are significant chemical differences between these ocelli and the surrounding diabasic matrix. The mesoscopic textural evidence and the chemical evidence suggest an origin of these ocelli by liquid immiscibility or magma mixing. (Authors' abstract)

ENGELDER, Terry, 1984, The role of pore water circulation during the deformation of foreland fold and thrust belts: J. Geophys. Research, v. 89, no. B6, p. 4319-4325. Author at Lamont-Doherty Geol. Observ., Columbia

Univ.

Volume-loss strain accompanying pressure solution of calcite occurred within both the Umbria-Marches Apennines of Italy and the Appalachian Mountains of western New York. Data from strain markers show that volume-loss strain was greater within the shallow portions of the Apennines than within the Appalachians. Within the deeper portions of both fold and thrust belts, strain was nearly volume-constant. Calcite solubility data suggest that downward circulation of meteoric water is necessary for the 35% volume-loss strain of the limestones within the Apennines. Strain at a depth of about 1 km was volume-constant and is interpreted as indicative of restricted pore fluid circulation. In the Appalachians, calcite comprises less than 1% of the clastic rocks, and a 10% volume-loss of this calcite may occur during circulation of connate or dehydration water derived from dewatering of the shales but in an environment that restricts the circulation of meteoric water. Here, the volume of calcite removed (0.1% of the total rock) is so small that circulation of meteoric water is not necessary for strain by pressure solution. (Author's abstract)

ENTOV, V.M., ZAK, S.A. and CHEN-SIN, E., 1984, On two-phase flow in porous environment with microheterogeneous wetting: Akad. Nauk SSSR Doklady, v. 274, no. 6, p. 1334-1337 (in Russian). Authors at Inst. of Problems of Mechanics, Moscow, USSR.

Pertinent to mineral- and inclusion formation from heterogeneous fluids. (A.K.)

EPATKO, Y.M. and LITVINSKAYA, M.E., 1984, Static magnetic field effect in ore-forming processes: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 85-90. Authors at Inst. Geochem. & Physics of Minerals, Acad. Sci. of the Ukrainian SSR, Kiev, USSR.

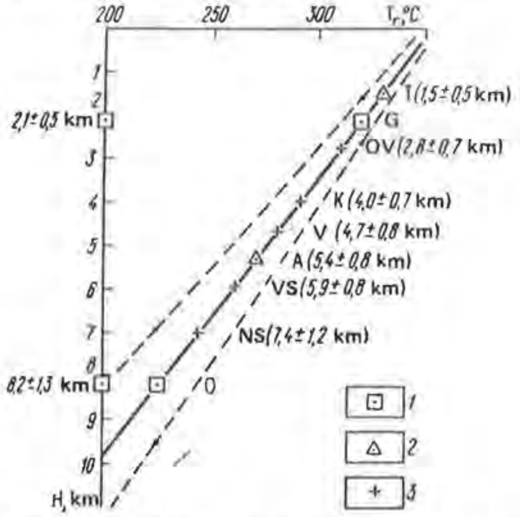
An external magnetic field can induce changes in the properties of salt aqueous solutions. An experimental research on the magnetic field effects on the migration ability of silica in the systems: quartz-H_2O; quartz-H_2O-CO_2; carbonaceous-magnetic* quartzite-H_2O; carbonaceous-magnetitic* quartzite-H_2O-CO_2 has been carried out. The experimental results present a cogent argument for the effect of rather weak magnetic fields on the chemical reaction kinetics. (Authors' abstract) *Sic.

EPEL'BAUM, M.B. and BUKHTIYAROV, P.G., 1983, Studies of immiscibility in the system diopside-nepheline-fluorapatite with admixtures of salts of hydrofluoric and phosphoric acids, in Experimental studies of endogeneous ore formation: "Nauka" Publ. House, Moscow, p. 220-229 (in Russian).

In the system diopside-nepheline-fluorapatite the admixtures of $Na_6P_6O_{18}$ and MgF_2 cause a distinct decrease of T of melting and extension of immiscibility over a wide area including average composition of the Khibiny apatite-ijolite intrusion. The immiscibility remains also under high H_2O or $H_2O + CO_2$ pressures. The inversion of densities of silicate and phosphate phases may be expected under influence of water dissolved in melts. (A.K.)

EPSHTEYN, Ye.M. and KABAN'KOV, V.Ya., 1984, The depth of emplacement and mineral potential of ultramafic, ijolite, and carbonatite plutons: Sovetskaya geologiya, 1984, no. 8, p. 85-98 (in Russian, English abstract; translated in Int'l. Geol. Rev., v. 26, no. 12, p. 1402-1415). First author at All-Union Inst. Min. Resources (VIMS).

The authors use Th of fluid inclusions to estimate the depth of formation of the UIC (ultramafic, ijolite, and carbonatite) plutons. They plot data from Samoylov (Fluid Inclusion Research--Proceedings of COFFI, v. 10, 1977, p. 243) as shown below. (E.R.)



Graph showing relations between mean homogenization temperatures (Th) of fluid inclusions in minerals of quartz-bearing rocks of the dolomite-ankerite phase and the emplacement depth of the UIC plutons: 1) standard; 2) control; 3) "test case": 0) Ozernyy, NS) Nizhnesayansk, VS) Verkhnesayansk, A) Afrikanda, V) Vuorijarvi, K) Kovdor, OV) Ozernaya Varaka, G) Guli, T) Turyy.

ERMAKOV, N.P. See also YERMAKOV, N.P.

ETHERIDGE, M.A., WALL, V.J., COX, S.F. and VERNON, R.H., 1984, High fluid pressures during regional metamorphism and deformation: implications for mass transport and deformation mechanisms: J. Geophys. Research, v. 89, no. B6, p. 4344-4358. First author at Bureau of Mineral Resources.

Evidence is presented to support the conclusion that pore fluid pressures P_F during regional metamorphism are generally greater than or equal to the minimum principal compressive stress S_3. The resultant very low effective stresses σ lead to significantly increased porosity and permeability, even at moderate to high metamorphic temperatures. Permeabilities between 10^{-18} and 10^{-15} m^2 are considered to be common, resulting in rapid fluid migration and the dominance of advective (infiltrative) over diffusive mass transport, even over relatively small distances. In view of the importance of intergranular mass transport to rock deformation during metamorphism, a mobile, high-pressure fluid will have substantial rheological effects, especially in polyphase rocks. The fluid is capable of influencing the rate of dislocation creep in a number of ways. More importantly, advective mass transport along fluid pressure gradients can give rise to a solution transfer deformation mechanism that competes with conventional pressure solution. The rate of deformation by advective mass transport could be controlled by a number of processes, including dissolution kinetics, advective transport rates, and the rate of crack growth. A specific deformation model, based on advective transport rate control, is developed, which can produce strain at competitive rates but with stress and temperature dependences of unusual form. (Authors' abstract)

EVANS, Brian, 1984, The effect of temperature and impurity content on indentation hardness of quartz: J. Geophys. Research, v. 89, no. B6, p. 4213-4222.

FABRICIUS, J., 1984a, Formation temperature and chemistry of brine inclusions in euhedral quartz crystals from Permian salt in the Danish Trough: Bull. Minéral., v. 107, p. 203-216. Author at Geol. Survey of Denmark, 31, Thoravej, DK 2400 Copenhagen NV, Denmark.

Classic microthermometry has been carried out on fluid inclusions in euhedral quartz from the Batum saltdome in the dome area of N. Jutland, Denmark. The salt studied is of Zechstein 1 and 2 age. The fluid inclusions are either isolated regular inclusions or populations of irregular thin inclusions on an internal crystal face. The inclusions are either fluid-gas inclusions or inclusions also containing a solid phase of NaCl.

The salinity and the $CaCl_2$:$MgCl_2$ ratio have been measured using phase diagrams of the system ($CaCl_2$ + $MgCl_2$)-NaCl-H_2O, the Ca:Mg ratios 3:1, 1:1 and 1:3. The salinity determined is from c.35 weight % to more than 45 weight % and the Ca:Mg ratio from 3:1 to 1:4.

Th of 231 fluid-gas inclusions give a mean of 98.1°C indicating a formation of the quartz crystals late in Zechstein 3. The formation temperatures (115°C - 180°C) and pressures (15 MPA - 90 MPa) have been measured/calculated on 14 quartz crystals indicating an individual crystallization in the period Early Triassic-Early Jurassic times. The calculated Rayleigh numbers indicate conditions of thermal convection in Late Triassic-Early Jurassic times. Both the Zechstein 1 salt and the Zechstein 2 salt were sedimented under uniform conditions. (Author's abstract)

FABRICIUS, Johannes, 1984b, Microthermometry, Vol. IV in Zechstein salt Denmark, Salt Research Project EFP-81, DGU Series C no. 1, 83 pp.

Fluid inclusions in quartz crystals from Danish salt domes have been studied in order to determine the chemistry of the brines present in the salt.

The crystallization temperatures and the corresponding pressures of several quartz crystals have been measured and calculated. These P-T conditions reflect the diapiric evolution: pillow stage, diapiric penetration phase and post-diapiric phase. Some of the P-T measurements give strong evidence of thermal convection conditions in the bedded rock salt.

Carnallite-bearing fluid inclusions have been studied in order to establish the dehydration conditions of natural carnallite in cognate geological environmetns. The inclusions are natural visual autoclaves and they represent a chemically closed system. Several dehydration temperatures have been measured and the corresponding pressures calculated. (Author's abstract)

FARFEL', L.S., SAVEL'YEVA, N.I. and MIRONOVA, O.F., 1983, Hydrothermal solutions at the Aksu gold-ore deposit: Geokhimiya, 1983, no. 12, p. 1781-1786 (in Russian; translated in Geochem. Int'l., v. 21, no. 1, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 72, 1983. (E.R.)

FELDMAN, M.D. and KNAUTH, L.P., 1984, Hydrogen isotope geochemistry of trace water in sedimentary dolomite (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 507. Authors at Dept. Geol., Arizona State Univ., Tempe, AZ 85287.

The trace water content of sedimentary dolomite has been investigated using a stepwise heating technique combined with hydrogen isotope measurements of the evolved water. Four types of water are sequentially evolved from dolomite: surface water (25-200°C); fluid inclusion water (200-

500°C); clay mineral contaminant water (500-1000°C); and structural water (540-720°C).

Comparison of the dolomite data with stepwise heating experiments on sedimentary calcite and hydrothermal dolomite suggest that the presence of structural water in sedimentary dolomite is related to the hydration of aqueous Mg^{++} ions. The structural water content of carbonates may also depend on whether the mineral formed as a primary precipitate or as a replacement of a preexisting carbonate.

The D/H ratios of fluid inclusion water extracted from whole rock carbonates by stepwise heating and vacuum crushing may be significantly different due to the presence of large fluid inclusions in cements which are eliminated by grinding prior to stepwise heating. Thermal extraction is better suited than vacuum crushing for the isotopic analysis of fluid inclusion water in carbonates.

Exchange experiments show that surface water exchanges rapidly at room temperature. The other types of water exchange much more slowly suggesting that they may preserve their D/H ratios over geologic time.

The isotopic composition of fluid inclusion water in dolomite has applications for geothermometry and for determining the types of water involved in dolomitization. The structural water content of dolomite may serve as an indicator of a replacement vs. primary origin. (Authors' abstract)

FENG, Zhiwen, WANG, Siyuan, HUANG, Yongke, YU, Hengweng and HU, Huyan, 1984, Lithofacies features and mechanism of formation of "Zihe-type" time- and strata-bound iron ore deposits in central Shandong province: Geochemistry, v. 3, no. 4, p. 384-395. First author at Wuhan College of Geology.

The Lower Palaeozoic system is a series of iron-bearing rocks consisting mainly of shallow sea-facies carbonates. On the basis of microfacies analysis of the carbonate rocks, the Lower Palaeozoic sedimentary sea basin is divided into two broad sedimentary-tectonic regions of sedimentary facies and eight subfacies. The original iron-rich carbonates were deposited in salt-lakes, lagoons, etc. of the resticted basins. Over the long geological history, the original iron formations were reconstructed to various extents by late tectonic processes. Geological observations and studies on the equilibrium mechanism of oxygen/sulfur isotopic fractionation and the composition and temperature of fluid inclusions in the minerals indicate that thermal brines played an important role in reworking of the original iron-rich carbonate rocks, which led to the formation of sedimentary-reworked strata-bound ore deposit. (Authors' abstract)

FENG, Zhongyan, YU, Fang and WEI, Qiying, 1984a The geologic characteristics of the contact metasomatic copper deposits in northern Taihang mountains, China and the properties and origin of their ore-forming solution: Acta Geologica Sinica, v. 58, no. 2, p. 143-152 (in Chinese; English abstract). Authors at Dept. Geol., Beijing Univ., China.

There are a number of contact metasomatic copper ore deposits in northern Taihang mountains, China. They are associated with intermediate-acid small-sized stocks and cupolas intruded during the Late Jurassic at a depth of no more than 2000 meters. Three successive stages of alteration and mineralization can be distinguished: garnet-pyroxene stage, quartz-iron oxides stage and quartz-sulphides stage. All the alteration and mineralization took place at a temperature of less than 400°C, lower than the critical temperature of the hydrothermal solutions. The solution not only consists of magmatic water but also of a great amount of meteoric water. The temperature interval of the first stage is about 400-285°C;

of the second stage, between 385-255°C; of the third stage, below 290°C. Inclusion liquids contain Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Cl^{-}, HCO_3^{-} and F^{-}, hence it belongs to Na^{+} - $Ca^{++}/Cl^{-}(F)$ - HCO_3^{-} saline water type. The properties of the ore-forming solutions are different depending on their temperature, pressure, and water component, as well as on the composition of the liquid inclusions and of stable isotopic elements in different alteration and mineralization stages. The writers came to a conclusion that the metals were derived from the magama. (Authors' abstract)

FENG, Zhongyan, YU, Fang and WEI, Qiying, 1984, The properties and origin of the ore-forming solution of the contact metasomatic copper deposits in northern Thai-Huang-Shan, China (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 93-94. Authors at Dept. Geol., Peking Univ., Peking, China.

There are a number of contact metasomatic copper ore deposits in northern Thai-Huang-Shan, China. Three successive stages of alteration and mineralization can be distinguished: garnet-diopside stage, iron oxides stage and quartz-sulphides stage. All the alteration and mineralization took place below 400°C, lower than the critical temperature of the hydrothermal solutions; the water of the solutions consisted of magmatic water and ground water. The temperature of the first stage [was] between 400°-300°C, with ground water about 15%; the second stage between 380°-250°C, with ground water about 40%; the third stage between 290°-140°C, with ground water up to 60%. Inclusion liquids contain Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Cl^{-}, HCO_3^{-} and F^{-}. They are saline waters, belong to Na^{+}-$Ca^{++}/Cl^{-}(F^{-})$-HCO_3^{-} type. The above information [does] not coincide with the traditional idea about the alteration and mineralization of contact metasomatic ore deposits. (Authors' abstract)

FERGUSON, J., 1984, The methane content of some Carboniferous limestones from the northern Pennines and its relationship to mineralization: Proc. of Yorkshire Geol. Soc., v. 45, pts. 1 & 2, p. 67-69.

Anomalous amounts of methane gas have been detected in Carboniferous limestones collected in an area to the south-east of Rookhope in the northern Pennines. The significance of this discovery is discussed in relation to the geology of the area. Two origins for the gas are postulated: either it has been generated as a direct result of the mineralization or it is a consequence of the prolonged existence of a high geothermal gradient in the area. It is argued that, since these two events are likely to be related, the location of methane anomalies might prove a useful technique for mineral exploration in similar geological settings. (Author's Summary)

FERRY, J.M., 1984, A biotite isograd in south-central Maine, U.S.A.: mineral reactions, fluid transfer, and heat transfer: J. Petrology, v. 25, p. 871-893. Author at Dept. Earth & Planet. Sci., The Johns Hopkins Univ., Baltimore, MD 21218, USA.

The biotite isograd in pelitic schists of the Waterville Formation involved reaction of muscovite + ankerite + rutile + pyrite + graphite + siderite or calcite to form biotite + plagioclase + ilmenite. P-T conditions at the biotite isograd were near 3500 bars and 400°C. C-O-H-S fluids in equilibrium with the petlitic rocks were close to binary CO_2-H_2O mixtures with XCO_2 - 0·02-0·04. During the biotite-forming reaction, pelitic rocks (a) decreased by 2-5 per cent in volume, (b) performed - (4-11) kcal/liter P-V work on their surroundings, (c) absorbed 38-85 kcal/liter heat from their surroundings, and (d) were infiltrated by at least

0·9-2·2 rock volumes H_2O fluid.

The biotite isograd sharply marks the limit of a decarbonation front that passed through the terrane during regional metamorphism. Decabonation converted meta-shales with 6-10 per cent carbonate to carbonate-free pelitic schists. One essential cause of the decarbonation event was pervasive infiltration of the terrane by at least 1-2 rock volumes H_2O fluid early in the metamorphic event under P-T conditions of the biotite isograd. Average shale contains 4-13 per cent siderite, ankerite, and/or calcite, but average pelitic schist is devoid of carbonate minerals. If the Waterville Formation serves as a general model for the metamorphism of pelitic rocks, it is likely that worldwide many pelitic schists developed by decarbonation of shale caused, in part, by pervasive infiltration of metamorphic terranes by several rock volumes of aqueous fluid during an early stage of the metamorphic event. (Author's abstract)

FERSHTATER, G.B., CHASHCHUKHINA, V.A. and VILISOV, V.A., 1984, Fluorine and chlorine distribution in apatite embedded in different rock-forming minerals of magmatic rocks: Dokl. Akad. Nauk SSSR, v. 276, no. 5, p. 1228-1233 (in Russian).

FINN, D.R. and BUCHANAN, L.J., 1984, Hayden Hill, California: epithermal Au-Ag mineralization associated with Cascade volcanism (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 509. First author at Mackay Sch. Mines, Univ. Nevada Reno, Reno, NV 89557.

Fluid inclusions from late quartz + adularia veins typically exhibit boiling textures. Preliminary measurements yield Th of 210°-295°C. These data strongly suggest that the mineralization formed at depths in excess of 500 meters and thus is not a "hot springs" deposit. (From the authors' abstract)

FISHER, D.E., 1984, Radiogenic rare gases in MORB and depleted mantle degassing (abst.): EOS, v. 65, no. 45, p. 1139. Author at School of Marine & Atmospheric Sci., Univ. Miami, Miami, FL 33149.

K, U, and rare gas isotopic abundances were measured in several MORB glasses, allowing calculation of U, Th/He, K/Ar, and U/Xe radiogenic ages. Fission track dating of the same glasses was carried out, giving ages orders of magnitude younger, as do sea floor spreading rates; the rare gas ages therefore indicate times of mantle accumulation, with internal patterns indicating mass fractionation effects. An upper limit to the rare gas accumulation time is $\lesssim 600 \times 10^8$ years, indicating the mantle source regions of MORB have not remained closed to degassing losses since early in earth history. Model calculations based on I/Xe xenology are shown to be in agreement with this interpretation. A stable, layered mantle is not suggested by these data. (Author's abstract)

FOLEY, S.F., 1984, Liquid immiscibility and melt segregation in alkaline lamprophyres from Labrador: Lithos, v. 17, p. 127-137. Author at Dept. Geol., Univ. Tasmania, Hobart, Tasmania 7001, Australia.

Sannaites (alkaline lamprophyres with Ti-rich mica and/or amphibole and K-feldspar) forming part of the Aillik Bay alkaline dyke swarm contain two varieties of leucocratic globular structures. Type I are interpreted to represent immiscible silicate liquids, whereas type II are caused by segregation of late-stage melt. Type I globules are characterized by enrichment in Al_2O_3, SiO_2, Na_2O and K_2O, and depletion in CaO, MgO, FeO (total Fe), TiO_2 and P_2O_5 relative to the sannaite groundmass. Mafic minerals inside and outside the type I globules have cores of similar composition, but rims which follow different trends. Type II globular structures are commonly zoned; they have a carbonate-analcite inner zone interpreted as the site of a former gas bubble, and an outer zone representing late-stage liquid. Minerals in the outer zones show extreme zonation along chemical trends similar to those in the groundmass, but contrasting with those in type I globules. Boundary nucleation is common in type II but rare in type I.

The Aillik Bay sannaites are believed to lie at the alkali + alumina-rich extremity of the miscibility gap. Rocks with type II structures frequently have a two-stage groundmass which may be caused by metastable immiscibility compositionally adjacent to the stable miscibility gap. (Author's abstract)

FONTES, J.C., BRISSAUD, I. and MICHELOT, J.L., 1984, Hydrological implications of deep production of chlorine-36, *in* Proc. Third Int'l. Symp. on Accelerator Mass Spectrometry, H.H. Andersen and S.T. Picraux, eds.: Zurich, Switzerland, April 10-13, 1984, Nuclear Instruments & Methods in Phys. Res., Sec. B: Beam Interactions with Materials and Atoms [B5]: 2, p. 303-307.

Indexed under Fluid Inclusions. (E.R.)

FORSLUND, Bertil and JELINSKI, Bohdan, 1984, A simple mini-furnace for thermo-microscopy and crystal growth experiments: Mat. Res. Bull., v. 19, p. 1031-1036. Authors at Dept. Inorganic Chem., Arrhenius Lab., Univ. Stockholm, S-106 91 Stockholm, Sweden.

A fairly simple and inexpensive device for the preparation of single crystals (mm dimensions) from a melt is described. This is a mini-furnace, permitting atmosphere control as well as continuous visual inspection of the sample through a stereomicroscope. A method to separate the crystals from the melt is also described. The device has been used for the preparation of crystals of several ternary compounds and for phase analysis studies in the $\underline{A}_2O-V_2O_5-V_2O_3$ systems ($\underline{A}$ = Rb, Cs) in the temperature range 400-800°C and the O_2 pressure range $1-10^{-25}$ atm. The oxygen activity which is crucial for these experiments, was controlled by the use of a $ZrO_2(Y_2O_3)$ solid electrolyte EMF-cell. (Authors' abstract)

FORSMAN, N.F., 1984, Durability and alteration of some Cretaceous and Paleocene pyroclastic glasses in North Dakota: J. Non-Crystalline Solids, v. 67, p. 449-461. Author at Dept. Geol., Univ. North Dakota, Grand Forks, ND, USA.

The presence and character of a Paleocene and two Upper Cretaceous volcanic ash deposits in North Dakota validates other workers' suggestions that natural glasses are stable for long periods of geologic time. Except for superhydration,* glass grains from each deposit are commonly unaltered. Grains which have altered to montmorillonite follow the same pattern of chemical change commonly reported for the origin of bentonites. (Author's abstract)

*Refers to formation of liquid H_2O-filled vesicles in hydrated glass. See Roedder and Smith, GSA Spec. Pap. 82, p. 164 (1964). (E.R.)

FORSTER, Hansgeorg, 1984, Physico-chemical criteria for the evolution of magmatic iron ore deposits at low pressure (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 105-106. Author at Inst. f. Mineral. u. Lagerstättenlehre RWTH, Aachen, FRG.

Thermochemical experiments were performed, verifying that Fe_2O_3 and sodium silicate melts are immiscible. These experiments were performed to understand the apatite-magnetite ores of Kiruna, Sweden, and Central Iran. (E.R.)

FORTEY, N.J., INGHAM, J.D., SKILTON, B.R.H., YOUNG, B. and SHEPHERD, T.J., 1984, Antimony mineralization at Wet Swine Gill, Caldbeck Fells, Cumbria: Proc. Yorkshire Geol. Soc., v. 45, pts. 1 & 2, p. 59-65.

A previously unrecorded quartz-antimony vein is described from Wet Swine Gill, a tributary of the River Caldew in the northern Lake District. Deposition of quartz gangue preceded that of metalliferous minerals, which include an early stibnite-berthierite assemblage, zinckenite and later-formed fülöppite and semseyite. Weathering products include bindheimite and stibiconite. The high antimony content in arsenopyrite (up to 7% Sb by weight) supports fluid inclusion data and a comparison with antimony deposits in the Massif Central, France, in pointing to deposition of the early assemblage at relatively high temperatures (above 200°C), and it is inferred that the vein is an expression of the nearby Early Devonian Carrock W-As deposit. The Pb-sulphantimonides may have formed by redeposition of antimony involving lead-bearing fluids during the Early Carboniferous. (Authors' Summary)

FOSTER, R.P., 1984, Gold '82: the geology, geochemistry and genesis of gold deposits: Proc. of the Symp. Gold '82, Univ. Zimbabwe, 24-28 May 1982, 753 pp., Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1).

FRANCE-LANORD, C., LE FORT, P., PECHER, A. and SHEPPARD, S.M.F., 1984, Microthermometry and carbon and oxygen isotope studies of fluid samples from the MCT Zone, central Nepal: 10e Reunion Ann. des Sci. de la Terre, Bordeaux, 1984, Abstracts, p. 232 (in French). First author at C.R.P.G., B.P. no. 20, 54501 Vandoeuvre-Nancy, France.

The MCT Zone is a thick (10 km), crustal shear zone which superposes high temperature terrains (la Dalle (thrust sheet) du Tibet) over low temperature terrains (formations of the Moyen pays Nepalais (Nepalese Middle Lands)), introducing an inverse, prograde metamorphism in the low-temperature rocks (Le Fort, 1975). The metamorphism, which locally reaches the kyanite isograd in the formations of the Middle Lands, is accompanied by major liberation of fluids. Fluid inclusions contained in numerous quartz lenses in the MCT Zone provide direct evidence of these fluids. A microthermometric study of five new samples confirms three earlier results of Pechner (1978): 1) within a single lens, the fluid inclusions are very homogeneous; 2) fluids are generally ternary mixtures of CO_2, H_2O, and salts; and 3) in the Middle Lands, the CO_2 concentration increases toward the MCT Zone.

The carbon-isotope composition of CO_2 extracted from four samples collected close to the MCT Zone is highly variable ($\delta^{13}C$: +1.2‰ to -15‰). This range of values implies contributions from several processes, particularly decarbonation and oxidation. As shown in the accompanying figure, one can hypothesize production of CO_2 in a variety of locations as well as several types of fluid circulation to account for the carbon isotope data.

The work currently in progress is directed toward understanding both the role of lithology in controlling the composition of the fluids and the scale of fluid circulation. (Authors' abstract, translation courtesy M.J. Logsdon)

Continued next page.

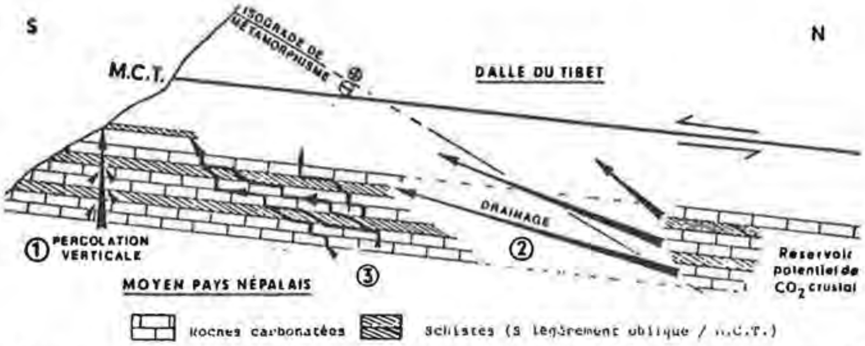


Figure caption: A sketch of the circulation of CO_2 below the MCT Zone. 1) Vertical flow on a scale of 100's of meters; 2) Long-distance flow of CO_2, originating in similar, but higher-grade terrains; 3) Percolation of CO_2 from intermediate distances along lithologic and tectonic discontinuities. N.B.: The figure is not to scale.

FRANKLIN, J.M. and SCOTT, S.D., 1984, Silver veins in the Thunder Bay area, Ontario (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 63. First author at Geol. Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada.

These silver-bearing veins occupy two separate fault zones that parallel the axis of the Keweenawan mid-continent rift zone. Each vein set is geologically distinct. The "island" veins, typified by the Silver Islet mine, are mercury rich, and contain native silver, acanthite, niccolite, gersdorfitte, and base metal sulphides, in a calcite-dolomite-quartz-barite-fluorite matrix. These occur in fractures normal to olivine diabase dykes (Ca 1045 Ma) and terminate in Aphebian Rove Shale. The "inland" veins occur almost entirely in Rove Shale, within the most westerly Keweeawan fault zone. These veins extend up to, but rarely cut, Logan diabase dykes (Ca 1100 Ma). They contain a relatively simple assemblage of native silver, acanthite, base metal sulphides, barite, fluorite, calcite and quartz.

Preliminary fluid inclusion data indicate a wide range of depositional temperatures, typically in the range of 277 ± 30°C to 320 ± 42°C. There is some evidence that boiling occurred. Galena from each vein set has a distinctive lead isotopic composition. The Silver Islet samples are homogeneous, and slightly more radiogenic, compared with compositions for the inland veins. The latter define a good secondary isochron, indicating a source age of Ca 2200 Ma if mineralization occurred at Ca 1200 Ma. Both vein sets are thought to have formed due to release of metamorphic water during the thermal events associated with Keweenawan rifting. Fluids migrated up marginal faults, and precipitation of vein constituents was due to adiabatic cooling, possibly accompanied by boiling, at high crustal levels. (Authors' abstract)

FRANKS, S.G. and FORESTER, R.W., 1984, Relationships among carbon dioxide, pore-fluid chemistry, and secondary porosity, Texas Gulf Coast (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). First author at ARCO Alaska, Inc., Anchorage, AK.

Sequences of diagenetic minerals associated with secondary porosity show striking similarities. The formation of quartz overgrowths on detrital quartz grains is followed generally by carbonate cementation. The dissolution of this carbonate is the main secondary porosity-forming event, which commonly precedes kaolinite precipitation and iron-rich carbonate cementation. In the Texas Gulf Coast, oxygen isotopic analyses provide temperature estimates of authigenic phases that predate and postdate secondary porosity development: quartz, ≥80°C (176°F); kaolinite, ≥70°C (158°F); albite, 100°-150°C (212°-302°F); late carbonate, >100°C (212°F). These data suggest that secondary porosity in the Tertiary Gulf Coast forms at temperatures of about 100° ± 25°C (212° ± 45°F).

Correlations among calcite saturation indices in pore fluids, abnormally high permeabilities, and mole % CO_2 in natural gases of the Eocene Wilcox Group imply a strong interrelationship between CO_2 and secondary porosity development in clastic reservoirs. The CO_2 content of gases varies systematically with both the reservoir age and temperature, which suggests a kinetic control on generation. The amount of CO_2 in natural gases increases rapidly at approximately 100°C (212°F); this coincides with a rapid increase in the ratio of secondary to primary porosity in associated sandstones. Stable isotopic analyses of carbonate cements indicate a strong component of organically derived carbon and therefore cycling of carbon between inorganic and organic systems. The type, amount and distribution of organic matter, and early carbonate in both shales and sandstones control the quantity of CO_2 available for generating secondary porosity. (Authors' abstract)

FRANTZ, J.D. and MARSHALL, W.L., 1984, Electrical conductances and ionization constants of salts, acids, and bases in supercritical aqueous fluids: I. Hydrochloric acid from 100° to 700°C and at pressures to 4000 bars: Am. J. Sci., v. 284, p. 651-667.

FRANZOSI, P., SALVIATI, G., COCITO, M., TAIARIOL, F. and GHLEZZI, C., 1984, Inclusion-like defects in Czochralski grown InP single crystals: J. Crystal Growth, v. 69, p. 388-398. First author at MASPEC-CNR, Via Chiavari 18/A, I-43100 Parma, Italy.

X-ray topography using both reflection and transmission geometry and scanning electron microscopy in the transmission cathodoluminescence mode have been used for studying a characteristic inclusion-like defect in InP single crystals grown by the liquid encapsulated Czochralski technique. The experiments were performed on a number of crystals which differed from each other in their doping and crystal orientation. The images confirm a previously postulated model which assumes that the defect consists of a central core from which prismatic dislocation loops are punched out in the (110) directions. The possible role of gaseous inclusions as being responsible for the observed defect is discussed. (Authors' abstract)

FRAPE, S.K., FRITZ, P. and McNUTT, R.H., 1984, Water-rock interaction and chemistry of groundwaters from the Canadian Shield: Geochimica Cosmo. Acta, v. 48, p. 1617-1627. First author at Dept. Earth Sci., Univ. Waterloo, Waterloo, Ontario, Canada N2L 3G1.

The chemical and isotopic compositions of groundwaters in the crystalline rocks of the Canadian Shield reflect different degrees of rock-water interactions. The chemistry of the shallow, geochemically immature groundwaters and especially of the major cations is controlled by local rock compositions, whereby dissolution reactions dominate. Conservative constituents, such as chloride and bromide, however, are not entirely a result of such reactions but appear to be readily added from leachable salts during the initial stages of the geochemical evolution of these waters. Their concentration changes little as major cations increase, until concentrations of Total Dissolved Solids (TDS) reach 3000 to 5000 mg l^{-1}. The isotopic composition of these shallow waters reflects local, present day precipitations.

In contrast to the shallow groundwaters, the isotopic and chemical compositions of the deep, saline waters and brines are determined by extensive, low-temperature rock-water interactions. This is documented in major ion chemistries, ^{18}O contents and strontium isotopic compositions. These data indicate that the deep brines have been contained in hydrologically isolated "pockets." The almost total loss of primary compositions make discussions on the origin of these brines very speculative. However, all brines from across the Canadian Shield have a very similar chemical composition, which probably reflects a common geochemical history. The concentrations of some major and most minor elements in these fluids appear to be governed by reactions with secondary mineral assemblages. (Authors' abstract)

FREIMAN, S.W., 1984, Effects of chemical environments on slow crack growth in glasses and ceramics: J. Geophys. Research, v. 89, no. B6, p. 4072-4076. Author at Inorganic Materials Div., Nat'l. Bureau of Standards.

This paper presents a review of our current understanding of environmentally induced slow crack growth in glasses, single crystals, and polycrystalline ceramics. It is shown that the rate of crack growth is controlled by the chemical activity of the active species in the environment as well as by the stress intensity at the crack tip. A recently developed molecular model of stress-induced chemical reaction between vitreous silica and water is described. The implications of this model for the effects of other chemical species on crack growth are discussed. Finally, the complications introduced by the presence of grain boundaries in polycrystalline ceramics are pointed out. (Author's abstract)

Note - Other papers on the same subject are in the same issue - see Kirby and Scholz, 1981, this volume. (E.R.)

FREUND, F., 1984, Volume instabilities in the mantle as a possible source for kimberlite formation, in Kimberlites, v. I: Kimberlites and related rocks, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 405-415.

Dissolved H_2O in nominally anhydrous minerals such as olivine is shown to form not only OH^- anions but peroxy anions plus hydrogen, O_2^{2-} + H_2 by an internal charge transfer (CT) process. If H_2 is lost by diffusion the system retains excess oxygen in the (1-) valence state. Dissolved CO_2 in non-carbonate minerals is shown to form O_2^{2-} + CO_2^{2-} rather than the carbonate anion, CO_3^{2-} widely believed to be the only solute species derived from CO_2. The CO_2^{2-} configuration has unusual bonding features. The carbon diffusion is fast and sensitive to stress. The possibility of long-range carbon diffusion in the mantle is predicted to occur below a certain depth where the carbon diffusion is anticipated to follow tectonic stress patterns related to plate motion leading to lateral inhomogeneities in the mantle. High carbon concentrations are expected for regions under tensile stress. A model is developed which is based on peroxy decay reactions predicted to occur in a given rock volume when O_2^{2-} dissociates upon decompression, leading to electrical potentials which in turn cause an electrochemically driven cation influx. This then causes in-situ melting and a self-amplifying gravitational instability. (Author's abstract)

FRICKE, A., SCHREYER, W. and MENDENBACH, O., 1984, Recrystallization, planar elements and fluid inclusions in quartz of the core crystallines in the Vredefort ring in South Africa (abst.): Fortschritte der Mineralogie, Beiheft 62, no. 1, p. 61-63 (in German).

See also Schreyer and Medenbach, 1981, Fluid Inclusion Research--

Proceedings of COFFI, v. 14, p. 184, 1981. (E.R.)

FRIDLEIFSSON, G.O., 1984, Mineralogical evolution of a hydrothermal system. II. Heat sources - fluid interactions: Geothermal Resources Council, Transactions, v. 8, p. 119-123. Author at Nat'l. Energy Authority, Geothermal Div., Grensasvegi 9, 108 Reykjavik, Iceland.

Interaction between hot intrusive rocks and hydrous fluids establish and maintain high-temperature hydrothermal activity. Mineralogical evidence from the Geitafell Central Volcano SE-Iceland shows that heat extraction from hot intrusive rocks may proceed via supercritical and/or superheated fluid layers into the hydrostatically controlled hydrothermal system hosted by the basaltic volcanics. In the case example two types of metamorphic and hydrothermal mineral assemblages resulted:

A. The development of an inner aureole of hornfels and an outer aureole of skarn minerals at the contacts of large intrusive bodies (gabbros); the skarn minerals being produced from supercritical fluid ($T \geqslant 400$°C, P(fluid) $\cong$ P(load) $\leqslant 0.3$ kbar) and,

B. The development of secondary mineral assemblages within shallow level intrusives, of higher grade than those existing within the host rocks at the same depths; apparently produced from superheated steam within the intrusive rocks ($T \geqslant 300$°C, P(fluid) < 0.1 kbar). (Author's abstract)

FRIEDMAN, G.M., CATTAFE, Joseph and BORAK, Barry, 1984, Deep-burial diagenesis of the Hunton (Late Ordovician to Early Devonian) carbonates in the Anadarko basin, <u>in</u> Limestones of the Mid-Continent, N.J. Hyne, ed.: Tulsa Geol. Soc., p. 183-199. First author at Dept. Geol, Rensselaer Polytech. Inst., Troy, NY 12181.

Carbonate rocks buried to depths of 20,000 to 30,000 feet exhibit characteristics that are diagnostic of deep-burial diagenesis. The rocks were sampled from depths where temperatures are about 210°C and pressures are about 2.5 kilobars. The thermal alteration of vitrinite present in well cuttings demonstrates that the maximum paleotemperatures were essentially the same as the measured, present-day, deep burial temperatures. These conditions have subjected the carbonates to structural deformation and diagenesis approaching metamorphism. The diagnostic textures observed seem to be due, primarily, to the pressure of 20,000 to 30,000 feet of overburden, whereas, the high temperatures appear to have had little visible effect. (From the authors' abstract)

FRIEDMAN, Irving, and GLEASON, J.D., 1984, Deuterium and water content of eruptive rocks (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 264 (in English). Authors at U.S. Geol. Survey, Denver Fed. Center, Denver, CO, USA.

Rhyolitic volcanic glass (obsidian) is a chilled sample of lava and might provide a sample of the water in the magma suitable for deuterium analysis. Previous attempts to use the deuterium content of phenocrystic biotite failed because of the oxidation reactions that biotite undergoes during cooling of the magma.

Samples of obsidian and perlite from drill cores taken through several rhyolite domes at the No Aqua, New Mexico, perlite deposits were analyzed for % H_2O and δD. The δD of the perlite is relatively constant within each core, and varies little between cores. This constancy is in keeping with the secondary origin from meteoric water of the perlite water. The obsidian δD varied by as much as 30% in a single core. There is a relation between δD and % H_2O, but not between δD and position in the core or cooling zones.

The obsidian with higher water content (.2 to .3% H_2O) has a higher deuterium content (-115 to -120) than the obsidian with low water content (.1 to .15% H_2O) $\delta D = -120$ to -150. These variations are not due to cooling or crystallization, and represent differences present during eruption. The implications of this to eruption mechanisms will be discussed. (Authors' abstract)

FRIEDMAN, M., DULA, W.F., GANGI, A.F. and GAZONAS, G.A., 1984, Structural petrology of experimentally deformed synthetic rocksalt: Proc. of First Conf. on The Mechanical Behavior of Salt, H.R. Hardy and M. Langer, eds., The Pennsylvania State Univ, Nov. 9-11, 1981, University Park, PA, p. 19-36. Authors at Center for Tectonophysics, Texas A&M Univ., College Station, TX, USA.

Warm-pressed cylinders of synthetic rocksalt, shortened 10% at $10^{-4}s^{-1}$, confining pressure (P_c) from 0 to 200 MPa, and temperatures from 25° to 300°C are studied microscopically to characterize their mechanical behavior. Upon deformation (1) a-axis fabrics are not altered; (2) grain-boundary bubbles and tubes tend to become aligned along the boundaries particularly when allowed to stress relax at 200° and 300°C; (3) their connectivity increases in part by hydraulic fracturing; (4) intragranular cubic fluid inclusions are complexly modified in size, abundance, and distribution under different sets of P and T conditions; (5) slip occurs on $\{110\}\langle 110\rangle$; and (6) subgrain size (d, μm) is inversely proportional to steady-state stress (σ, MPa) as: $d = (146 \pm 27)\sigma^{-1}$ with rms error = ± 3.5 μm. This relation is independent of P_c (20 to 200 MPa), and probably also of temperature (100 to 300°C), stress relaxation (to 1800 s) and the addition of data from experimentally deformed natural rocksalt. Synthetic and natural rocksalt deform by similar deformation mechanisms despite differences in grain size (0.30 mm versus 1.0 to 20 cm, respectively) and impurity content. (Authors' abstract)

FRITZ, P., FRAPE, S.K. and CLARK, W.B., 1984, Methane in the rocks of the Canadian Shield (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 2, p. 55-56. First author at Univ. Waterloo, Waterloo, Ontario, Canada.

A discussion of the geochemical and isotopic evidence as to the origin of the N_2-CH_4 gases found, along with high-Ca brines, in crystalline rocks. (E.R.)

FU, Jiamo and JIA, Rongfen, 1984, Main forms of disseminated organic matter in carbonate rocks, their evolutionary characteristics and significance in oil-gas evaluation: Geochimica, no. 1, p. 1-9.

FUJINO, Toshio and YAMASAKI, Tatsuo, 1984, Geologic and geothermal structure of the Hatchobaru field, central Kyushu, Japan: Geothermal Resources Council, Transactions, v. 8, p. 425-430. First author at WJEC-West Japan Engrg. Consultants, Inc., Fukuoka, Japan.

Recent investigations and explorations in the Hatchobaru geothermal field have confirmed the up-flow of thermal fluids along high-angle faults. The fluids seem to be flowing up from the basement in the footwall of the faults which form the main reservoirs in the Usa group and the Hohi volcanic rocks. The acid altered zones which extend near the surface act as the cap rock. The main reservoirs are chloride-water-dominated and are found along the Kamatsuike sub-fault and Hatchobaru fault. The temperature is estimated to be 240-270°C on the basis of fluid inclusion thermometry and measured temperatures. Furthermore, there is a large possibility of finding high temperature reservoirs of 290-300°C in the Basement. (Authors' abstract)

FUZIKAWA, K. and ALVES, J.V., 1984, Stretching of fluid inclusions in plagioclases from Lagoa Real uranium province, Caetité, BA: Anais do XXXIII Congresso Brasileiro de Geol., Rio de Janeiro (Proc. 33rd Brazilian Geol. Congress), p. 4453-4461 (in Portuguese; English abstract). Authors at the Nuclebrás, Av. Uruguai 531, Belo Horizonte, Minas Gerais, Brazil.

The main host rocks of the Cachoeira uranium deposit are albite-gneisses (albitites), formed by strong Na-metasomatism associated to the mineralization.

During the fluid inclusion microthermometry of Na-rich plagioclases, an increase in the homogenization temperatures (Th) was noticed in several inclusions when they were overheated.

Stretching phenomena have already been studied in fluorite and sphalerite samples subjected to overheating. Data on the stretching of fluid inclusions in plagioclases seem to have not been published yet.

To study these phenomena, mineralized and unmineralized plagioclases have been tested by several heating runs. The resulting data confirmed the stretching but with no constancy in the overheating/stretching ratio. No clear distinction could be made between uraniferous and non-uraniferous samples.

Testing of associated pyroxene indicated only minor stretching in the range of temperatures studied. (Authors' abstract)

FYFE, W.S., 1984, Chemical transport processes, plate tectonics and ore deposits: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 30-31.

FYFE, W.S. and KERRICH, R., 1984, Gold: Natural concentration pressures, in Gold '82: the geology, geochemistry and genesis of gold deposits, ed. R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1), p. 99-127.

Reviews the various types of gold deposits and the evidence for the nature of the transporting fluids. (E.R.)

FYON, J.A., SCHWARCZ, H.P. and CROCKET, J.H., 1984, Carbonatization and gold mineralization in the Timmins area Abitibi greenstone belt: genetic links with Archean mantle CO_2 -- degassing and lower crustal granulitization (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 65. Authors at Dept. Geol., McMaster Univ., Hamilton, Ontario, L8S 4M1, Canada.

Locally, volcanic rocks have been intensely carbonatized, and largely replaced by a mixture of quartz and ferroan dolomite. The $\delta^{13}C$ of this dolomite is -4.2 ± 0.7%* (PDB), regardless of the size, stratigraphic position or gold tenor of the carbonatization zone, except where graphitic sediments are present. The replacement dolomites would have precipitated from CO_2-bearing fluids having a $\delta^{13}C$ (ΣC) of -3 to -5%* (PDB). While such an isotopic composition could represent a 30:70 mixture of marine carbonate or metamorphic CO_2 with mantle-derived (magmatic) CO_2, the uniformity of the ^{13}C value suggests that the replacement carbon is from a single source (mantle).

The carbonatized volcanic rocks are enriched in certain large-ion-lithophile (LIL) elements (K, Li, Rb, B). Precambrian granulites are

depleted in these elements as well as gold. Newton et al. (1979) proposed that such granulites formed by permeation by mantle-derived CO_2-rich fluids. Partitioning of the LIL suite as well as gold into the CO_2 fluid during granulitization would allow transfer of these elements from the lower crust to the supracrustal sequences by escaping along deeply-penetrating crustal structures (Destor-Porcupine fault). The temporal coherence during Early Precambrian between gold deposits associated with carbonatized volcanic rocks and regional granulitization of lower crust rocks may reflect a genetic link via the mechanism of extensive CO_2 outgassing during this phase of the earth's history. (Authors' abstact)
*Sic; ‰ meant?

GALIMOV, E.M., 1984a $^{13}C/^{12}C$ of diamonds. Vertical zonality of diamond formation in the lithosphere (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 266 (in English). Text: Proc. 27th Int'l. Geol. Cong., v. 11, p. 279-307 (1984).

GALIMOV, E.M., 1984b Variations of isotopic composition of diamonds and their relation to conditions of diamond-formation: Geokhimiya, 1984, no. 8, p. 1091-1118 (in Russian; English abstract).

GALIMOV, E.M. and KVENVOLDEN, K., 1984, Geochemistry of gases in the gas-hydrate-bearing sediments of the Blake Outer Ridge area, Atlantic Ocean: Geokhimiya, 1984, no. 7, p. 1075-1082 (in Russian; English abstract).

Distribution and isotopic composition of carbon of CH_4 and CO_2 in the sedimentary sequence of the sea floor at the Blake Outer Ridge area, Atlantic Ocean, have been studied. Gas sampling was made in the process of drilling of the hole 533 during 76 leg of the drillship Glomar Challenger (DSDP). Some evidences of presence of the gases in the gashydrate form were obtained. Isotopic composition of carbon of CH_4 varies from -95‰, in the near-surface sediments to -66‰. in lower part of the 400-meters sequence. In parallel with this variation the isotopic composition of CO_2 varies from -25 to -4‰ . The observed values of $\delta^{13}C$ of the gases and close parallelism of their variations are in accordance with the concept of formation of CH_4 as the result of microbiological reduction of CO_2 which was derived from organic matter. Thus gashydrates in the studied sea-floor sequence are formed by biogenic CH_4 and CO_2. (Authors' abstract)

GALLINATTI, B.C., 1984, Initiation and collapse of active circulation in a hydrothermal system at the Mid-Atlantic Ridge, 23°N: J. Geophys. Res., v. 89, no. B5, p. 3275-3289. Author at Union Oil Geothermal.

Gabbro and basalt, collected from an area south of the Kane Fracture Zone along the Mid-Atlantic Ridge, have three stages of alteration which record the cooling of a hydrothermal system: (1) Stage 1. Penetration of seawater began between 400° and 550°C, altering pyroxene to fibrous green amphibole. (2) Stage 2. Propylitic alteration formed along connected fractures between 250° and 300°C. As fracture density increased, the Fe/Mg ratio of chlorite increased, the final result being an Fe chlorite - quartz - sulfide breccia. (3) Stage 3. Late smectite veinlets formed at low temperatures (<200°C) after active circulation ceased. The study focuses on stage 2 alteration. By assuming local equilibrium between alteration minerals and the hydrothermal fluid, constaints can be placed on the fluid composition responsible for stage 2 alteration, the stage associated with deposition of sulfides. The following activities of species in solution were determined for the system $FeO-Na_2O-CaO-MgO-Al_2O_3$-

SiO_2-H_2O at 350 bars and 250°C: log $a(Ca^{++})/a^2(H^+) = 8.0$, log $a(Na^+)/a(H^+) = 5.0$, log $a(Fe^{++})/a^2(H^+) = 1.7$, log $a(Mg^{++})/a^2(H^+) = 6.0$. Log $a(SiO_2)$ was set at quartz saturation (-2.3 at 350 bars and 250°C). Fluid inclusions record the introduction of a low temperature, seawater-salinity fluid during formation of the latest quartz veins associated with stage 2 alteration. Mixing of this and the hydrothermal fluid caused a drop in temperature and increase in oxidation state, resulting in increased precipitation of quartz, pyrite and chalcopyrite. The salinities of fluid inclusions trapped in quartz during stage 2 alteration are as much as 3 times that of seawater. Concentration of a fluid initially of seawater salinity may be the result of boiling at $\geqslant$350°C and $\leqslant$3000 m depth. (Author's abstract)

GANEEV, I.G., 1984, Physico-chemical model of the joint migration of vein and ore substance in hydrothermal solutions: Akad. Nauk SSSR Doklady, v. 274, no. 5, p. 1189-1192 (in Russian). Author at Inst. of Lithosphere, Moscow, USSR.

The proposed model suggests that there exist physico-chemical conditions of joint migration of essential components of vein and ore minerals in weakly alkaline to weakly acid hydrothermal solutions, that is caused by the unlimited buffering capacity of wall rocks. The transport of substance takes place in the form of hydroxocomplexes of various complexity, heteropolyanions, decomposition of which and crystallization of minerals are caused by acid hydrolysis in anisotropic heat field with presence of acid-alkaline differentiation of solutions. (A.K.)

GANZEYEV, A.A., SOTSKAV, Yu.P. and LYAPUNOV, S.M., 1983, Geochemical specialization of ore-bearing solutions in relation to rare-earth elements: Geokhimiya, no. 8, p. 1179-1183 (in Russian, English abstract; translated in Geochem. Int'l., v. 30, no. 4, p. 160-164, 1984). Authors at Inst. Rarer-Element Mineral., Geochem., and Crystal., Moscow, USSR.

The distribution of REE in metasomatites surrounding ores is considered in relation to that in the unaltered parent rocks. It has been found that the original REE composition varies very slightly during skarning, greisenization, and beresitization of silicate rocks, in spite of the considerable alteration in the rock. Newly formed minerals such as apatite and fluorite take up the REE released by the substitution processes because of their high distribution coefficients for the lanthanoids. Therefore, the REE compositions in the hydrothermal minerals may be independent of the depth specialization of the mineralizing solutions and may be determined by the local redistribution. It is concluded that mineralizing solutions show no specialization in relation to REE in particular cases. (Authors' abstract)

GARANIN, V.K., KROT, A.N. and KUDRYAVTSEVA, G.P., 1983, The evolution of peridotite and eclogite magmas in kimberlite pipes: Geol. rudnykh mestor., no. 4, p. 14-28 (in Russian; translated in Int'l. Geol. Rev., v. 26, no. 1, p. 82-97, 1984). Authors at M.V. Lomonosov Univ., Moscow, USSR.

Includes a review of published data on volatiles in kimberlite and in diamond. (E.R.)

GARVEN, Grant, 1984, Theoretical study of regional mass transport in the genesis of carbonate-hosted lead-zinc deposits (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 66. Author at The Johns Hopkins Univ., Baltimore, MD 21218. Continued next page.

Epigenetic ore deposits in sedimentary basins have received a large amount of research, yet the quantitative relationship between fluid flow and geochemical mass transfer has only begun to be unravelled. The extent to which water-rock interactions occur along a flow path will depend on the mineralogy, pore structure, temperature, fluid composition, and rates of fluid flow. At the regional scale, however, it is the flow patterns and dispersive properties of the flow systems that control the focusing of mass through a ore-forming site. Quantitative analysis of ore genesis must therefore account for processes of fluid flow, heat flow, solute mass transport, and geochemical mass transfer.

Numerical modelling of transport phenomena can be used to provide a heuristic analysis of ore formation in sedimentary basins. Finite-element solutions of the fluid- and heat-flow equations are incorporated into a probabilistic model that predicts advection and dispersion of a single ore-forming component. Geochemical mass transfer is computed with the code EQ3/EQ6, but this is restricted to providing scenarios at the ore site and it is uncoupled from the regional transport modelling. A suite of generic simulations are used to quantify: the effects of hydrodynamics in focusing flow, the role of dispersion, and the comparison of precipitation mechanisms for lead-zinc ores in carbonate strata. Basinwide transport (100-300 km) of metal with sulfide is probably unimportant in ore genesis because dispersion dilutes the low equilibrium concentrations even lower. Hydrodynamic conditions that might result in ore formation through mixing of regional flow systems are rare, in which case a model of metal and sulfate being transported in the same fluid is more defensible. (Author's abstract)

GAUPP, R., MOLLER, P. and MORTEANI, G., 1984, Tantalum pegmatites: Berlin, Gebruder Borntraeger, 124 pp. (in German).

GAUTHIER-LAFAYE, Francois and WEBER, Francis, 1984, Effects of post-burial siliceous diagenesis deformations on the microthermometric behavior of fluid inclusions: an example in the Francevillian uraniferous sandstone reservoir (Gabon): C.R. Acad. Sci. Paris, v. 299, Ser. II, no. 9, p. 555-560 (in French; English abstract).

New data on fluid inclusions associated with siliceous diagenesis show that deformation in the first stage of catagenesis disturbed their microthermometric behavior. Nevertheless, T and P of fluids associated with the uraniferous paragensis and contemporary with the Oklo natural reactors are estimated at 140-160°C and 250-500 bar. (Authors' abstract)

GEGUZIN, Ya.Ye., DZYUBA, A.S. and IONGZU, Yu., 1984, Distribution of an impurity during the crystallization of a melt with macroscopic inclusions (the shadow effect): Akad. Nauk SSSR Doklady, v. 277, no. 3, p. 597-600 (in Russian). Authors at Khar'kov State Univ., Khar'kov, USSR.

The authors discuss the case when during crystallization admixed materials accumulate in front of the face of a growing crystal, indicating that similar considerations may be made for the case of formation of a zone poor in such admixture. If a screen (permeable to heat but impermeable to atoms) is placed in the way of the crystallization front with a static distribution of admixture, behind the screen the static distribution should reestablish. Experiments were made with air-saturated water crystallizing in a thin layer in a constant T gradient = 100 K/cm causing a crystallization rate of ~10^{-3} cm/sec. Screens were of copper, Cu + Ni alloy, plastic and porous paraffin in the shape of a slab or sphere. Crystallization of water causes segregation of air bubbles when local gas concentration exceeds the critical supersaturation level, and then certain typical shadow structures appear. If a flat screen is used, the width of shadow does not depend on the material of the screen. When the size of the screen is small, shadows have peculiar features caused by the existence of admixture reservoirs (gas bubbles) at the edges of screen. (Abstract by A.K.)

GENKIN, A.D., SAFONOV, Yu.G., BORONIKHIN, V.A., NAUMOV, V.B., VASUDEV, V.N., RAO, B.K., CHERNYSHEV, I.V. and NOSIK, L.P., 1984, New data on the mineralogy and geochemistry of a gold ore field of Kolar, India in F.V. Chukhrov, ed., Geol. Polezn. Iskop. Drevnikh Platform, Mater. Indo-Sov. Simp. Nauke Zemle, 4th 1981, p. 82-99 (in Russian).

Two types of Au-bearing veins occur in the Kolar Au ore deposit: Au-quartz (Champion Reef) and Au-sulfide-quartz (Oriental, Mactaegart). Fluid inclusion studies in quartz show that the lithostatic pressure during mineralization was 270 bars/km. The $\delta^{34}S$ data yielded a formation temp. of 210-240° (for the Champion Reef) and 405° (for Oriental). (Abstracted from CA 101: 114252t)

GENSHAFT, Yu.S. and SALTYKOVSKIY, A.Ya., 1984, Peculiarities of basaltoid volcanic manifestations in intracontinental tectonic structures: Akad. Nauk SSSR Doklady, v. 275, no. 3, p. 688-691 (in Russian). Authors at Inst. Earth's Physics, Moscow, USSR.

Temperatures (Th?) of basaltoid magmas of the Baikal-Mongolia region equal 1000-1250°C. (A.K.)

GERASIMOV, M.V. and MUKHIN, L.M., 1984, Studies of the chemical composition of gaseous phase released from laser pulse evaporated rocks and meteorite materials (abst): Lunar and Planet. Sci. XV, p. 298-299. Authors at Space Res. Inst., Acad. Sci. USSR, Moscow, USSR.

This paper presents 12 GC-MS (LKB-9000) analyses of the chemical composition of gases that originate as a result of sample evaporation by laser pulses of variable intensities in a He or H atmosphere. A highly nonequilibrium mixture of H_2, O_2, CH_4, CO, CO_2, SO_2, H_2S, CS_2, H_2O, HHC (up to C_6), C_2H_4O, HCN, CH_3CN, etc. was formed. (E.R.)

GERDENICH, M.J., LAUBACHER, R.C. and PRIDE, D.E., 1984, Regional study of mineralizing fluids, Breckenridge mining district, Colorado (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 517. Authors at Dept. Geol. & Mineral., The Ohio State Univ., Columbus, OH 43210.

Tertiary base- and precious-metal mineralization, plus quartz-pyrite-molybdenite mineralization in the Breckenridge district developed during evolution of the composite Breckenridge stock. District-wide characteristics of the mineralizing fluids have been examined by means of a reconnaissance fluid inclusion study of 128 sections (506 inclusions) of quartz (vein, phenocryst), sphalerite, and calcite. Four centers of hydrothermal activity ("hydrothermal cells") have been identified, based on the presence of high salinity inclusions, elevated fluid temperatures, and evidence of boiling. Ranges in Th for Type I (L-V) and Type III (L-V-NaCl±KCl) inclusions, and in salinities for the Type III inclusions are as follows: 230-467°C; 210-525°C; 32-65 wt %. Pressure determinations from the fluid inclusion data indicate mineralization depths of .8 to .9 km, corresponding perhaps to the upper part of one or more porphyry-metal systems. (From the authors' abstract)

GERLACH, T.M., 1984a, The volatile budget of Kilauea Volcano (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 517. (See next item.)

GERLACH, T.M., 1984b The degassing of Kilauea Volcano (abst.): EOS, v. 65, no. 45, p. 1131. Author at Sandia Nat'l. Labs., Albuquerque, NM 87185.

A quantitative model has been formulated for the degassing of Kilauea Volcano. The model is constrained by matrix glass, glass inclusion, and volcanic gas analytical data and by summit chamber volume changes as inferred from the Uwekahuna summit tiltmeter. The primary volatile influxes into the chamber in tons/μrad inflationary tilt are 2500 (H_2O), 5400 (CO_2), 1100 (S), 75 (Cl), and 295 (F). Sustained Halemaumau eruptions can degas primary volatiles directly and produce volcanic gases characterized by (vol %) 50% CO_2, 38% H_2O, and 12% SO_2; such eruptions, however, have been rare during the past 60 years. More typically, primary volatiles are fractionated between a chamber gas phase (90% CO_2, 10% SO_2) and chamber equilibrated melt. Average chamber gas discharges of CO_2 to the atmosphere are 3670 tons/day. Discharges of chamber equilibrated melt into rift zones give volatile outfluxes in tons/μrad, which implies 19000-20000 tons of SO_2 emission. The volcanic gases emitted during eruptions of chamber equilibrated melt are characterized by 5% CO, 80% H_2O, 15% SO_2. The model provides a conceptual basis for geochemical monitoring procedures, which have been largely empirical in approach up to the present time. It also establishes a natural standard against which to compare anthropogenic sources of atmospheric pollution for CO_2, SO_2, HCl, and HF. (Author's abstract)

GIBSON, E.K., Jr., CRONIN, J.R., KOTRA, R.K., PRIMUS, T.M. and MOORE, C.B., 1984, Amino acids, carbon and sulfur abundances in Antarctic carbonaceous chondrites (abst): Lunar and Planet. Sci. XV, p. 300-301.

GIBSON, E.K., Jr. and KOTRA, R.K., 1984, Chemical analysis of fluid inclusions using laser microprobe-gas chromatography (abst.): Abstracts of the Am. Chem. Soc. Meeting, April 1984, St. Louis, Div. of Geochemistry (unpaginated). First author at SN4, NASA Johnson Space Center, Houston, TX 77058.

The composition of volatiles present in fluid inclusions may represent the volatiles present at the time of formation of the host material. Direct chemical analysis of volatiles in fluid inclusions as opposed to bulk volatile measurements may provide more accurate information on conditions of formation and subsequent alteration. Due to the minute amounts of volatiles present in inclusions their direct analysis is a difficult task.

We have developed a laser microprobe technique which provides quantitative information complementary to that derived from non-destructive techniques and in cases with very small quantities of volatiles, unique information. A laser microprobe is utilized to "open" the fluid inclusions or to release gases from the host mineral. A stream of high-purity helium is used to sweep the released gases into a chromatograph system with an ultra-sensitive helium ionization detector. We have examined over twenty different materials such as volcanic glasses, tektites, terrestrial basalts, sedimentary rocks and meteorites. The compositional data agree reasonably well with previous estimates, when they exist. The application of the laser microprobe-gas chromatographic technique to the study of fluid inclusions in geological samples will be illustrated. (Authors' abstract)

GIBSON, E.K., Jr., PRESLEY, B.J. and HATFIELD, J., 1984, Salts in the dry valleys of Antarctica (abst): Lunar and Planet. Sci. XV, p. 302-303.

GIBSON, E.K., PRIMUS, T.M. and KOTRA, R.K., 1984, Carbon and sulfur abundances in Antarctic carbonaceous chondrites, ordinary chondrites, eucrites, and the Martian shergottite (abst): Lunar and Planet. Sci. XV, p. 304-305.

GIGGENBACH, W.F., 1984, Mass transfer in hydrothermal alteration systems--A conceptual approach: Geochimica Cosmo. Acta, v. 48, p. 2693-2711. Author at Chem. Div., DSIR, Private Bag, Petone, New Zealand.

At very low fluid/rock mass ratios the hydrothermal alteration process corresponds to isochemical recrystallization of the primary rock. The resulting full equilibrium assemblage with the composition of an average crustal rock contains the phases albite, K-feldspar, K-mica, biotite, quartz and (depending on temperature) epidote, prehnite or one of the Ca-zeolites. Relative Na^+, K^+, Mg^{2+} and Ca^{2+}--solution activities in such a rock-dominated alteration system are uniquely fixed and provide useful reference points with regard to the degree of attainment of full fluid/rock equilibrium. With increasing fluid/rock mass ratios the composition of now increasingly fluid-dominated alteration assemblages is determined by the interplay of three major processes: hydrogen metasomatism as a function of CO_2 reactivity increasing with the horizontal distance from major fluid upflow zones and leading to the formation of Al-enriched alteration assemblages; potassium metasomatism accompanied by silicification in or close to major fluid upflow zones leading to potassic and phyllic alteration; sodium, magnesium, calcium metasomatism associated with descending and heating solutions leading to propylytic alteration of recharge zones. Two new parameters, reactivity and exchangeability, determining the effectiveness of fluid components with respect to hydrothermal alteration are introduced. (Author's abstract)

GILETTI, B.J. and YUND, R.A., 1984, Oxygen diffusion in quartz: J. Geophys. Research, v. 89, no. B6, p. 4039-4046. Authors at Dept. Geol. Sci., Brown Univ.

Diffusional oxygen exchange between quartz and water was studied by determining ^{18}O profiles in the quartz using an ion microprobe. Inverse error function plots of the data are linear as required for a diffusion mechanism. One natural and two synthetic samples were used, and although they had different impurity concentrations (OH^-, Na, and Al per 10^6 Si atoms are 7-4000, 35-835, and 67-127, respectively), the D values were the same within experimental uncertainty. Diffusion parallel to c is about 2 orders of magnitude faster than that normal to c at 700°C, and diffusion normal to the rhombohedron is intermediate. The data indicate a change in slope on an Arrhenius plot at the α-β boundary. At 100-MPa (1 kbar) water pressure the preexponential factors (D_0, in square centimeters per second) and activation energies (Q, in Kilojoules per mole) for α quartz (500°-550°C) are as follows: $D_0 = 190$ and $Q = 284$ parallel to c, and $D_0 = 8 \times 10^{-2}$ and $Q = 238$ normal to the rhombohedron. For β quartz (600°-800°C), $D_0 = 4 \times 10^{-7}$ and $Q = 142$ parallel to c, $C_0 = 9 \times 10^{-7}$ and $Q = 155$ normal to the rhombohedron; and $D_0 = 1 \times 10^{-4}$ and $Q = 234$ normal to c. D increases with PH_2O and between 25 and 350 MPa log D versus log fH_2O has a slope of approximately 1.1. These D values are all several orders of magnitude larger than previously reported values for oxygen diffusion in water-free systems. (Authors' abstract)

GINZBURG, A.I., 1983, Genesis of rare-metal granitic pegmatites, *in* Geology and Genesis of Pegmatites, "Nauka," Leningrad, p. 96-133 (In Russian).

Quotes many Th values for pegmatite minerals from published works of others. (A.K.)

GIULIANI, G., 1984, Vein concentrations of tungsten-tin in the granitic massif of Zaër (Central Morocco): Mineralization and associated liquid phase: Mineral. Deposita, v. 19, p. 193-201 (in French; English abstract). Author at Allée des Bruyères, 83700 Boulouris, France.

The Sokhret Allal tungsten-tin deposit is located in the southern part of the two-mica Zaër granite (Central Morocco). The mineralization occurs in a swarm of subparallel quartz veins striking N 100-110°E. The veins are spatially associated with feldspathic episyenite-veins that seem to control their emplacement. The paragenesis is divided in three stages: I. oxide stage; II. intermediate stage; III. late sulphide stage. Fluid inclusions have been studied in the massive quartz of stage I. using microthermometric and Raman analyses: it is characterized by fluids evolving from aqueous-carbonic vapors (75 to 90 mole% H_2O, 17 to 12 mole% CO_2, 0.5 mole% CH_4, 5 to 3 mole% N_2, 2.5 to 2 mole% eq. NaCl; $T \simeq$ 450-500°C, $P \simeq$ 800 to 850 bar) to aqueous solutions (98 to 99 mole% H_2O, 2 to 1 mole% eq. NaCl traces of CO_2, CH_4, N_2; $T \simeq$ 300°C, $P \simeq$ 300 bar). Their evolution corresponds to the mixing of early carbonaceous fluid by an aqueous solution. Ore deposition would occur during this process of dilution. The early CO_2 bearing fluid seemsto play an important role in tungsten transport. (Author's abstract)

GLASSLEY, W.E., BRIDGWATER, David and KONNERUP-MADSEN, Jens, 1984, Nitrogen in fluids effecting retrogression of granulite facies gneisses: a debatable mantle connection: Earth & Planet. Sci. Letters, v. 70, p. 417-425. First author at Dept. Geol., Middlebury College, Middlebury, VT 05753, USA.

The abundance patterns of nitrogen, and chlorine in retrogressed granulite facies gneisses from southern East Greenland exhibit strong enrichment in the vicinity of small-scale shear zones. Sulfur in the shear zones occurs at the same concentration levels as in the adjacent country rock, but is depleted in the transition zone between shear zone and country rock. Within the shear zone sulfur occurs as sulfate, whereas in the country rock granulites it occurs as sulfide. Recrystallization of rock in the shear zone to scapolite-bearing, hornblende-absent assemblages, along with changes in the major element chemistry, demonstrates that these zones define migration pathways of chemically reactive fluids. Consideration of the computed fluid compositions, and of the mass ratios of chlorine/sulfur and nitrogen/sulfur demonstrate that the fluid equilibrated with continental crust prior to its passage through gneisses in the study area. Previous suggestions have been made that the mantle may act as a source region for nitrogen-rich fluids. However, equilibration of these S-, N- and Cl-rich fluids with crustal material precludes the use of element abundances to identify a mantle signature; the bulk of these fluid constituents must be considered crustal derived. (Authors' abstract)

GODOVIKOV, A.A., MARKOV, V.G., BELITSKIY, I.A., BOGDANOVA, V.I. and PAVLYUCHENKO, V.S., 1984, About hypogene thenardite: Akad. Nauk SSSR Doklady, v. 274, no. 1, p. 167-169 (in Russian). Authors at Inst. Geol. & Geophys. Siberian Br. Acad. Sci. USSR, Novosibirsk, USSR.

Thenardite found as lenses and veinlets in underground pits of the "Slepaya" mine in nepheline syenite of the Vishnevye Mts. proves the more extensive role of SO_4 in hypogene processes than it is commonly supposed. (A.K.)

GOFFÉ, Bruno and VILLEY, Michel, 1984, Textural study of carbonaceous matter in a high-pressure - low-temperature metamorphic terrane (French Alps). Do the high pressures influence the coalification?: Bull. Minéral., v. 107, p. 81-91 (in French; English abstract). First author at ER 224, Lab.

Géol., Ecole Normale Superieure - 46, rue d'Ulm, 75005 Paris, France.

In high-pressure, low-temperature metamorphic areas (6 kbar - 300°C) of the internal part of Brianconnais zone, organic matter-bearing metasediments contain hydrocarbon compounds (oils and wet gas) as inclusions in metamorphic minerals (quartz, lawsonite ...). In contrast with the metamorphic conditions, the degree of transformation of the organic matter is much less than that predicted by classical models of organic matter evolution during metamorphism.

The textural study of solid organic matter in these metasediments indicates the coexistence of two phases: I has a structure similar to a kerogen of deep catagenesis. The degree of organization is compatible with the existence of associated hydrocarbon compounds; and II has a structure similar to anthracite. Its degree of organization is more compatible with the thermal conditions of metamorphism, but seems to [be the] result of shearing effects.

An hypothesis is proposed: at a given temperature, the kinetics of organic matter evolution is considerably slowed by increasing static pressures (hydrostatic type). This inhibiting effect of pressure is locally cancelled, in the case of carbonification, by shear stress, which promotes the transformation of kerogen. (Authors' abstract)

GOLDFARB, Richard, PICKTHORN, William and TRIPP, Richard, 1984, The distribution of epigenetic gold-quartz lodes and base metal lodes within the Valdez Group, Alaska (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 286. Authors at U.S. Geol. Survey, Box 25046, MS 973, Denver, CO 80225.

Two distinct epigenetic, mineralized vein systems can be recognized within rocks of the Cretaceous Valdez Group. The Valdez Group is the major component of the Chugach terrane, a large sedimentary wedge accreted to the Gulf of Alaska margin during Late Cretaceous to early Tertiary time.

Gold-quartz lodes are localized within fissures in middle to upper-grade greenschist facies rocks. Fluid-inclusion and stable-isotope data from the Port Valdez district show that a mixture of metamorphic and meteoric waters deposited the auriferous veins at a minimum temperature of 240°C. The lodes are neither evenly nor randomly distributed, but group into 12 distinct regions. Quartz veins containing mainly gold, arsenopyrite, pyrite, calcite, and scheelite cluster on the northern Kenai Peninsula, near Coghill Lake, north of Miners River, and both north and southeast of Port Valdez. Similar lodes, which additionally contain abundant chalcopyrite, are localized around Cleave Creek Glacier, Schwan and Woodworth Glaciers, Portage Pass, western Port Wells, Kenai Lake, Port Nellie Juan, and the southern Sargent Icefield. (While the last two localities are mapped as younger Tertiary Orca Group, they seem to have many similarities with the Valdez Group.) Wall rock alteration was not observed at any of the above localities, and fresh K-feldspar was found next to many of the mineralized veins.

In contrast with these occurrences are lodes that are rich in galena, sphalerite, barite, arsenopyrite, chalcopyrite, and pyrite, but contain little gold. These lodes group north of College Fiord and from Harriman glacier northwest to Goat Mountain, as well as in Orca Group rocks south of Miners River. Extensive alteration of the adjacent country rock indicates that these veins formed under conditions quite different than those responsible for the gold-quartz lodes. (Authors' abstract)

GONCHARENKO, A.I. and SIMONOV, V.A., 1984, Fluid inclusions in plastically deformed olivines in alpine type hyperbasic rocks: Akad. Nauk SSSR

Doklady, v. 276, no. 1, p. 228-231 (in Russian). First author at Tomsk State Univ., Tomsk, USSR.

Olivines (Fa_5) from dunites of the Srednetersinskiy massif (Kuznetskiy Alatau) have dimensions 10 x 2 mm and are surrounded by smaller (3 x 2 to 2 x 1 mm) grains oriented in agreement with the large ones. Olivines bear signs of plastic deformation. Fluid inclusions were found in olivine tectonites of early plastic deformation, and identified as inclusions of methane and nitrogen. Inclusions of methane (size 2-5 µm) occur together with polyphase (L + crystals) and one-phase inclusions. Triple point of inclusions of L methane equals -182.5°C, Th of such inclusions in dunites are from -135 to -145°C, in dunite-pegmatites from -120 to -122°C, specific volumes 2.5 - 2.6 cm^3/g. Methane presence is confirmed by gas chromatography. Inclusions of nitrogen (size about 5 µm) are one-phase, transparent, and occur in olivines of dunites but not in dunite pegmatites. Their heterogenization takes place at about -190°C, Th -194.3 to -194.9°C, specific volume of L nitrogen equals 1.25 cm^3/g. Both kinds of inclusions form regular zones in olivine, up to 0.5 mm wide. Formation of methane inclusions at ~1000°C needed P 8-8.7 kbar, nitrogen inclusions - up to 11.5 kbar. High pressures and reduced gases indicate their deep origin. (Abstract by A.K.)

GONCHAROV, V.I., 1983, Hydrothermal ore formation in the marginal volcanic belts, 216 pp, "Nauka" Publ. House, Moscow, 700 copies printed, price 2 rbls. 50 kopecks (in Russian). Author at North-East Complex Sci.-Research Inst. of Far-East Sci. Center of Acad. Sci., Magadan, USSR.

The book characterizes the conditions of ore formation in the complex ferric-sialic Okhotsk-Chukotka volcanic belt. The author was interested in Au and Ag ore mineralization; he distinguishes gold-silver ore formation by deposit types: Ag-argentite, Au-sulfoantimonite, Au-argentite, Au-sphalerite-galena and Au-pyrite; Au-As-Sb formation, Au-Cu-Mo formation, Au-low-sulfide formation, Au-rare metal formation with Au-tetradymite-Bi and Au-cobaltite deposit types, and Sb-Hg ore formation. Section presenting fluid inclusion studies describes methods of investigation (thermometric and P determinations, analysis of water leachates and gas composition in individual inclusions, salt concentrations and pH of inclusion solutions), theoretical foundations of inclusion use and inclusion data for the Au-Ag deposits from Okhotsk-Chukotka belt. Ag-argentite type: inclusions in quartz of early quartz-chlorite association homogenize in L or G at 350-240°C (Td 420-240°C), solutions of Cl-Na-K type, total concentration >260-300 g per l, gases consist essentially of N_2 and CO_2. The following sulfide-polymetal association yielded the data: Th 395-240°C (quartz) and 320-315°C (sphalerite), Td 350-320 and 300-260°C (quartz), 330-220°C (galena), solution of Cl-Na-K type, concentration <20%, gases - CO_2 + N_2; commerical Ag-argentite association - Th 385-260°C (quartz), but ores precipitated at (Th) 270-260°C, Td 440-430, 360-340 and 300-240°C, solutions of HCO_3-Cl-Na-K type from high concentrations (dm halite and sylvite in inclusions) to 43 g per l; gases N_2 + CO_2 + occasionally O_2; rhodonite-rhodochrosite association - Th 370-260°C, solutions of Cl-K-HCO_3-Mg-Na, salt concentration 40 g per l; helvite-garnet association formed from Cl-HCO_3-Na-Mg solutions. Au-sulfoantimonite type: pre-ore quartz-sulfide association - Th 130-160°C, quartz-kaolinite metasomatites Th 130-240°C, quartz-adularia association Th 180-200°C to 290-300°C (for geodes) at shallow levels, to 290-345°C at deep levels, solutions were of HCO_3>> (SO_4+F+Cl)-Ca-Na-K type with concentration 105-195 g per l; gases N_2 + CO_2 (+ scarce O_2, CO, H_2), post-ore calcite-adularia association - Th 130-140°C and 120-290°C (two types of quartz), P 5-75 atm, solutions of HCO_3-Ca-Na-K type with concentration 90-93 g per l (in dried precipitate of water leachate from calcite Au makes up 0.01 wt.%, Ag 0.001 to 0.03 wt.%): gases N_2 + CO_2 (plus up to 14 vol.% of CO). Au-argentite type: Th 225-400°C, Te -18 to -31°C, salt concentration 7.2-10.5 wt.% of NaCl equiv., P 112-280 atm, HCO_3-Cl-Na-K-(Mg) solutions; gases CO_2+N_2(±O_2). Au-sphalerite-galena type: Th 50-365°C, Te -16 to -24°C, salt conc. 6.2-9.3 wt.%, P 25-190 atm, HCO_3-Cl-Na-K solutions; gases CO_2+N_2(±O_2). Au-pyrite type: Th 100-445°C, Cl-Na-K solutions; gases CO_2+N_2(+CO+"acid gases"). Au-As-Sb formation: Th 100-400°C, P 170-1400 atm, parent solutions are concentrated chloride brines; gases - prevaling CO_2. Au-Cu-Mo formation: Th 50-700°C, P 455 to >1000 atm, Cl-HCO_3-Na-K-Ca-Mg solutions, concentration 66 to 2933[sic] g per l; CO_2 is the main gas. Au-low-sulfide formation: 80-360°C, P 111-1100 atm, Cl-Na-K solutions with conc. 12-30 g per l; main gas - CO_2. Au-rare metal formation: Th 200 to 4800°C, very conc. solutions (brines). Sb-Hg formation: Th 150-250°C. The book contains also results of experiments made for elucidation of the state of Au and Ag in hydrothermal solutions. Note: literature quotations and reference list bear a number of errors. (Abstract by A.K.)

GONZALEZ PARTIDA, Eduardo, 1983a, Fluid inclusions and genetic characteristics of polymetallic mineralization in Tierra Caliente: Geomimet, v. 123, p. 35-55 (in Spanish). Author at Univ. Nac. Auton. Mex., Mexico.

Fluid inclusions of the polymetallic mineralization of Tierra-Caliente were studied. The physico-chemical conditions of the different episodes of mineralization are fundamentally different.

The first, presumably contemporaneous with exhalative phenomenon associated with submarine volcanism and massive sulfide precipitation, was from extremely concentrated brines of 57-67 equiv. wt. percent NaCl at 400-500°C.

Next, development of regional metamorphism in the rocks during two episodes of mineralization created essentially a complex carbon-rich phase where CO_2 + CH_4 + N_2 coexisted with H_2O. The mean composition of the carbon-rich fluid mixture was measured directly in place (Raman microprobe).

The third and final episode of mineralization produced polymetallic veins. The fluids of these veins are classic: low salinity of 1-10 equiv. wt. % NaCl and 150-350°C, formed from solutions of meteoric origin, which selectively remobilized sulfur and metals initially present in the metamorphosed rock section. (From the author's abstract, translation courtesy G.P. Landis) (See also Gonzalez Partida 1983b and 1983c.)

Note: Numerous aspects of the fluid inclusion studies reported in this paper are not in the above author's abstract, so G.P. Landis has provided the following more detailed abstract. Apparently much of this material is given in an earlier paper, cited there as: Gonalez Partida, E., 1981, The Gold-silver vein province of Taxco-Guanajuato: Characteristics of the hydrothermal solutions, sulfur isotopic compositions, and proposal of a metallogenetic model, with examples from the Miahuatlan, Sultepec, and Temascaltepec veins. [Thesis for Dr. of Engineering] I.N.P.L.-E.N.S.C. (France). Edited by C.R.P.G./C.N.R.S. (in French) 234 p.

There are three main styles of mineralization in the province, in chronologic order of development: a) massive sulfide bodies genetically associated with volcano-sedimentary sequence (of Plio-Quaternary age), including neovolcanic ejecta, b) metamorphic quartz segregation veins, from the episode of regional metamorphism, and c) mineralized hydrothermal quartz veins. The massive sulfide mineralization is not Kuroko-type in any sense of the concept, but as the author suggests, is perhaps an intermediate case between Kuroko and Kupferschiefer-type in a submarine volcano-sedimentary sequence. Estimated fluid temperature of 450 deg.C, and 250 bars, and approximately 15 mole percent CH_4 (Raman microprobe) are proposed.

The regional metamorphism produced a green schist country rock which consists of biotite-quartz-feldspar at the lowest exposure to two-mica biotite/chlorite with leucoxene at the top. Celadonite-paragonite substitution permits an estimate of 540 deg.C and 4 kb at the base, to 470 deg.C and 2.5 kb at the top. In zones of intense hydrothermal alteration, near sulfide accumulations, fluid inclusions are abundant but very small (5-20 microns). Fluid density ranges from 0.50 - 0.75 g/cm^3, estimated from CO_2 content. Mole fraction in the gas phase of CO_2 is XCO_2 = 0.93-0.95, that for XCH_4 = 0.013-0.019, and that for XN_2 = 0.03-0.12. CO_2 hydrate clathrate melting is +5 to +9 deg.C, making the salinities of 2-8 eq.wt.% NaCl overestimated. This effect is offset by the CH_4 presence. N_2 is an important component of the metamorphic fluids. The presence of pure CO_2 fluids with CO_2-H_2O fluids (plus CH_4 + N_2 + NaCl) suggests several explanations: a) dilution of pure CO_2 fluids by an externally derived mixed fluid, b) immiscible segregation of a homogeneous fluid of CO_2 + CH_4 + H_2O-NaCl(+N_2) at a temperature of 350-400 deg.C. The author does not suggest a choice.

At Miahuatlan, quartz veins associated with a lower Miocene monzonite stock have been studied in detail. These veins cut andesite and the alteration is quartz, chlorite, epidote, sericite, calcite, pyrite, and chalcopyrite. In contrast the Sultepec district no intrusion is present to give rise to the mineralization. Selvage alteration next to the veins is principally sericite. Three main stages of mineralization are characterized by the following mineral parageneses: Early - sphalerite with chalcopyrite exsolutions, pyrite, chalcopyrite, arsentite, proustite, polybasite, native silver generally in low concentrations, but with some rich pods; Middle - arsenopyrite, sphalerite without exsolution, and marcasite; Late - stibnite, cinnabar, marcasite, pyrite, chalcopyrite, and covellite. Gangue minerals are principally quartz with minor sericite and calcite. Fluid inclusions are 10-30 microns, generally irregular in shape, with few negative crystals, the early stage hosts the most inclusions, and single phase inclusions (liquid) are seen in the late stage minerals. Gas phase is 10-25 percent. The following general conclusions are possible: a) the salinity is low, on the order of 1-10 percent eq.wt.% NaCl, and universally decreases with temperature, b) Th uniformly decreases through each stage to the late stage mineralization, a median range of 150-350 deg.C is observed, with 150-250 deg.C dominant for the late stage. An exception to the direct relation between salinity and temperature is seen in the Middle stage sphalerite which exhibits relatively high salinities with relatively low temperatures. This observation is explained by either the presence of other solutes such as $FeCl_2$, or errors in measuring the freezing point depression in sphalerite-hosted inclusions because of poor visibility of ice at the melting point. Approximately, the minimum pressure to prevent boiling of a 0.80 g/cm^3 fluid at 280 deg.C is 62 bars, which is 720 meters depth hydrostatic, or 200 meters lithostatic. Based upon measurements at two elevations in the Sultepec vein, using temperature and salinity, an estimated geothermal gradient of 8 deg./100 meters is obtained. Leachate analyses from Temascaltepec and Miahuatlan quartz illustrate different chemical compositions at different stages of mineralization: for the former, K/Na = 0.33, Ca/Na = 0.43 and Ca/Mg = 2.19, for the later, K/Na = 0.27, Ca/Na 0.17, and Ca/Mg = 0.57. The results of 88 sulfur isotope analyses of pyrite, sphalerite, and stibnite from Sultepec, Miahuatlan, Zacualpan, Temascaltepec, and Tizapa-Santa Rosa range from -8.0 to -2.9 permil and show no relation to massive sulfide versus hydrothermal vein genetic settings. Sulfur isotope values are generally uniform in the diverse geologic environments, are lower in the veins than in the enclosing sediments, and not typical of magmatic sources. (Abstract courtesy G.P. Landis)

GONZALEZ PARTIDA, Eduardo, 1983b, Study of the fluid phase and its relations with the gold-silver vein mineralization in Miahautlan-Ixtapan del Oro, state of Mexico: Geomimet, v. 125, p. 89-100 (in Spanish). Author at Univ. Nac. Auton. Mex., Mexico.

The polymetallic sulfide mineralization of Miahuatlan-Ixtapan del Oro forms part of a Tertiary metallogenic province in which the auriferous-arsentiferous mineralization occurs as veins.

The Miocene emplacement of a monzonite stock into andesites gave rise to a propylitic hydrothermal alteration characterized by the association of chlorite, epidote, calcite, sericite, and quartz, accompanied by pyrite and chalcopyrite.

The sulfide stage mineral paragenesis (mineral assemblage) is represented by gold, native silver, argentite, sphalerite, galena, chalcopyrite, pyrite, pyrrhotite, marcasite, arsenopyrite, and secondarily emplaced covellite, in a quartz gangue with minor sericite and calcite.

The fluid phase is characterized by a salinity that varies from 0.0 to 7.85 eq. wt. % NaCl. The temperature of formation for the hydrothermal alteration varies from 400°C to 260°C, and for the sulfide mineral stage from 280°C to 140°C (without pressure corrections).

Isotopic analyses of D/H and $^{18}O/^{16}O$ permit [are compatible with] an origin of mineralizing fluids from within a meteoric water convection cell circulating at about 350°C and of low water-rock ratio. (Author's abstract, translation courtesy G.P. Landis).

Mineralization is in quartz veins that cut the andesites at Miahuatlan, whereas in Ixtapan del Oro veins are encased in Upper Cretaceous sediments. Intense propylitic alteration of the andesite is present near the stock. Less abundant phyllitic alteration exists likewise, which is represented by chlorite spherules, sericite and quartz, with a little pyrite.

From microscopic study of inclusions throughout the diverse stages of mineralization a population of more common two-phase inclusions and a population of multiphase inclusions are observed. Multiphase inclusions occur earlier than two-phase inclusions and have an average of 30 percent vapor, and typically a small solid phase exhibiting Brownian motion. A very common solid phase is an anisotropic, fibrous, multiradiating star. The vapor/liquid ratio varies from 30% to 10% from first to last stage of mineralization. AA-analyses of K, Na, Ca, Mg, and Cl leached from quartz-hosted inclusion fluids were performed, and show NaCl to be the predominant solute responsible for the -0.2 to -5.0°C freezing point depression of ice in the fluids. K/Na atomic ratios of 0.27 in andesite hosted veins, to 0.21, 0.32 for veins in calcareous sediments, show no consistent difference (each number is average of 4 analyses). δD and $\delta^{18}O$ are approximately -45 to -60 per mil and 3 to 5 per mil respectively, and show no relation to different host rocks of the quartz veins. (Added data from text, translated by G.P. Landis) (See also preceding item.)

GONZALEZ PARTIDA, Eduardo, 1983c, Petrographic, crystallochemical, and fluid inclusion analysis of the Paleozoic metamorphic series in Tierra Caliente: Geomimet, v. 124, p. 61-71 (in Spanish). Author at Univ. Nac. Auton. Mex., Mexico.

The metamorphic series at the base of the lithostratographic units in the region of Tierra Caliente are characterized by a mineral assemblage of quartz, biotite, muscovite, and detrital tourmaline.

Crystal-chemical analysis of white micas show a temperature of formation that varies from 540°C at the base of the unit to 470°C at the top, and a pressure of 4.0 to 2.5 kb.

Carbon-bearing components, CO_2, and CH_2-N_2, included in the fluid phase, resulted from the transformation of dispersed organic material initially in the pelitic sediments. (Author's abstract, translation courtesy G.P. Landis) (See also preceding items.)

GOODRICH, C.A., 1984, The formation of metallic iron in mafic magmas: the role of carbon (clues from native iron in Kisko Island basalts) (abst): Lunar and Planet. Sci. XV, p. 312-313.

GORBATYI, Yu.K. and DEM'YANETS, Yu.N., 1984, Pressure influence on near ordering in liquid water: Akad. Nauk SSSR Doklady, v. 275, no. 4, p. 903-906 (in Russian). Authors at Inst. Experimental Mineralogy, Chernogolovska near Moscow, USSR.

P causes bending of hydrogen bonds and change of angles, initially close to that of tetrahedron, and density increment due to decrease of distance between closest molecules and increase of coordination number; pertinent to physics of inclusion fluids. (A.K.)

GOSTYAYEVA, N.M. and DIMITROV, G.Kh., 1984, Temperature conditions for the formation of metasomatic prehnite rock (from inclusion study): Geokhimiya i Rudoobrazovaniye, v. 12, p. 33-35 (in Russian). Authors at Inst. Geochem. & Physics of Minerals of Acad. Sci. of Ukrainian SSSR, Kiev, Ukraine.

The studied prehnite metasomatic rocks occur in a tectonic zone in Precambrian rocks of the Kirovograd block, Ukrainian shield. Thickness of stratabound prehnite body reaches 14 m. Wall-rocks are amphibolites, amphibole-biotite gneisses and granites. Prehnite content in metasomatites ranges from 55 to 90% [by vol.? - A.K.], plus clinozoisite, quartz, albite and chlorite. Grain size of rock varies from 0.03 to 2 mm. Prehnite bears azonal P inclusions. Cracking and decrepitation of some of these inclusions occurred at T >300°C, but most inclusions did not leak. Naturally decrepitated inclusions were not found in prehnite. Hence the obtained results of inclusion studies are valid. Size of inclusions ranges from 3 to 20 µm, filling degree from 70 to 90 vol. %. Inclusions homogenize in L phase at 380-100°C, but most of them at 280-120°C. Remnant quartz bears S L and G/L inclusions (3-15 µm long) with filling degree 70-100 vol. % and Th 370-100°C (most inclusions Th 370-120°C), all in L phase. By cryometry, inclusion fluids are Cl-Ca solutions of concentration 8-12 wt. %, rarely only 2.5 wt. %. Triple water leachates yielded the following composition of inclusion solutions: Na 67.5, Ca 31, K 1.5, HCO_3 73.5, Cl+F 35, SO_4 1.5; composition of gases (analysis of individual inclusions) is as follows (vol. %): N_2+rare gases 40-80, CO_2 8-42, acid gases 13-28, CO 6-20, CO_2 concentration in fluid ~1 mole/l l of water. (Abstract by A.K.)

GÖTZINGER, M.A., 1984a, The quantification of fluid inclusions in crystals by means of infrared spectroscopy, for example in fluorite: Fortschr. Mineral., v. 62, Beiheft 1, p. 74-76 (in German).

An infrared analysis of doubly polished fluorite plates, and cleavage plates, showed a positive correlation between the NaCl- resp. water-content and the sum of the absorption attributed to the 3400 cm^{-1} OH^- stretch vibration band.

To verify the use of the Lambert-Beer law, a series of fluorite plates of different thicknesses were made from samples of light-green fluorite from Stulln Hermine mine, BRD. These show, under the microscope, a homogeneous distribution of inclusions. The thickness of the plates varied from 0.2 to 0.78 mm. A 2-mm diaphragm permitted identical illuminated areas. Fig. 1 shows a satisfactory linearity between extinction and plate thickness at a constant concentration of fluid inclusions. For quantitative measurements, the range between 0.3 and 0.6 mm of plate thickness seems applicable; differences between polished plates and cleavage plates have not been observed.

The following basic specimen requirements should be observed: 1) the inclusions must be distributed homogeneously in the crystal; 2) the inclusions should not be larger than 0.05 mm diam.; 3) domains with solid inclusions and fissures must be avoided; 4) the plates must be plane parallel.

The content of water does not depend on the genesis, and younger formations generally have less inclusions, or none. The same can be said for the CO_2-content, which can also be detected quantitatively by this method (absorption band at 2340 cm^{-1}). The turbidity of the crystals generally correlates with the water content. Organic substances (C-H-absorption band at about 2900 cm^{-1}) appear in sedimentary fluorites and in those from alpine fissures; they can often be positively correlated with the water content. (Author's abstract, translation courtesy H.A. Stalder).

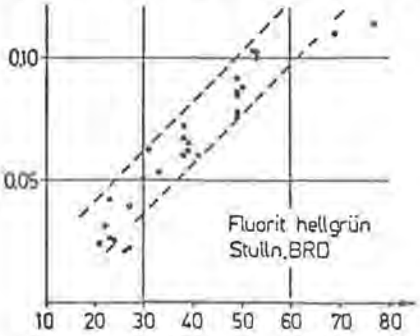


Fig. 1: Linear dependence of the extinction (ordinate = log I_0/I; OH-absorption-band at 3400 cm^{-1}) on the thickness of plates in fluorite (abcissa; mm/100), at the same concentration of H_2O-inclusions.

GÖTZINGER, A., 1984b, Sedimentary fluorite mineralization in Triassic carbonate rocks from the Drau area, Kärnten, Austria: Aufschluss, v. 35, p. 351-358 (in German).

A compilation on the fluorites in Triassic carbonate rocks. Fluid inclusions are mentioned, as well as REE-spectra. (Abstract courtesy H.A. Stalder)

GÖTZINGER, M.A. and WEINKE, H.H., 1984, Trace-element contents and genesis of fluorite mineralizations in the Gutensteiner-Schichten (Anis - Mid-Triassic), Northern Calcareous Alps, Austria: TMPM Tschermaks Min. Petr. Mitt., v. 33, p. 101-119.

Fluorite mineralization in fissures of the Gutenstein Strata (Anis - Mid-Triassic) is located in tectonic zones, near evaporites. The trace-element contents (including REE) of fluorite, calcite and dolomitic limestone have been determined by neutron activation analysis (NAA). Na- and Cl-contents have been measured by short-time-NAA. In fluorites with high Na- and Cl-contents three-phase inclusions are observed by microscope and are characterized by specific IR-spectra. Both the low trace-elements contents, especially in REE, and the distribution patterns of REE suggest an origin of the fluorites in a sedimentary environment. The inclusions in the fluorite suggest that the fluorites in the fissures of the Gutenstein Strata have been deposited from brines; evaporites occur in the immediate vicinity. The origin of fluorite is ascribed to fluorine-rich parts of Gutensteiner Kalk and/or dolomite. Dispersed fluorite occurs in bituminous carbonate sediments. (Authors' abstract)

GOW, A.J., 1984, Crystalline structure of urea ice sheets used in modeling experiments in the CRREL test basin: CRREL Report 84-24, ILIR Project No. DA4A161101A91D, Work Unit 347, 55 pp. Author at U.S. Army Cold Regions Res. & Engrg. Lab., Hanover, NH 03755.

This report describes the growth characteristics and crystalline textures of urea ice sheets which are now used extensively in the CRREL test basin for modeling sea ice. The aims of the report are to describe the different kinds of crystalline texture encountered in urea ice sheets and to show that even small variations in texture can drastically influence the mechanical behavior of urea ice sheets. Standard petrographic techniques for studying microstructure in thin sections were used on 24 urea ice sheets. These investigations entailed observations of the crystalline texture of the ice (including details of the subgrain structure), grain size measurements, and studies of the nature and extent of urea entrapment and drainage patterns in the ice. Increased knowledge of the factors controlling the crystalline characteristics of urea ice sheets has progressed to the point where test basin researchers at CRREL are now able to fabricate ice sheets with prescribed structures leading to predictable mechanical properties. (Author's abstract)

Contains numerous photographs showing the changes in fluid inclusions during recrystallization of the host. (E.R.)

GRAF, J.L., Jr., 1984, Effects of Mississippi Valley-type mineralization on REE patterns of carbonate rocks and minerals, Viburnum Trend, southeast Missouri: J. Geol., v. 92, p. 307-324.

GRAHAM, C.M., ATKINSON, Janet and HARMON, R.S., 1984, Hydrogen isotope fractionation in the system chlorite-water: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 139-140.

GRAHAM, C.M., HARMON, R.S. and SHEPPARD, M.F., 1984, Experimental hydrogen isotope studies: Hydrogen isotope exchange between amphibole and water: Am. Mineralogist, v. 69, p. 128-138. First author at Dept. Geol., Edinburgh Univ., Edinburgh, Scotland EH9 3JW.

Equilibrium hydrogen isotope fractionation factors ($\alpha^{e}(\text{min-H}_2\text{O})$) were determined experimentally for various amphiboles over the temperature range 350 to 950°C.

The water content of ferroan pargasitic hornblende (in equilibrium with water) decreased from 2.1 wt.% at 350°C to 1.2 wt.% at 950°C, probably because of oxy-hornblende reactions.

A consequence of the low activation energies calculated for hydrogen diffusion is that amphiboles in volcanic rocks may readily quench in their high-temperature hydrogen isotopic compositions, whereas amphiboles in slowly-cooled metamorphic and hydrothermal environments may continue to exchange hydrogen with a coexisting fluid down to temperatures much lower than those of initial amphibole crystallization. (From the authors' abstract)

GRANOVSKAYA, N.V., 1984, Mineralogy and thermobarogeochemistry of the Belaya Reka barite deposit (North-West Caucasus): Zapiski Vses. Mineral. Obshch., v. 113, no. 4, p. 454-463 (in Russian). Author at Rostov Univ., Rostov, USSR.

Two main commercial mineral associations were distinguished in the studied deposits: quartz-barite and galena-barite with fluorite (the latter subordinate). All described barite veins and stratiform bodies formed from Ca-Na-HCO_3-Cl solutions under P<40 MPa. Th of inclusions in barites of the first and second generation (of commerical value) are 180-140 and 90-70°C, respectively. Cooling of solutions is accompanied by increment of Ca/Na ratio in fluids. CO_2 occurs in inclusions in subordinate amounts. (Abstract by A.K.)

GRATIER, J.P. and JENATTON, L., 1984, Deformation by solution-deposition, and reequilibration of fluid inclusions in crystals depending on temperature, internal pressure and stress: J. Structural Geol., v. 6, no. 1/2, p. 189-200. Authors at I.R.I.G.M., BP 68, 38402 Saint Martin d'Hères Cédex, France.

Changes of shape and density of fluid inclusions in crystals were demonstrated when these crystals were subjected to temperatures and internal pressures greater than those of their growth. Experimental relations have been established between the rate of length-change of the inclusions and the different parameters of the experiment: nature of the crystal, temperature and internal pressure, state of stress on the crystal, geometric characters of the inclusion (length, width), orientation of the inclusion with respect to the optical axes of host mineral. It is essentially the effect of the variation of surface energy with the curvature around the cavity which causes a mass transfer of the host crystal by diffusion through the fluid under pressure. The rate of length-change is limited by the rate of dissolution at the median part of elongate inclusions. This change of shape and density is known to occur in naturally deformed crystals. An example of such a behavior is given which allowed us to use the inclusions as markers of the conditions of temperature and pressure subsequent to the growth of crystal. (Authors' abstract)

GREEN, H.W., II, 1984, "Pressure solution" creep: some causes and mechanisms: J. Geophys. Research, v. 89, no. B6, p. 4313-4318. Author at Dept. Geol., Univ. California, Davis.

Despite the widespread evidence of stress-controlled dissolution and precipitation in diagenetically altered and low-grade metamorphic rocks, a great deal of controversy remains concerning the driving forces and transport mechanism involved. To clarify the various driving forces, the free enthalpy equation is expanded here to allow identification of different terms contributing to the overall phenomenon. It is argued that under diagenetic conditions, stress concentrations at grain-to-grain contacts will be the largest source of chemical potential gradients and that upon burial and cementation these inhomogeneities decline and the orientation dependence of normal stress in a quasi-homogeneous stress field becomes important as well. These mechanisms operate efficiently enough under these relatively cold, H_2O-rich conditions that stresses can remain below the threshold for crystal plastic deformation. Water on grain boundaries provides at the very least a high diffusivity path and in cases of large volume losses must also contribute directly through fluid flow. Most experimental work on this phenomenon has not distinguished carefully between stress-enhanced solubility and solubility enhancement due to plastic deformation or microcracking. A new thermodynamic analysis of the results of some experiments by Sprunt and Nur suggests that in at least some of their experiments, true pressure solution creep has been activated. A related phenomenon, volume transfer creep during phase transformations which involve significant volume change, displays many of the characteristics of pressure solution. (Author's abstract)

GRIB, E.N. and SHUGUROVA, N.A., 1984, Gas-phase composition of the acid lavas of Uzon-Geyserny region (according to the results of a minor inclusion study): Vulkanol. Seismol. 1984, no. 3, p. 87-90 (in Russian). Authors at Inst. Vulkanol., Petropavlovsk-Kamchataskii, USSR.

During the Quaternary, three cycles of magmatic activity are recognized in the area each of which commenced with the extrusion of andesites and dacites and culminated with the formation of rhyolitic flows. The acidic rhyolite lavas consist of orthopyroxenes, clinopyroxenes, magnetite, rare olivine, etc. During the magma crystallization, mineral phenocrysts captured residual melts and gases (as bubbles). Results are presented of the microchemical estimation of CO_2, H_2S (+ SO_2 + SO_3 + HCl +HF), hydrocarbons, CO, H_2 and N_2 (+ rare gases) in the gas phase in plagioclase and in the glassy groundmass. (C.A. 101: 76310a)

GRICHUK, D.V. and BORISOV, M.V., 1983, A thermodynamic model of a hydrothermal system in the oceanic crust: Dokl. Akad. Nauk SSSR, v. 270, no. 2, p. 424-426 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 158-160, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 94, 1983. (E.R.)

GRIFFIN, W.L., WASS, S.Y. and HOLLIS, J.D., 1984, Ultramafic xenoliths from Bullenmerri and Gnotuk Maars, Victoria, Australia: Petrology of a sub-continental crust-mantle transition: J. Petrol., v. 25, Part 1, p. 53-87. First author at Min.-Geol. Museum, Sarsgt. 1, Oslo 5, Norway.

The basanite tuffs of Bullenmerri and Gnotuk maars, Victoria, enclose abundant xenoliths of spinel lherzolites, many of which contain amphibole ± phlogopite. The xenolith suite also includes cumulate wehrlites, spinel metapyroxenites and garnet metapyroxenites. All xenolith types contain abundant large CO_2-rich fluid inclusions. Microstructural evidence suggests that all the metapyroxenites have formed from cumulates by exsolution and recrystallization during cooling to the ambient geotherm. Garnet pyroxenites show a series of reactions to successively finer-grained, lower-P mineral assemblages, which imply a relatively slow initial upward transport of the xenoliths in the magma, prior to explosive eruption. The same process has allowed crystallization of phenocrysts from small patches of interstitial melt within xenoliths of lherzolite, wehrlite and metapyroxenite. (From the authors' abstract)

GRIGORYAN, S.V. and OVCHINNIKOV, L.N., 1984, Geochemical exploration methods for concealed mineralization (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 279-280 (in English). Authors at Inst. Mineralogy, Geochem. & Crystal. of Rare Elements USSR Ministry Geol. and Acad. Sci., Moscow, USSR.

The following types of concealed mineralization are distinguished: deposits covered by autochthonous formations; blind ore bodies with primary halos* exposed in the present erosion surface; blind-covered ore bodies, combining the features of the first two groups of deposits; buried-stripped by the ancient erosion surface and later overlapped by allochthonous sediments; blind-buried - occurring under allochthonous sediments. Prospecting of the first group of mineralization is based on their secondary halo detection. However, reliable evaluation of the revealed anomalies is possible only in case of satisfactory correlation between primary and secondary halos, when parameters of adequate primary halos are used for determination of the erosion level and the approximate scale of the concealed mineralization including distinguishing of zones with non-commerical dispersed mineralization. Prospecting of blind mineralization is carried out by revealing their primary halos exposed in the present erosion surface. During prospecting of blind-covered ore bodies, the degree of correlation between primary halos and secondary dispersion halos, formed during their hypergene decomposition, is preliminarily determined. Prospecting of buried and blind-buried mineralizations is carried out by detection of their superimposed halos (including gaseous ones) in overlapping allochthonous sediments. In recent years, increasing efficiency of prospecting of concealed ore bodies in the USSR depended on the successfully used universal geochemical zoning established for primary halos of sulphide-bearing hydrothermal deposits as well as on the application of halos multiplicative parameters, mineralogical-geochemical criteria and considering metasomatic zoning of the anomaly. (Authors' abstract) [*I.e., fluid inclusion features? Ed.]

GRINENKO, L.N., 1984, Hydrogen sulfide gas accumulations as a source of sulfur for sulfidation of magma in the commerical ore bearing intrusions of the Noril'sk region: Dokl. Akad. Nauk SSSR, v. 278, no. 3, p. 730-732 (in Russian). Author at Moscow State Univ., Moscow, USSR.

Gas samples from gabbro-dolerites of the Noril'sk intrusion, depth 880.9 m bear 47% H_2S, and from the depth 975 m - up to 67% H_2S. The author supposes that H_2S comes from H_2S-hydrocarbon deposits in underlying beds of the Tunguska oil-gas province. Sulfidation of magma might occur in the intermediate magma chamber. (A.K.)

GRINENKO, L.N., ARTEMENKO, V.M. and PONOMAREV, V.G., 1984, Sulfur isotope composition of rocks and ores of the Gorevskoye lead-zinc ore deposit: Geokhimiya, 1984, no. 5, p. 653-667 (in Russian; English abstract).

GRISHINA, S.N., 1984, Effect of CH_4 contents on the final melting temperature of CO_2 in the system CO_2-CH_4 (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 52-53 (in English). Author at Inst. Geol. & Geophy. Siberian Br. USSR Acad. Sci., Novosibirsk, USSR.

Liquid methane-CO_2 inclusions in halite from Dneprovsk-Donetsk depression are convenient for studying the system CO_2-CH_4 with various ratios of the components (to $X(CH_4) = 0.6$). The binary composition of the inclusions has been fixed by means of four independent methods. The presence of isolated groups of inclusions of similar types, high density of filling of the vacuoles and low temperature of their destruction permitted one to apply gas chromatography with various regimes of destruction, mass-spectrometry, freezing stage, crushing stage and Raman microprobe analysis to study the composition of the inclusions.

All methods have shown the presence of practically pure methane-CO_2 mixture in the studied inclusions. In several inclusions insignificant amounts of nitrogen ($X(N_2) \leq 0.005$) were found by Raman microprobe analysis and mass-spectrometry. Comparisons of various regimes of destruction for chromatographic determination has shown the change in the component composition at elevated temperature over 400°C.

The study of the same inclusions on the freezing stage and crushing stage permitted one to fix the correlation between the final melting temperature of CO_2 and the CH_4 contents. The obtained correlation makes it possible to evaluate the relationship of the components contained in methane-CO_2 inclusions found in minerals of various geological origin providing valuable information of physico-chemical parameters of the mineral-forming solutions. (Author's abstract)

GROVES, D.I., PHILLIPS, G.N., HO, S.E., HENDERSON, C.A., CLARK, M.E. and WOAD, G.M., 1984, Controls on distribution of Archaean hydrothermal gold deposits in western Australia, in Gold '82: the geology, geochemistry and genesis of gold deposits, ed., R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1), p. 689-712. First author at Geol. Dept., Kambalda Nickel Operations, Kambalda, W.A.

Gold production from the Archaean of Western Australia (2100 tonnes Au) has come predominantly from discordant, epigenetic, but essentially stratabound deposits, mainly within tholeiitic metabasalt/metadolerite but also within BIF hosts in greenstone belts of the Yilgarn Block. Integration of presently-available data on the nature of auriferous veins and wall rock alteration, the association of gold with sulphide-rich, vein-related alteration, the predominantly syn- to post-peak metamorphic timing of mineralization, and the nature of primary fluid inclusions from auriferous quartz veins allows formulation of a genetic model for gold mineralization.

Gold appears to have been transported as reduced sulphur complexes in a hot, alkaline, reduced H_2O-CO_2 fluid of low salinity derived by metamorphic dehydration and decarbonation of greenstone sequences at upper amphibolite-granulite facies deep in the greenstone pile. These fluids were channeled along fault zones and access to a large volume of reactive host rock was provided by hydraulic fracture at high fluid pressures within or adjacent to the zones of fluid-access. Deposition over a P-T range of c. 0.8-2.0 kb and 300-450°C was largely related to fluid-wall rock interaction, which lowered total dissolved sulphur and changed pH and fO_2 of the fluid. The preferred host rocks -- tholeiites and BIF -- appear important because they provide Fe for pyritization (rarely pyrrhotization) reactions, determine Fe-related redox reactions, and are relatively competent and thus susceptible to hydraulic fracture. Apart from the reduction of dissolved gold species to elemental gold, there is no universal reaction leading to gold deposition. Therefore other rock types may also host gold mineralization and there are numerous small deposits in all rock types as well as the few large deposits in a more limited range of lithologies.

A number of regional controls of gold mineralization appear consequent on the metamorphic model for gold genesis. Most of the larger deposits occur in greenschist to amphibolite transition facies metamorphic domains, presumably reflecting a broad temperature interval (300-450°C) over which gold solubility decreased to levels where deposition could be readily induced by fluid-wall rock reactions. In many areas, vein-type mineralization is associated with broad, fault-bounded, anticlinal zones in which the hosts to gold mineralization are uplifted relative to flanking zones. Such a control is consistent with the initiation of hydraulic fracture in zones of high fluid pressure where lowering of confining pressure accompanied selective uplift.

The age of greenstone belts also appears to exert an important, albeit an indirect, control on the abundance and type of gold mineralization. Possible causes of much lower gold production from the older Pilbara terrain (c. 3.5 Ga) include unsuitable, sulphide- and gold-depleted source-rocks, early removal of gold by silicification, absence of suitable fluid components, and unfavorable metamorphic style. BIF-hosted deposits are important in the apparently older (c. 2.9-3.0 Ga) Murchison Province, whereas tholeiite-hosted deposits dominate the younger (c. 2.8 Ga) Eastern Goldfields Province. The apparent changes in the nature and abundance of gold deposits may reflect fundamental temporal changes in the magmatic, tectonic, and metamorphic evolution of greenstone belts. This can only be established when the province-scale setting of the gold deposits, the alteration and metamorphic histories of the greenstones, and the gold distribution in them are more fully understood. (Authors' abstract)

GUGUSHVILI, V.I., APKHAZAVA, M.A. and BAGDASARYAN, G.P., 1984, Conditions of formation of pyrite-barite-polymetallic deposits of the South-East Georgia: Sovetskaya Geologiya, no. 11, p. 48-56 (in Russian). First author at Geol. Inst. of Georgian Acad. Sci., Tbilisi, Georgia.

At the Madneuli deposit Th for chalcopyrite and pyrite ores is about 370°C and decreases for Cu-polymetallic, barite-polymetallic and quartz-barite - the latter 120-60°C. (A.K.)

GUIJARRO, U., HOYOS, M.A., CASA, J. and MARTIN DE VIDALES, J.L., 1984, Study of the fluid inclusions in the veins of the stockwork of Cerro de San Cristobal (Logrosan, Spain): Bol. Geol. Min. (Madrid), v. 94, no. 6, p. 521-529 (in Spanish; English abstract). First author at Dept. Geol. & Geoquimica. Facultad de Ciencias. Univ. Autonoma de Madrid.

In the stockwork running across the adamellitic apex of Cerro de San Cristobal (Logrosan, Spain) we have distinguished four generations of fractures which were refilled by mineralizing solutions. This process originated veins whose appearing order is: Type I veins, unproductive with NW-SE direction; Type II veins, with N-S direction slightly mineralized in sulphides; Type III veins with NE-SW direction and strongly mineralized in sulphides and cassiterite; Type IV veins, E-W direction and unproductive.

Homogenization temperatures of the primary fluid inclusions increase from Type I veins (228-242°C) to Type II (332-345°C) and reached in Type III veins a temperature up to 350°C. Thereinafter temperature falls in Type IV veins (318-338°C).

Relative homogenization temperatures of the secondary fluid inclusions are quite similar in the diverse vein generations because they are ranging between 236 and 254°C. (Authors' abstract)

GUILHAUMOU, Nicole, VELDE, Bruce and BENY, Claire, 1984, Raman microprobe analysis of gaseous inclusion in diagenetically recrystallized calcites: Bull. Minéral., v. 107, p. 193-202. First author at E.N.S. 46, rue d'Ulm, 75230 Paris Cedex, France.

Raman microprobe studies have been made on two core samples from the Smackover formation (Jurassic) Perry County Mississippi, at about 6.5 kilometers depth. Inclusions were found in calcite cements. Among other interesting aspects, one can see following gaseous inclusion assemblages - H_2S, CH_4, CO_2, carbon; H_2S, CH_4, CO_2, H_2O, carbon; and H_2S, CH_4, carbon where a characteristic low temperature behavior is noted for the CH_4-H_2S system. The solid phase appears to be a very poorly ordered form of graphite, similar to that found in the earliest stages of the kerogengraphite transition found in metagenesis. Other series of inclusions are calcic saline aqueous. Corrected Th for these inclusions are near those of the samples in situ. This indicates that the inclusions have readjusted to present conditions, those of present day bottom hole temperatures and pressures. Considering the importance of early decrepitation one can assume that a readjustment occurred between early entrapment conditions and those currently prevalent at depth.

The observations suggest either an evolution of gaseous inclusions up to the conditions of the upper stability of methane and methane-CO_2 mixtures in the presence of H_2O or the evolution of trapped hydrocarbon liquids which evolved to produce a gas-kerogen assemblage exempt of any organic molecules more complex than CH_4. (Authors' abstract)

GUMENYUK, V.A. and GLYUK, D.S., 1983, The ore-metamorphic zoning of gold-silver deposits: Dokl. Akad. Nauk SSSR, v. 269, no. 1, p. 179-184 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 41-44, 1984).
Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 97, 1983. (E.R.)

GUMENYUK, V.A., GRANOVSKIY, A.G., IVANISHENKO, A.K. and PROKOPOV, N.S., 1984, Relative role of thermobaric and geochemical factors in the formation of ore and metasomatic zoning (as exemplified by a gold-polymetallic deposit in the Priamur'ye): Akad. Nauk SSSR Doklady, v. 275, no. 4, p. 979-984 (in Russian). First author at Far-East Sci.-Research Inst. Mineral Raw Materials, Khabarovsk, USSR.

The deposit occurs in the Lower Proterozoic granodiorite basement of a Mesozoic volcanic structure. It formed under 700-1000 m overburden of coal-bearing lake sediments, now mostly eroded together with the upper 500-meter-thick part of the deposit. The sediments prevented the influence of meteoric O_2 and CO_2, [permitting the] introduction of non-oxidizing Ca(Cl,B) solutions into the deposit formation zone. The deposit has vertical and asymmetric lateral zoning, in the following sequence from north to south and from the present-day surface to the bottom: 1. Sericite + quartz + chlorite + garnet + pyrite + sphalerite + pyrrhotite + Zn-spinel; 2. Sericite + quartz + garnet + pyrite + sphalerite; 3. Quartz + sericite + garnet + pyrite + sphalerite + galena; 4. Quartz + K-spar + sericite + garnet + pyrite; 5. Quartz + sericite + gold + argentite. The paper presents 158 determinations of Td by thermovacuum method for 11 minerals and Th values for inclusions in quartz; they show that all minerals, including Fe-Mn-Ca garnet and Zn-spinel, formed over the wide T interval 180-360°C, and for a number of samples at 160-400°C. T varies in vertical section by 100°C, and laterally by 20-80°C. Water leachates (15 determinations) yielded the composition of solutions: Ca, K, Fe, NH_3 (± Mg), Cl, sulfur ions, $HSiO_3$, F, B and admixtures of Na and HCO_3. The decrepitation of inclusions in the ranges of lower-T peak A (230 ± 20°C) released CO, CO_2 (the ratio $CO:CO_2$ ranges from 140 to 0.7), N_2 (and CH_4 in spinel), but in the ranges of higher-T peak B (320 ± 20°C) - CO, CO_2 ($CO:CO_2$ ratio 17-0.5), CH_4, NH_3, H_2S. The probable reactions producing these gases and influencing the $CO:CO_2$ ratio, are indicated. Pressures of formation are estimated for 0.2-0.5 kbar. (Abstract by A.K.)

GUNAWARDENE, Mahinda, 1984a Inclusions in taaffeites from Sri Lanka: Gems & Gemology, v. 20, p. 159-163. Author at Lanka Foundation for the Research of Gemstones, Colombo, Sri Lanka.

This article reports on a gemological and mineralogical study of inclusions in taaffeites from Sri Lanka, with photomicrographs of some of the most characteristic occurrences. The presence of minerals such as apatite, phlogopite, spinel, and muscovite is noted and their significance in the genesis of taaffeite is discussed. (Authors' abstract)

GUNAWARDENE, M., 1984b The internal paragenesis of taaffeite from Sri Lanka: Z. Dt. Gemmol. Ges., v. 33, no. 3/4, p. 91-95 (in German; English abstract).

Gemmological and mineralogical studies of the internal paragenesis of taaffeites from Sri Lanka are described. Photomicrographs of the most characteristic inclusions of taaffeites are given. The presence of such minerals as apatite, phlogopite, spinel, muscovite as well as the rare occurrence of zircon and garnet within the gem contribute to the knowledge of its origin. (Author's abstract)

GUNNESCH, M. and JAKSCH, H., 1984, Fluid inclusion studies in fluorite at Milpo Mine (Atacocha district), Central Peru, in Syngenesis and Epigenesis in the Formation of Mineral Deposits, A. Wauschkuhn, C. Kluth and R.A. Zimmerman, eds.: Springer, Heidelberg, p. 328-341. First author at Min.-Petrogr. Inst., Im Neuenheimer Feld 236, 6900 Heidelberg, FRG.

Fluid inclusions in fluorite from Milpo mine (Atacocha district) Central Peru provide interesting observations on the hydrothermal phase in these deposits. The inclusions can be divided into four compositionally distinct types. Type I (liquid + vapor + halite ± sylvite) shows homogenization temperatures between 415° and 345°C and salinities of 35-59 wt.% NaCl equiv. The evolution of this type takes place in the succession as follows: $I_a \rightarrow I_b \rightarrow I_c$. All inclusions for type I_a homogenize by halite disappearance. Type II (liquid + vapor) homogenizes to vapor in the same temperature range as type I_a. This fact suggests boiling conditions. Type III (liquid + vapor + halite) homogenizes between 190° and 350°C and contains 30-37.5 wt.% NaCl. Type IV homogenizes between 160° and 300°C and has low salinities of 6-18 wt.% NaCl. Type I inclusions occupy a compositionally distinct field in the $NaCl-KCl-H_2O$ system and correspond to a fluid A of magmatic origin. The inclusions of type III and type IV occupy a very small field along the $NaCl-H_2O$ boundary and represent a fluid B which initially had low salinity. The fluid A has gross densities of 1.10-1.05 g/cm^3 and the fluid B densities of 0.8-0.93 g/cm^3. Mixing phenomena of these fluids with different densities occur. The approximated pressure at the time of trapping is low, from 140 to 200 bars. (Authors' abstract)

GURAU, Andrei, 1984, Mineralization of fluorite in the Valea Caselor basin, Leaota Mountains (Arges County) [Romania]: Stud. Cercet. Geol., Geofiz., Geogr. Geol., v. 29, p. 55-60 (in Romanian). Author at Intreprinderea Prospectiuni Geol. Geofiz., Bucharest, Romania.

Fluorite occurs as vein and tectonic-breccia deposits associated with a pre-Jurassic fracture system in crystallized rocks (Leaota series) of the Voinesti-Papusa quartzofeldspathic complex. Associated minerals are galena, sphalerite, chalcopyrite, and auriferrous quartz. The fluorite crystals are 96.69% CaF_2; trace-element contents are Cu ~100, Y 121-150, Yb ~2, Sr 26-30, and Rb 17 ppm. Decrepitation and Th studies of fluid inclusions in fluorites indicate hydrothermal mineralization at 310-350°. Silicic magmatic activity at depth is the probable source of the mineralizing fluids. Textural and paragenetic relations suggest mineralization in several pulses related to repeated movement along a major fracture zone. (C.A. 102: 65085a)

GURNEY, J.J., HARRIS, J.W. and RICKARD, R.S., 1984a, Minerals associated with diamonds from the Roberts Victor mine, in Kimberlites, v. II: The mantle and crust-mantle relationships, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 25-32.

GURNEY, J.J., HARRIS, J.W. and RICKARD, R.S., 1984b, Silicate and oxide inclusions in diamonds from the Orapa mine, Botswana, in Kimberlites, v. II: The mantle and crust-mantle relationships, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 3-9.

GURULEV, S.A., 1983, Conditions of formation of basic layered intrusions: "Nauka," Moscow, 249 pp., 700 copies printed, price 2 rbls. 90 kopecks (in Russian).

The book describes varieties of layered intrusions, their structure, magma reactions with wall rocks, minerals of layered intrusions and conditions of formation of such intrusions. (A.K.)

GUTIERREZ, G.N. and KYLE, J.R., 1984, Nature and controls of sandstone-hosted lead deposits, Indian Creek district, southeast Missouri (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 526. Authors at Dept. Geol. Sci., Univ. Texas at Austin, Austin, TX 78713.

Fluid inclusion data for sphalerite from the Indian Creek mine indicate that the mineralizing fluid was a Na-Ca-Cl brine ranging in temperature from 100 to 120°C. The Lamotte served as the aquifer that channeled the metalliferous brines into the Bonneterre near depositional pinchouts. (From the authors' abstract)

GUTSALO, L.K., 1984a A new method for evaluating the helium isotopic balance in contemporaneous hydrotherms: Dokl. Akad. Nauk SSSR, v. 275, no. 4, p. 985-987 (in Russian).

GUTSALO, L.K., 1984b Mantle helium, neon, and argon in cold waters of the Sinegorsk Springs (Sakhalin): Dokl. Akad. Nauk SSSR, v. 274, no. 6, p. 1457-1462 (in Russian).

HAGNI, R.D., 1984, Precambrian silver-tungsten-tin mineralization and its relationship to granitic magmatism in southeastern Missouri, USA: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 345-347.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 91, 1980. (E.R.)

HALAS, S., 1984, Isotope analysis on nano-mole gas samples: ZFI-Mitteilungen, "Isotope in der Natur," no. 84, p. 103-106: Leipzig, Akad. Wissen. der DDR (in English). Author at Inst. Physics, Maria Curie-Sklodowska Univ., 20-031 Lublin, Poland.

The technique of isotope analysis developed by Halas and Krouse has recently been adopted for extremely small-size samples at Maria Curie-Sklodowska University. 50-100 nmol of CO_2 extracted from gaseous inclusions in natural quartz shows $\delta^{13}C$ values around -24‰ which indicate an organic origin of this gas, while dispersed hydrocarbons extracted from Permian sediments (mainly CH_4) have $\delta^{13}C$ below -40‰. (Author's abstract)

HALFMAN, S.E., LIPPMANN, M.J., ZELWER, R. and HOWARD, J.H., 1984, Geologic interpretation of geothermal fluid movement in Cerro Prieto field, Baja California, Mexico: Am. Assoc. Petrol. Geol. Bull., v. 68, no. 1, p. 18-30.

HALL, W.E., SCHMIDT, E.A., HOWE, S.S. and BROCH, M.J., 1984, The Thompson Creek, Idaho, porphyry molydenum deposit - an example of a fluorine-deficient molybdenum granodiorite system: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 349-357. First author at U.S. Geol. Survey, Menlo Park, CA, USA.

The Thompson Creek molybdenite deposit is in a belt of I-type granitoid plutons extending from southeastern California to southeastern Alaska that host porphyry molybdenum systems. Molybdenite is associated with a composite biotite granodiorite/biotite granite stock of Late Cretaceous age that is near the east side of the Idaho batholith. Quartz-molybdenite stockwork veins occur within the stock in an elongate tabular body, closely associated with strong potassic alteration, that trends N 45° W and plunges 23° NW.

The geologic, fluid-inclusion, and isotopic data are consistent with a genetic model wherein magmatic fluids that evolved from differentiation of a granodioritic parent magma and caused extensive potassic alteration of the core and crest of a dome-shaped stock mixed with heated meteoric water during quartz-molybdenite deposition. Such mixing resulted in fluids with temperatures of 250° to 300°C, salinities of 6 to 11 wt % NaCl equivalent, and varying amounts of carbon dioxide. Lead-isotopic analyses and heavy $\delta^{34}S$ values indicate a deep crustal source from a 2.1-b.y.-old basement for the lead and sulfur. (Authors' abstract)

HALLBAUER, D.K., 1984, Characterization of pyrite by microinclusions and trace element content (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 54-55 (in English). Author at Chamber of Mines of S.A. Research Organization, Johannesburg, RSA.

As the most common ore mineral pyrite is present in many deposits, often as more than one generation. Mineragraphic differences are usually subtle or ambiguous and often absent. Characteristic differences between pyrites of diverse origin could, however, be obtained by comparing and correlating the type and nature of microinclusions with the trace elements contained in single pyrite grains. For this purpose between 10 and 30 pyrite grains per locality and of about 1 mm or more in diameter were split mechanically. Using electrothermal atomic absorption spectrophotometry one half of each grain was analyzed for 25 to 27 trace elements. The other half was mounted in a SEM to study and analyze the microinclusions and fluid inclusions. The most common microinclusions were found to be quartz, various phyllosilicates and feldspar in different combinations and proportions, and of different composition. Specific inclusions with regard to a classification were carbonates, anhydrite, magnetite and various sulphide minerals. Factor analysis and multivariate discriminant analysis of the trace element contents and their correlation [in a] particular inclusion finally completed the classification. Detrital pyrites from Witwatersrand conglomerates could thus be differentiated according to primary sources and their distribution mapped. (Author's abstract)

HALLEY, S., SOLOMON, M. and HIGGINS, N.C., 1984, Pressure, temperature and source conditions for the fluids of the Aberfoyle (Tasmania) tin-tungsten vein system (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 55-56 (in English). First author at Australian Nat'l. Univ., Canberra, Australia.

The Lutwyche sheeted vein system lies between the Aberfoyle and Storys Creek systems in NE Tasmania. The Lutwyche veins strike NW, N or NE, dip westerly, and cut folded pre-Devonian quartzwackes and shales. The veins are largely milky quartz with wolframite, cassiterite, sphalerite, chalcopyrite, pyrrhotite, pyrite, muscovite, topaz, fluorite and carbonates. Slices of country rock in the veins testify to repeated opening, and faulting and fine-scale fracturing is both pre- and post-vein formation. Poorly defined textures indicate quartz grew inward from the walls. Fluid inclusions in quartz are of five types: A, 3-phase with L-CO_2, V-CO_2 and aqueous solution of about 3.5 equiv. wt.% NaCl; B, 2-phase with V-CO_2 and aq. solution; C, 2-phase with aq. solution and vapor; D, multiphase with aq. solution, vapor and daughter salts; E, vapor with aq. solution. In types A and B Th (270-360°C) and compositional data (mole % CO_2) define CO_2-H_2O-NaCl solvii. Pressures estimated from experimental data are between 200 and 500 bars. Types D and E are relatively late and higher temperature (Th = 304 to 489°C) and represent the components of a CO_2-poor, two-phase H_2O-NaCl system. $S^{34}\delta$ values of sulphides range from -3.3 to +1.3‰ and $\delta^{18}O$ values of quartz from +13.94 to +14.90‰. Calculated fluid compositions indicate mainly magmatic solutions throughout vein history. Early solutions were near 350°C, with CO_2/CH_4 molar ratio >100:1 (R.W.T. Wilkins, pers. comm.), neutral to 1.5 units acid, total sulphur $>10^{-2}$ m, and $fO_2 \approx 10^{-31}$ or lower. Later solutions were higher temperature and CO_2-poor. The veins grew by rapid precipitation during repeated phases of fracture dilation. The pressure range recorded may reflect oscillation from lithostatic to hydrostatic. Gas loss during phases of fluid immiscibility developed during pressure drop possibly led to fall in temperature, and increase in pH and fO_2; these were probably the major factors in mineral precipitation. (Authors' abstract)

HAMPTON, C.M. and BAILEY, D.K., 1984, Gas extraction experiments on volcanic glasses: J. Non-Crystalline Solids, v. 67, p. 147-168. Authors at Dept. Geol., Univ. Reading, Whiteknights, Reading, RG6 2AB, England.

Glasses from a range of geological environments and of various compositions, were heated through the range 600-1250°C, and the released gases were continuously analyzed by mass spectrometer. Gas release-temperature profiles fall into two broad groups. Felsic glasses (>60 wt% SiO_2) have simple gas emissions, where the gas species peak at the melting temperature; this is controlled by a simple viscosity-temperature relationship. Mafic glasses (<50 wt% SiO_2) have complex gas release profiles where gases peak at different temperatures. H_2O emitted ~200°C below the main release of the other gases. These glasses have a complex viscosity-temperature relationship which is affected by nucleation and crystallization induced by heating. The felsic/mafic division depends on the ratio of network forming to network modifying ions. It appears that the mafic glasses, which have a large excess of network modifying ions, over those required to maintain charge balance in the silica-alumina framework, produce a more open glass structure which enables easier diffusion of gases and less strongly bonded ions. Gas emissions often accompany structural changes such as glass transformation, nucleation, liquid exsolution, and phenocryst melting. Temperatures of release suggest that CO_2 occurs in molecular form as CO_3^{2-}, while H_2O occurs as OH^- in the glass/melt. (Authors' abstract)

HANNAH, J.L. and STEIN, H.J., 1984, Evidence for changing ore fluid composition: stable isotope analyses of secondary carbonates, Bonneterre Formation, Missouri: Econ. Geol., v. 79, p. 1930-1935.

HANOR, J.S., 1984a, Variation in the chemical composition of oil-field brines with depth in northern Louisiana and southern Arkansas: implications for mechanisms and rates of mass transport and diagenetic reaction: Transactions - Gulf Coast Assoc. Geol. Soc., v. 34, p. 55-61.

HANOR, J.S., 1984b, Determining pore-water salinities from SP response: a thermodynamic reevaluation (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). Author at Louisiana State Univ., Baton Rouge, LA.

Quantitative knowledge of the salinity of deep formation waters is critical in assessing the degree of hydrocarbon saturation in sands, in predicting methane solubility, and in deducing pathways of fluid migration. Calculation of salinity from the spontaneous potential (SP) response of borehole logs using conventional algorithms can yield inaccurate values, particularly for geopressured waters. Thus, a theoretical reevaluation has been made of the relation between pore-water salinity in NaCl-dominated waters and SP response, taking into account pressure as a variable and recently-developed, improved, thermodynamic models for brines.

The following expression satisfactorily relates pore-water salinity, as molality of total dissolved NaCl, to the static spontaneous potential (SSP) over P-T-salinity conditions of sedimentary interest:

$$\log m\,\mathrm{NaCl}\ (\text{pore water}) = (\mathrm{SSP} \times F)/(2.303\,RT \times b \times t) + \log m\,\mathrm{NaCl}\ (\text{mud filtrate})$$

where m = molality, F = faraday constant, R = gas constant, and T = absolute temperature. The complex, non-ideal behavior of NaCl solutions can be described by a single, pressure-temperature dependent, concentration independent variable, b. The term t accounts for the differential mobility of Na^+ and Cl^- ions through sands and shales.

Use of the equation provides several important advantages over conventional techniques: (1) pore water salinity is given explicitly as a dependent variable, facilitating analysis of error; (2) the expression is simple and avoids use of electrical resistivities, which have no direct theoretical role in the relation between SP and salinity; (3) the improved thermodynamic base provides a more rigorous means of assessing the effects of grain size, mineralogy, and streaming potential on SP response. (Author's abstract)

HANSEN, E.C., NEWTON, R.C. and JANARDHAN, A.S., 1984a Fluid inclusions in rocks from the amphibolite-facies gneiss to charnockite progression in southern Karnataka, India: direct evidence concerning the fluids of granulite metamorphism: J. Metamorphic Geol., v. 2, p. 249-264. First author at Dept. Geophys. Sci., Univ. Chicago, Chicago, IL 60637, USA.

Fluid inclusion studies of rocks from the late Archaean amphibolite-facies to granulite-facies transition zone of southern India provide support for the hypothesis that CO_2-rich H_2O-poor fluids were a major factor in the origin of the high-grade terrain. Charnockites, closely associated leucogranites and quartzo-feldspathic veins contain vast numbers of large CO_2-rich inclusions in planar arrays in quartz and feldspar, whereas amphibole-bearing gray gneissses of essentially the same compositions as adjacent charnockites in mixed-facies quarries contain no large fluid inclusions. Inclusions in the northern-most incipient charnockites, as at Kabbal, Karnataka, occasionally contain about 25 mol. % of immiscible H_2O lining cavity walls, whereas inclusions from the charnockite massif terrane farther south do not have visible H_2O.

Microthermometry of CO_2 inclusions shows that miscible CH_4 and N_2 must be small, probably less than 10 mol. % combined. Densities of CO_2 increase steadily from north to south across the transitional terrane. Entrapment pressures calculated from the CO_2 equation of state range from 5 kbar in the north to 7.5 kbar in the south at the mineralogically inferred average metamorphic temperature of 750°C, in quantitative agreement with mineralogic geobarometry. This agreement leads to the inference that the fluid inclusions were trapped at or near peak metamorphic conditions.

Calculations on the stability of the charnockite assemblage biotite-orthopyroxene-K-feldspar-quartz show that an associated fluid phase must have less than 0.35 H_2O activity at the inferred P and T conditions, which agrees with the petrographic observations. High TiO_2 content of biotite stabilizes it to lower H_2O activities, and the steady increase of biotite

TiO_2 southward in the area suggests progressive decrease of aH_2O with increasing grade. Oxygen fugacities calculate from orthopyroxene-magnetic-quartz are considerably higher than the graphite CO_2-O_2 buffer, which explains the absence of graphite in the charnockites.

The present study quantifies the nature of the vapors in the southern India granulite metamorphism. It remains to be determined whether CO_2-flushing of the crust can, by itself, create large terranes of large-ion lithophile-depleted granulites, or whether removal of H_2O-bearing anatectic melts is essential. (Authors' abstract)

HANSEN, E.C., NEWTON, R.C. and JANARDHAN, A.S., 1984b, Pressures, temperatures and metamorphic fluids across an unbroken amphibolite facies to granulite facies transition in southern Karnataka, India: Archaean Geochem., 1984, p. 161-181. Authors at Dept. Geophys. Sci., Univ. Chicago, Chicago, IL 60637, USA.

Geobarometry based on the indicator assemblage garnet-pyroxene-plagioclase-quartz indicates regular increase in pressure of metamorphism from ~5 near Channapatna (12°40'N) to 7.5 kbar in the highest-grade rocks, near 12°00'N. Geobarometry based on densities of CO_2 fluid inclusions in quartz, determined from Th measurements from seven localities, agrees quant. with the mineralogic geobarometry. The average temperature in the transition zone is 750°, as determined by the Fe and Mg distribution between garnet and pyroxene pairs. The K/Rb whole-rock ratios of charnockites and gray gneisses are ~300 (normal upper crust values) in the northern half of the traverse and increase southward to very high values, indicating extreme Rb depletion, where charnockite becomes the dominant country rock. This depletion is patchy, even in the southernmost high-grade massif areas. Continuous prograde transition south of Kabbal is established. A depth-zone arrangement of amphibolite facies and granulite facies is indicated. The source of CO_2 in inclusions was deep-seated and streaming of CO_2-rich fluid was an important process in charnockite formation. (C.A. 102: 98676x)

HARDIE, L.A., 1984, Evaporites: Marine or non-marine?: Am. J. Sci., v. 284, p. 193-240. Author at Dept. Earth & Planet. Sci., The Johns Hopkins Univ., Baltimore, MD 21218.

It is imperative to find criteria to distinguish marine from non-marine evaporites, particularly in view of the growing recognition of the significance of salt deposits in global tectonics. It is crucial to recognize that a marine depositional setting does not guarantee that the salts were derived mainly or exclusively from seawater, but that the extreme hydrologic restriction necessary for evaporite formation means that there could be a significant, perhaps even dominant, non-marine water input, as demonstrated by many modern sabkhas.

The specific criteria for making these distinctions are the following: (1) kinds of fossils, (2) sedimentology of the associated non-saline facies, (3) kinds of primary saline minerals, (4) association of such saline minerals, both in qualitative and quantitative terms, (5) trace element, isotope, and fluid inclusion geochemistry of such saline minerals. The first two tell us mainly about the depositional setting while the third and fourth are the most reliable signatures of parent water chemistry. The last criterion, involving geochemical tracers such as Br, contrary to widely held belief, is not an unequivocal one for distinguishing between marine and non-marine parent waters and in fact can yield misleading results if sampling and interpretation are not guided by petrographic study. (From the author's abstract)

HARDWICK, J.F., Jr., 1984a Epithermal vein and carbonate replacement mineralization related to caldera development, Cunningham Gulch, Silverton, Colorado: MS thesis, Univ. Texas at Austin, Austin, TX.

Epithermal vein and carbonate replacement deposits in Cunningham Gulch are located within the western San Juan Tertiary volcanic field in southwestern Colorado.

Regional propylitic alteration of the hosting volcanics to a chlorite-calcite-pyrite assemblage preceded vein-associated alteration and mineralization. The veins are enveloped by a narrow phyllic alteration assemblage of quartz, sericite, illite, kaolinite, and pyrite. The veins are comprised of sphalerite, galena, chalcopyrite, pyrite, hematite, magnetite, quartz, pyroxmangite, calcite, and minor barite. Substantial bodies of replacement ore are present where the vein structures intersect the limestone blocks; the mineral assemblages of the replacement deposits are identical to those of the feeding vein structures. Commonly, replacement textures are spectacular concentrations, especially the "zebra ore" which primarily consists of regularly spaced, alternating bands of sulfides and quartz. These "zebra" laminations are stratigraphically controlled and appear to represent replacement of a depositional or diagenetic fabric. Main ore-stage mineralization began with widespread deposition of quartz with or without pyrite, followed by sphalerite, chalcopyrite, and galena. Post ore-stage brecciation and silicification events are evident and were followed by deposition of calcite and minor barite during the waning stages of the hydrothermal system.

The distibutions of Fe, Mn, Pb, and Ca suggest a lateral component of fluid flow from northwest the southeast, away from the structural margin of the Silverton Caldera. Fluid inclusion data from both vein and replacement-type sphalerite and quartz indicate that mineral deposition occurred over a range of 200 to 312°C (mean 243°C) from solutions containing 1 to 5% total salts. The high base metal to precious metal content of the ore, the phyllic alteration assemblage, and the temperature and composition of the ore-forming fluid indicate that the mine workings are within the lower portion of a fossil geothermal system. (From the author's abstract)

HARDWICK, J.F., 1984b Epithermal vein and carbonate replacement mineralization in Cunningham Gulch, Silverton, Colorado (abst.): Geol Soc. Amer. Abst. Prog., v. 16, p. 224. Author at Dept. Geol. Sci., The Univ. Texas at Austin, Austin, TX 78712.

Vein and carbonate replacement ore deposits occur in the area and are largely hosted by the caldera-collapse breccia. Veins are comprised of sphalerite, galena, chalcopyrite, pyrite, hematite, magnetite, quartz, pyroxmangite, calcite, and minor barite. Substantial bodies of replacement "zebra" ore are present where the carbonate blocks are intersected by feeder veins. Although the major flux of fluid flow was probably directed upward within this highly fractured area, the distribution of Fe, Mn, Pb, and Ca suggests a lateral component of fluid flow from northwest to southeast along the vein system, away from the structural margin of the Silverton Caldera. Fluid inclusion data indicate that mineral deposition occurred over a range of 201-312°C from solutions containing 1-5% NaCl eq. These features indicate that the mine workings are within the lower portion of a fossil geothermal system. (From the author's abstract)

HARRIS, D.M. and ANDERSON, A.T., Jr., 1984, Volatiles H_2O, CO_2 and Cl in a subduction related basalt: Contrib. Mineral. Petrol., v. 87, p. 120-128. First author at Dept. Geol., Univ. Oregon, Eugene, OR 97403-1272, USA.

The products of the 1974 eruption of Fuego, a subduction zone volcano in Guatemala, have been investigated through study of silicate melt inclusions in olivine. The melt inclusions sampled liquids in regions where olivine, plagioclase, magnetite, and augite were precipitating. Comparisons of the erupted ash, groundmass, and melt inclusion compositions suggest that the inclusions represent samples of liquids present in a thermal boundary layer of the magma body. The concentrations of H_2O and CO_2 in glass inclusions were determined by a vacuum fusion manometric technique using individual olivine crystals (Fo77 to Fo71) with glass inclusion compositions that ranged from high-alumina basalt to basaltic andesite. Water, Cl, and K_2O concentrations increased by a factor of two as the olivine crystals became more iron-rich (Fo77 to Fo71) and as the glass inclusions increased in SiO_2 from 51 to 54 wt.% SiO_2. The concentration of H_2O in the melt increased from 1.6 wt.% in the least differentiated liquid to about 3.5% in a more differentiated liquid. Carbon dioxide is about an order of magnitude less abundant than H_2O in these inclusions. The gas saturation pressures for pure H_2O in equilibrium with the melt inclusions, which were calculated from the glass inclusion compositions using the solubility model of Burnham (1979), are given approximately by $P(H_2O)(Pa) = (SiO_2 - 48.5\ wt.\%) \times 1.45 \times 10^7$. The concentrations of water in the melt and the gas saturation pressures increased from about 1.5% to 3.5% and from 300 to 850 bars, respectively, during pre-eruption crystallization. (Authors' abstract)

HART, Roger and HOGAN, Lewis, 1984, Solar noble gas component in glassy submarine basalts (abst): Lunar and Planet. Sci. XV, p. 347.

HART, S.R., 1984a, Studies of temporal variations of lead isotopes in ore fluids related to Mississipi-Valley-type ore deposits: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 32-39.

HART, S.R., 1984b, He diffusion in olivine: Earth & Planet. Sci. Letters, v. 70, p. 297-302. Author at Center for Geoalchemy, Dept. Earth, Atmospheric & Planet. Sci., Mass. Inst. Tech., Cambridge, MA 02139, USA.

Helium diffusion in olivine (dunite xenolith) has been measured in the temperature range 1180-1460°C; a linear Arrhenius function was obtained with an activation energy of 120_{-27}^{+32} kcal/mole, and a pre-exponential factor $(D_0) = 2.2 \times 10^8\ cm^2/s$.

Diffusion mechanisms are not a viable means of degassing He from the mantle. Olivine phenocrysts can be expected to retain previously trapped He, during cooling in extrusive basalts, provided the flow units are thinner than ≃ 50 m; xenoliths will retain mantle He signatures only if magma transport times are less than ≃ 50 years, or if the He fugacity in the magma is high enough to prevent xenolith degassing. The lower oceanic crust is probably substantially degassed of He. Trapped He will be qualitatively retained in quenched submarine basalt glass only if the cooling rate is faster than $\sim 5 \times 10^{14}$°C/m.y.; glass at several centimeters depth in a basalt flow (near the spherulite zone) will have cooling rates lower than this, so He loss may be significant in many basalt glass samples. (Author's abstract)

HARWOOD, A., 1984, Geothermometric studies at the Chojlla mine, Bolivia (abst.): J. Geol. Soc., v. 141, part 2, p. 391-392. Author at Univ. Cardiff.

The Chojlla tin tungsten deposit is situated in the Cordillera Real to the NE of La Paz, Bolivia. The mine is the most important tungsten producer in Bolivia, and ranks ninth in world producers. The deposit is closely associated with the contact of the Taquesi batholith, of Triassic age, part of which is exposed as dyke-like genetic apophyses in the lower levels of the mine. It is enclosed within a thick pile of Upper Ordovician slates, which have been metamorphosed and metasomatically tourmalinized. The slates dip uniformly NE and are cut at right angles by a system of parallel en-echelon ore-bearing quartz veins which dip to the SW.

The deposit is of the hydrothermal type (high temperature) with ore minerals wolframite and cassiterite, with minor sulphide minerals in veins consisting of over 95% quartz.

Detailed mineralogical studies revealed a single prolonged hydrothermal history, divided into a number of phases:

1. Greisen stage: alteration phase associated with some tungsten mineralization in the granite apophyses;
2. Early vein stage: dominated by deposition of quartz, cassiterite, wolframite, arsenopyrite and apatite;
3. Main vein stage: deposition of quartz and sulphides; Pyrite chalcopyrite, sphalerite, pyrrhotite and minor stannite;
4. Late vein stage: alteration of pyrrhotite to 'Bird's eye' pyrite and marcasite aggregates, deposition of galena, fluorite and siderite.

Fluid inclusion data for quartz, cassiterite, fluorite and siderite were obtained from vein sections and various veins from the different levels of the mine. These revealed decreasing Th with vein paragenesis from 400°C (Greisen stage) to 280°C (Late vein stage). This also corresponded to a rise and fall in salinity from 20 wt% NaCl (Greisen stage) to 24 wt% NaCl (Early vein stage) down to 14 wt% NaCl in the Late vein stage. Data from vein sections revealed a dramatic decrease in salinity between the ore-bearing Early vein stage to the sulphide Main and Late vein stages. Some boiling is also evident in the fluid inclusions from the Greisen and Early vein stage.

Detailed E.P.M.A. studies were also performed on the validity of the arsenopyrite and wolframite geothermometers; the former revealed a similar picture to the fluid inclusion data. Sphalerite geobarometric studies were applied to resolve problems in depth of burial and pressure corrections--these proved erratic.

Sulphur isotope geothermometry was also applied to sulphide pairs (sphalerite-pyrrhotite and sphalerite, chalcopyrite) appearing to coexist; the study revealed that, in fact, pairs were not in isotopic equilibrium when deposited. (Author's abstract)

HASELTON, H.T., Jr., 1984, Solubility of quartz in dilute HF solutions at 600°C and 1 kbar (abst.): EOS, v. 65, p. 308.

HASZELDINE, R.S., SAMSON, I.M. and CORNFORD, C., 1984a, Dating diagenesis in a petroleum basin, a new fluid inclusion method: Nature, v. 307, p. 354-357. First author at Britoil PLC Stratigraphic Lab., 150 St. Vincent St., Glasgow G2 5LJ, UK.

The final porosity and permeability of sandstone petroleum reservoirs is greatly affected by the diagenetic growth of minerals after deposition. For example a sand may be deposited with a porosity of 25% and a permeability of 5,000 mdarcy (mD); diagenetic growth of quartz around detrital sand grains may leave a rock with only 10% porosity, and later growth of clays may partly fill these remaining pores and block inter-pore connections, reducing permeability to 100 mD. If the depth and timing of such diagenetic alteration can be measured and the extent of diagenesis estimated, then prediction of the diagenetic state of undrilled sandstones may become possible and diagenesis related more closely to the timing of hydrocarbon migration and the formation of hydrocarbon traps. We present an example of a new method for estimating the date of quartz diagenesis using a combination of techniques from thin section petrogaphy, fluid inclusion thermometry, organic geochemical thermometry and sedimentary basin stratigraphic analysis. These results suggest that quartz in the Beatrice oil field was precipitated from moving and cooling pore fluids, at a temperature between 68°C and 94°C in the late Jurassic. (Authors' abstract)

HASZELDINE, R.S., SAMSON, I.M. and CORNFORD, C., 1984, Quartz diagenesis and convective fluid movement: Beatrice oilfield, UK North Sea: Clay Minerals, v. 19, p. 391-402. First author at Stratigraphic Lab., Britoil, 150 St. Vincent St., Glasgow G2 5LJ.

The extent of diagenesis in Lower Jurassic shoreline sandstones of the Beatrice oilfield was controlled primarily by their detrital clay content. Sandstones rich in detrital clay had low depositional permeabilities; these show preservation of detrital feldspars to the present day and have no extensive diagenetic quartz overgrowths. Sandstones poor in detrital clay had high permeabilities and show large quartz overgrowths as part of a normal sub-arkosic diagenetic sequence. Such quartz occurs preferentially below, but not above, impermeable mudstones. These low- and high-permeability features suggest that pore-fluid flow was important during diagenesis. Fluid inclusions trapped in diagenetic quartz overgrowths formed between 68° and 94°C. This silica was probably supplied in solution from the temperature-driven illitization of smectitic clays surrounding these sandstones deeper in the basin. Fluid volumes from clay dewatering, from mechanical compaction, or from influx of overlying seawater were too small to transport diagenetic silica volumes. Silica-rich fluids were probably transported up-dip by convective cells within the sandstones and authigenic quartz precipitated as these fluids cooled. This episode of quartz diagenesis could not have been completed within $1{\cdot}6 \times 10^6$ yr if fluid velocities were 3·1 m/yr. Similar convective fluid flows could have transported the fluids responsible for secondary porosity development and the hydrocarbons expelled from mudstones later in the basin burial history. (Authors' abstract)

Salinity of inclusions in quartz overgrowths was 8-17 wt.% NaCl equiv. Organic isomer measurements on associated mudrocks yielded a maximum temperature of 78-94°C. Pressure estimates are also made. (E.R.)

HAWKSWORTH, M.A. and MEINERT, L.D., 1984, Fluid inclusion characteristics and mineral zoning in the Groundhog vein system, Central district, New Mexico (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 532-533. First author at FMC Corp., Suite 2720, City Center 4, 1801 California St., Denver, CO 80202.

In the upper 300 m of the Groundhog Mine, Zn-Pb-Ag-Cu mineralization associated with quartz veins has been deposited in open fissures along faulted diorite sill-granodiorite porphyry dike contacts. Vein ore bodies extend to within 2.5 km of the Santa Rita porphyry Cu deposit, and overlie extensive skarn mineralization deeper in the Groundhog Mine. Th for 600 inclusions show: primary inclusions in quartz 270-405°C, with a peak near 313°C, and evidence for local boiling at 390°C. Primary Type I inclusions in sphalerite 270-340°C, with a peak at 305°C. Paragenetic relations show sphalerite deposited later and at lower temperatures than most quartz stages. 134 salinity determinations indicate that hydrothermal fluids contained an average of 7 wt.% NaCl equiv. during sulfide deposition, within a range of 1 to 11 wt.%. Daughter minerals, possibly dawsonite, anhydrite, and carbonate, are present in some inclusions. Based on evidence of boiling, a pressure estimate of 220 to 250 bars has been determined. This implies mineralization occurred at a depth between 1000 m (lithostatic est.) and 3600 m (hydrostatic est.), and suggests a pressure correction of 10 to 20°C should be added to Th. Fluid inclusion characteristics are similar to those in the underlying skarn, the phyllic alteration stage at Santa Rita, and the deep root zones below some epithermal Au-Ag vein systems. (From the authors' abstract)

HAYBA, D.O., 1984, Documentation of thermal and salinity gradients and interpretation of the hydrologic conditions in the OH vein, Creede, Colorado (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 534. Author at U.S. Geol. Suvey, MS-959, Reston, VA 22092.

Detailed fluid inclusion studies (Roedder, 1977, IAGOD, v. 2) on growth banded sphalerite from the OH vein showed that the color variations of growth zones correspond to abrupt changes in the nature of the ore fluids. The base of a distinct orange-brown growth zone marks a sharp increase in both temperature and salinity relative to the preceding yellow-white zone and provides a useful time line throughout the vein. Along this marker horizon, temperatures and salinities of fluid inclusions show a gradual decrease from about 280°C and 12 wt.% NaCl eq. at the basal, northern end of the vein to 250°C and 8 wt.% NaCl eq. at localities 200m higher and 1000m further to the south. This thermal and salinity gradient, which matches the fluid flow path inferred from metal zoning, is interpreted as the progressive mixing of deeper, saline hydrothermal fluids with overlying, dilute ground waters that have been preheated to ~160°C. The greater density of the overlying ground water promoted convective mixing, resulting in solutions that were >30% ground water in the upper parts of the vein. Occasionally, these upper levels were totally engulfed by these overlying waters (Foley et al., 1982, GSA Abs., v. 14, no. 7). Localities in the lower vein levels show discrete salinity variations, which suggest that the hydrothermal component may have undergone an earlier (deeper) period of mixing before mixing with ground water high in the system.

Where it is possible to establish a time line, thermal and salinity gradients provide a means of distinguishing among cooling due to conduction, boiling, or mixing. Whereas boiling is an effective depositional mechanism and has been documented in the upper levels of the OH vein, this study shows that at least some of the coarse-grained sphalerite deposition resulted from mixing high in the system of a deep, hot, saline fluid with an overlying, dilute water. (Author's abstract)

HAYBA, D.O., FOLEY, N.K. and HEALD-WETALUFER, P., 1984, Characteristics that distinguish types of epithermal deposits (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 21. Authors at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

Three distinctive groupings of epithermal deposits were recognized from a literature study of fifteen well-described precious- and base-metal epithermal districts, supplemented by L.J. Buchanan's 1981 compilation of data from 47 less-completely documented deposits. The three groups are distinguished primarily by the type of alteration and the sulfur fugacity indicated by the vein mineral assemblage. Additional discriminating criteria include composition of the host rock, timing of ore deposition relative to emplacement of the host, and relative abundances of gold, silver, and base-metals. The first group, typified by Goldfield, Nevada, has advanced argillic alteration and a vein mineral assemblage (enargite + pyrite ± covellite) which reflects relatively high sulfur fugacities. Both gold- and silver-rich members are present and have moderate concentrations of base metals, notably copper. Ore deposition in this group closely followed emplacement of the host which in most cases is rhyodacite. The second group, typified by Creede, Colorado, has sericitic ± argillic alteration, a less-sulfidized vein mineral assemblage, and adularia. This group tends to have high concentrations of silver and moderate to high concentrations of base metals, especially lead and zinc. The third group, for example, Round Mountain, Nevada, has sericitic alteration, a vein mineral assemblage that reflects low sulfur fugacities, and adularia. Compared with the other groups, sulfides and sulfosalts are rare. The main ore minerals are native gold and silver, and electrum, with silver/gold ratios near unity. For the latter two groups, ore deposition usually occurred significantly later (>1 m.y.) than emplacement of the host rocks. These distinguishing features provide significant constraints for genetic models of epithermal mineralization. (Authors' abstract)

HAYNES, F.M., 1984, A geochemical model for sulfide paragenesis and zoning in the Cu-Fe-As-S system (Tsumeb, South West Africa/Namibia): Chem. Geol., v. 47, p. 183-190. Author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109, USA.

The Cu-bearing hypogene mineralization at Tsumeb, south west Africa/Namibia, is interpreted to have resulted from the interaction of hot circulating Cu-rich saline solutions and host dolomites. Fluids attending formation of the main sulfide stage were warm (210-280°C) and moderately saline (6-12 wt.% NaCl equivalent).

Phase relations within the Cu-Fe-As-S system suggest that the observed paragenetic sequence (chalcopyrite → bornite → chalcocite → enargite → tennatite) is consistent with a model calling for successive introduction of a single Cu-rich solution into a host dolomite. The Cu and As content of the solution decreased as it passed through the permeable dolomite precipitating Cu-As-sulfides and sulfosalts. A concomitant increase in pH created by the dissolution and buffering effect of dolomite produced sufficient changes in the fluid chemistry to shift the stable sulfide mineral assemblage. (Author's abstract)

HAYNES, F.M. and KESLER, S.E., 1984a Evolution of brine chemistry during sulfide deposition in the East Tennessee zinc district (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 535. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Energy dispersive SEM analyses of fluid inclusion decrepitates from the East Tennessee Zinc District (ET) reveal major differences among inclusion compositions in sphalerite, ore-stage gangue dolomite, and regional unmineralized dolomite. $CaCl_2$/NaCl ratios fluctuated from as low as 0.2 in unmineralized dolomite and early light-colored ZnS to as high as 1.5 in later darker ZnS and ore-associated dolomite.

These differences are thought to record changes in fluid chemistry as metal-transporting basinal brines deposited ZnS. Brines entering the Knox Group limestone units apparently encountered sufficient S to deposit early light green ZnS whose inclusions contain Ca/Na ratios only slightly higher than those detected in unmineralized dolomite from brines that presumably did not deposit ZnS. Concomitant with sulfide deposition these brines dissolved limestone creating the widely recognized "limestone edge" as the

ZnS depositing reaction is acid producing ($ZnCl_2(aq) + H_2S = ZnS + 2HCl(aq)$). This dissolution of limestone lead to a local increase in the Ca/Na ratio of the fluid as observed in the inclusion decrepitates from the later dark green ZnS and the solution cooled to 120-150°C as observed in fluid inclusions. The presence of several alternating bands of light and dark ZnS indicates that this cycle was repeated as each new pulse of warm (150-180°C) metalliferous brine entered the limestone. Formation of post-ore dolomite ("snow on the roof") followed the final influx of brine after the acid producing, sulfide generating process ceased.

No sulfur was detected in any of the decrepitates suggesting that ZnS deposition in ET may have been limited by S availability, unlike other MVT districts (Pine Point) where abundant S has been detected and where the amount of metal-rich brine may limit sulfide deposition. (Authors' abstract)

HAYNES, F.M. and KESLER, S.E., 1984b, Direct measurement of the major element chemistry of individual fluid inclusions, Pine Point district, N.W.T. (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 72. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

We have refined a method of determining the major element chemistry of individual fluid inclusions by SEM energy dispersive analysis of evaporites produced on polished thick sections by thermal decrepitation of individual fluid inclusions. Application of this method to Mississippi Valley-type mineralization at Pine Point, N.W.T. reveals that fluids attending sulfide deposition were predominantly Na-Ca chloride brines. Subordinate but significant amounts of K, Mg, and Fe are also observed. A significant population of inclusion evaporites from sphalerite and dolomite also contain appreciable S, occasionally in amounts equalling or exceeding Cl. A 10 to 30% excess of cations in the analyses of many of the S-rich salts may signal the presence of carbonate species undetectable in energy dispersive analysis.

While the Na-Ca chloride chemistry of Pine Point fluids is in reasonable agreement with similar analyses in sphalerites from MVT ore in East Tennessee, the presence of S as a major anion in Pine Point inclusion evaporites represents a significant difference from the East Tennessee ores. If equilibrium is assumed, the presence of Ca and S together in the Pine Point inclusion evaporites without daughter anhydrite requires reduced sulfur speciation and supports mixing models involving metal-rich chloride brines and sulfur-rich waters in ore formation. However, in the low temperature environment of Pine Point, it is possible that the apparent oversaturation of anhydrite results from the presence of unstable sulfur complexes such as thiosulfate, thus negating the need for two fluids in transporting essential ions to the site of deposition. (Authors' abstract)

HAYNES, S.J., 1983, Typomorphism of turbidite-hosted auriferous quartz veins, southern Guysborough County: Nova Scotia Dept. of Mines & Energy, Mines and Minerals Branch Report of Activities Report 83-1, 1982, K.A. Mills, ed., Halifax, Nova Scotia, 1983, p. 183-224.

The mineralogy and form of the veins, and their attendant wall rock alteration effects, suggest that gold was deposited initially from hydrothermal solutions, that passed upward through the fault systems, as they were ejected into seawater as low density plumes from submarine hot springs. This resulted in aprons of siliceous sinter being deposited at the spring orifices and a flanking mat of siliceous chemical sediment being deposited from the plume. Phase relations and the composition of fluid inclusions suggest that CO_2 boiled off from low-salinity hydrothermal solutions to yield potassium silicate assemblages in the feeders and carbonate assemblages in the sediments (stratiform veins). The origin of these solutions is as yet unknown, but may be related to dewatering of the lower Meguma Group or the basement. Although hydrothermal mobilization of gold and silica during early Acadian dynamo-thermic events cannot be discounted, syn-deformational quartz veins emplaced during the main period of Acadian deformation and metamorphism (discordant, radial and vertical veins) are devoid of gold. This casts doubt on those previous theories that invoked deposition of the auriferous quartz veins during Acadian dynamo-thermal metamorphism and deformation. (From the author's abstract)

HE, Luqing, 1984, Situation of analysis on gaseous constituents in mineral inclusions: J. Central-South Inst. Mining & Metal., Sum 41, no. 3, p. 81-87 (in Chinese; English abstract). Author at Chem. Analysis Center.

The advantages and the limitations of nondestructive analytical methods for gaseous constituents in mineral inclusions, the present situation of destructive analytical methods, and a variety of sources of gaseous constituents are described in this paper.

In order to avoid major contamination and loss from a variety of sources, it is particularly important that extractive systems and their devices be applied to any destructive analytical method(sic). Therefore, typical extractive systems and extractive devices used for the analysis of gaseous constituents in mineral inclusions are discussed. (Author's abstract)

HEALD-WETLAUFER, P. and PLUMLEE, G.S., 1984, Significance of mineral variations in time and space along the Bulldog Mountain vein system with respect to the district-wide hydrology, Creede district, Colorado (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 535. Authors at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

Conclusions based in part on fluid inclusion studies. (E.R.)

HEDENQUIST, J.W., 1984, Adiabatic boiling and ocean metal transport: Nature, v. 310, no. 5979, p. 636. Author at DSIR, Geotherm. Res. Cent., Wairakei, Taupo, New Zealand.

Discusses incorrect statements of R.N. Anderson (this volume) and of Delaney and Cosens (1982, Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 51-52) concerning supposed development of highly saline fluids in deep sea geothermal areas by boiling. (E.R.)

HELGESON, H.C., 1984, Mineral deposition and dissolution as a function of fluid pressure in hydrothermal systems (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 290 (in English). Author at Dept. Geol. & Geophy., Univ. California, Berkeley, CA, USA.

Thermodynamic calculations indicate that relatively minor changes in fluid pressure may affect significantly mineral equilibria in hydrothermal systems. The standard partial molal volume changes accompanying the hydrolysis of minerals in the upper 5 or 10 km of the Earth's crust are negative and maximize with increasing temperature at constant pressure. As a consequence, isothermal flow of fluid toward a region of lower hydraulic head and fluid pressure may be accompanied by a substantial decrease in mineral solubility. However, in the special case of downward flow, spatial differences in hydraulic conductivity and/or the cross-sectional area off low channels may result in intervals of increasing mineral solubility in response to increasing fluid pressure in the direction of fluid flow. Under these conditions, precipitation is favored in the narrow portions of flow channels and mineral dissolution in the wider intervals. It follows that steady state downward flow of a fluid may lead to a self-sealing system with "pinch and swell" vein characteristics. In contrast, upward flow should lead to precipitation and self-sealing, regardless of vein geometry. Correlation of interphase mass transfer and fluid flow calculations with field observations can be used to assess directions and relative rates of fluid flow in hydrothermal systems. (Author's abstract)

HELVACI, C., 1984, Apatite-rich iron deposits of the Avnik (Bingöl) region, southeastern Turkey: Econ. Geol., v. 79, p. 354-371. Author at Mineral.-Geol. Museum, Sarsgate 1, Oslo 5, Norway.

Evidence suggests that the apatite-rich iron deposits formed initially during volcanism, and it is concluded that they were immiscible liquids which had separated from strongly fractionated magmas. Similar rare earth element values in coexisting apatite and magnetite and in the associated metavolcanic rocks support this conclusion. The apatite-rich iron deposits were remobilized into stockworks containing large crystals of magnetite, apatite, and actinolite where these have been intruded by the Avnik granitoid. (From the author's abstract)

HELZ, R.T., 1984, In situ fractionation of olivine tholeiite: Kilauea Iki lava lake, Hawaii (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 536-537. Author at U.S. Geol. Survey, Reston, VA 22092.

The line of descent of the liquid produced by crystallization of an olivine tholeiite has been determined for Kilauea Iki lava lake, formed in 1959. Eruption pumices cover the range of liquid compositions from 10.0 to 6.0% MgO. Interstitial glasses in partially molten core obtained by lava lake drilling extend the compositional range to 0.2% MgO. (From the author's abstract)

HEMLEY, J.J., CYGAN, G.L. and WHITNEY, J.A., 1984, The concentration of iron in chloride solutions equilibrated with a synthetic granitic composition: the sulfur bearing system (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 537.

HENDERSON, C.M.B. and MANNING, D.A.C., 1984, The effect of Cs on phase relations in the granite system: Stability of Pollucite: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 41-42.

HENLEY, R.W., 1984, Structure of active geothermal systems and implications for the origins of some hydrothermal gold deposits: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 40-43.

HENLEY, R.W., TRUESDELL, A.H. and BARTON, P.B., Jr., 1984, Fluid-mineral equilibria in hydrothermal systems: Reviews in Econ. Geol., v. 1, 267 pp.

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HERSKOWITZ, Mordechai and KISCH, H.J., 1984, An algorithm for finding composition, molar volume and isochors of CO_2-CH_4 fluid inclusions from T_h and T_{fm} (for $T_h < T_{fm}$): Geochimica Cosmo. Acta, v. 48, p. 1581-1587. First author at Dept. Chem. Engrg., Ben-Gurion Univ. of the Negev, P.O.B. 653, Beer-Sheva 84105, Israel.

A modified Redlich-Kwong equation of state is used to calculate the solubility of CO_2 in methane at various temperatures and pressures. From the solubility of CO_2 in CH_4 at the triple point and at final melting ($T_h < T_{fm}$), and the molar volume of solid CO_2, the volume of solid at the triple point, and the molar volume of the inclusion can be calculated using a mass balance. The pressure at the melting point is calculated from the equation of state.

The algorithm predicts composition, molar volume, pressure at final melting and the isochor pressure (for a given temperature of trapping) for CO_2-CH_4 fluid inclusions for the case $T_h < T_{fm}$, given T_h, T_{fm} and experimental data on P_h and d(CO_2) (solid) at T_h. (Authors' abstract)

HICKS, Brian, APPLIN, K.R. and HOUSEKNECHT, D.W., 1984, Crystallographic controls on the hydrothermal etching of quartz (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 539. Authors at Geol. Dept., Univ. Missouri-Columbia, Columbia, MO 65211.

Euhedral quartz crystals, crushed quartz, quartz sand, and quartzose sandstone were etched in distilled water at 280°C and 1.3 kb pressure. Crystallographically oriented etch pits were observed using a scanning electron microscope. Rhombohedral crystal faces exhibit a relatively uniform distribution of shallow, triangular etch pits. Deep, diamond-shaped pits presumably formed by the combination of two triangular pits were observed on prism faces. With further etching the diamond-shaped etch pits appear to coalesce into rectangular etch tubes. Deep etch pits and tubes appear to be nonuniformly distributed over individual crystals as well as corresponding faces of a suite of crystals. Etched, polished basal sections of quartz crystals exhibit a mammiform morphology which reflects the growth development of quartz crystals. Thus, the morphology of etch features in sedimentary quartz may be a useful indicator of the crystallographic orientation of quartz grains. The extent of etch pit development may also serve as a qualitative indicator of the state of dissolved silica saturation in pore fluids.

In an attempt to determine possible crystallographic controls on the intergranular pressure solution of quartzose sandstones, a limited petrographic study was performed on the Bromide Sandstone, Simpson Group, Oklahoma. Using a universal stage the orientation of the optic axes and poles to the contact planes were measured on 160 pairs of quartz grains exhibiting long, sutured, or concavo-convex contacts. The results indicate that grain orientation plays a minor role in the type and extent of intergranular pressure solution in quartzose sandstones. (Authors' abstract)

Of pertinence to the formation of fluid inclusions. (E.R.)

HIGGINS, M.D. and SHAW, D.M., 1984, Boron cosmochemistry interpreted from abundances in mantle xenoliths: Nature, v. 308, p. 172-173. Authors at Dept. Geol., McMaster Univ., Hamilton, Ontario, Canada L8S 4M1.

Recent technical advances have made it possible to measure the abundance of boron in ultramafic xenoliths from alkali basalts thought to be representative of the upper mantle. Such data can provide information on the cosmochemistry of boron, particulary the temperature and mode of condensation of this element from the solar nebula. Analysis of xenoliths, selected by Jagoutz et al. to represent fertile unaltered mantle, shows that the mean boron abundance is more than three times that expected for the condensation temperature of 700 K calculated by Cameron et al. Our measurements, reported here, suggest that boron condensed at approximately 1,200 K as a solid solution in alkali feldspar or anorthite and not as an independent phase. (Authors' abstract)

HILDRETH, Wes, CHRISTIANSEN, R.L. and O'NEIL, J.R., 1984, Catastrophic isotopic modification of rhyolitic magma at time of caldera subsidence, Yellowstone Plateau volcanic field: J. Geophys. Res., v. 89, no. B10, p. 8339-8369.

HILTON, D., O'NIONS, R.K., OXBURGH, E.R., GRONVOLD, K. and KRISTMANSDOTTIER, H., 1984, Regional distribution of ^{3}He anomalies in the Icelandic crust (abst.): EOS, v. 65, p. 295.

HOBBS, B.E., 1984, Point defect chemistry of minerals under a hydrothermal environment: J. Geophys. Research, v. 89, no. B6, p. 4026-4038. Author at Dept. Earth Sci., Monash Univ.

The kinetics of rock/water interactions are sufficiently rapid that most hydrothermal systems in nature will be in equilibrium with the adjacent rock mass. The bulk rock chemistry buffers the fugacity of oxygen, which in turn fixes the fugacities of water and of hydrogen for a given pressure and temperature. Systems in which only water, oxygen, and hydrogen are present as fluid phases are considered here. Variations in the fugacity of oxygen by several orders of magnitude are possible locally, controlled by variations in local rock chemistry; these lead to relative small variations in the fugacity of water. Incorporation of a hydrogen defect that is capable of acting as an acceptor into silicates leads to a strong dependence of point defect chemisty upon the fugacities of both water and oxygen. The strong dependence on the fugacity of water is capable of explaining the hydrolytic weakening effect, but in view of the strong dependence on oxygen fugacity, the question should also be raised whether it is an oxygen effect that is observed in the classical hydrolytic weakening process or solely a dependence on changes in the fugacity of water. Examples are given for impure natural quartz, olivine, and albite with trace amuonts of calcium. (Author's abstract)

HOERNES, S. and HOFFER, E., 1984, The oxygen isotopic composition of the fluid phase from regionally metamorphosed pelitic rocks of the Damara orogenetic belt, Namibia (abst.): Terra Cognita, v. 4, p. 94. First author at Inst. Mineral. und Petro., Poppelsdorfer SchloB, D-5300 Bonn-1.

The sedimentary starting material of the medium to high grade metamorphic pelitic rocks from the Damara orogenetic belt can be reconstructed from very low grade material from the Nama Group and from pre-Damara basement samples. The isotopic composition of the fluid phase during the Damara metamorphic event can be deduced from the recent isotopic composition of the metapelites since the metamorphic temperatures are known from previous petrologic and isotopic work. Quartz segregations which primarily formed parallel to a first schistosity and transform to concretions during continuing deformation are of special importance for the reconstruction of the fluid phase. Quartz forming mineral reactions may also contribute to these quartz segregations. The initial quartz segregations show higher $\delta^{18}O$-values (+18‰) than most quartz concretions in the medium to high grade area which average around +15‰. Significantly lower values (+13‰) are found in rocks which suffered anatexis. It can be shown that decrease in the isotopic composition is not a function of decreasing mineral-water fractionation in a closed system. The isotopic composition of the fluid phase therefore follows that of the analyzed quartzes. This decrease is not continuous. Two positive anomalies can be observed, the first in the temperature region of 550°C, the second at about 620°C. We explain this deviation from the general trend by dehydration reactions of chlorite and muscovite, which introduce isotopically heavy oxygen into the partially dehydrated system. (Authors' abstract)

HOFFMANN, C.F., MACKENZIE, A.S., LEWIS, C.A., MAXWELL, J.R., OUDIN, J.L., DURAND, B. and VANDENBROUCKE, M., 1984, A biological marker study of coals, shales and oils from the Mahakam Delta, Kalimantan, Indonesia: Chem. Geol., v. 42, p. 1-23.

HOFMANN, A.W., 1984, Mantle evolution by crustal recycling or by mantle metasomatism? (abst.): Terra Cognita, v. 4, p. 82.

HOFMANN, R. and BAUMANN, A., 1984, Preliminary report on the Sr isotopic composition of hydrothermal vein barites in the Federal Republic of Germany: Mineral. Deposita, v. 19, p. 166-169. First author at Inst. Kristal. & Petrogr., Univ. Hannover, FRG.

Sr varies from 0.5 to 3.8% and $^{87}Sr/^{86}Sr$ from 0.71018 ± 6 to 0.7205 ± 11 in 59 samples of barite from 21 localities. (E.R.)

HOFMEISTER, A.M., 1984, Spectroscopic and chemical study of the coloration of feldspars by irradiation and impurities, including water: PhD dissertation, California Inst. Tech., Pasadena, CA, USA, 425 pp.

Indexed under Fluid Inclusions. (E.R.)

HOGAN, L.G. and HART, Roger, 1984, Fractionation of noble gases in ocean ridge silicate melts by volatile exsolution (abst.): EOS, v. 65, p. 295.

HOLLOWAY, J.R., 1984, Graphite-CH_4-H_2O-CO_2 equilibria at low-grade metamorphic conditions: Geology, v. 12, p. 455-458. Author at Depts. Chem. & Geol., Arizona State Univ., Tempe, AZ 85287.

Equilibrium calculations and published phase equilibria are used to show that at temperatures below 400°C and pressures above 300 bar, the fluids coexisting with graphite in the C-O-H system consist either of CO_2-H_2O mixtures or CH_4-H_2O mixtures. Bulk fluid compositions consisting of CH_4-H_2O will unmix to methane-rich fluid and H_2O-rich liquid at temperatures below about 325°C. Compositions on the CO_2-H_2O join will unmix only at temperatures below about 275°C. Oxygen fugacity in the CH_4-H_2O-graphite three-phase region is fixed (at constant P and T) and approximately equal to that of the quartz-magnetite-fayalite assemblage. In the CO_2-H_2O-graphite three-phase region, oxygen fugacity is about three orders of magnitude greater. From the end stages of diagenesis to temperatures of 300°C (and possibly 400°C in salt-rich systems), many metamorphic rocks may contain CH_4-H_2O fluids rather than CO_2-H_2O mixtures. Thus, metamorphic reactions involving carbonate minerals would involve CH_4, graphite, and H_2O rather than CO_2. The immiscibility between CH_4 and H_2O could result in the common occurrence of methane (natural gas) in low-grade metamorphic terrains. (Author's abstract)

HORN, Elfrun, 1984, Studies of elements in individual closed fluid inclusions using the Heidelberg proton microprobe (PIXE) (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 55-57 (in English). Author at Geol.-Paläon. Inst. Univ. Göttingen, Goldschmidtstr., Göttingen, FRG.

At Heidelberg a proton induced X-ray emission (PIXE) microprobe has been constructed and is being successfully applied for quantitative analysis of trace elements in single biological cells, in minute inclusions of lunar materials and of meteorites. The purpose of this paper is to demonstrate the feasibility of using PIXE to study the elements in selected fluid inclusions. Under controlled conditions individual closed fluid inclusions in minerals can be investigated with PIXE. Principally it is possible to detect elements with atomic numbers greater than 11, corresponding to Na, however, in reality this is matrix dependent. Between atomic number, matrix, beam and limit of detection there are distinct relationships. The detection limit increases with higher atomic numbers. Therefore it is possible to analyze heavier elements, e.g., Fe, Br, Sr in [unopened] inclusions from a depth of 10-50 μm beneath the sample surface.

For investigations with PIXE the same samples can be used as for fluid inclusion studies. Therefore it is possible to observe microthermometric data and to study chemical composition of fluid inclusions in successive order within the same sample.

Initial qualitative investigations were carried out on quartz samples. (Author's abstract)

HOSTETTLER, J.D., 1984, Electrode electrons, aqueous electrons, and redox potentials in natural waters: Am. J. Sci., v. 284, p. 734-759.

HOVORKA, S.D., 1984, Textures formed during shallow water halite deposition--an example from Permian of Palo Duro basin, Texas (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). Author at Bur. Econ. Geology, Austin, TX.

The Palo Duro basin, part of the broad northern shelf of the Midland basin during the Late Permian, accumulated cyclic, regressive, carbonate-anhydrite-halite sequences. Detailed interpretation of more than 2,000 m (6,500 ft) of halite core from 9 wells drilled by the United States Department of Energy in the northern Palo Duro basin permitted recognition of textures formed during halite deposition.

Textures formed on the bottom of a halite-saturated water body include color banding due to variation in composition and amount of impurities in halite beds, and vertically elongated anhedral halite mosaic, formed due to competition for space on the pool floor. Abundant fluid inclusions trapped along halite growth faces reflect rapid precipitation of halite in shallow water. Darker halite with sparse inclusions may have formed less rapidly in slightly deeper water.

Anhydrite partings, truncating the bottom-deposited fabrics, represent influx of marine-derived brine concentrated during transport across the broad, shallow shelf. The brine corroded existing halite and deposited gypsum before evaporation increased salinity and reinitiated halite deposition.

Halite precipitation ceased when brine supply decreased and then became emergent. Mudstone was transported onto the flat by wind sheetwash. Exposure of the halite to meteoric water during this phase caused development of halite karst and destruction of other fabric recrystallization. (Author's abstract)

HOWE, S.S., 1984, Formation of Mississippi Valley-type lead-zinc deposits by periodic expulsion of basin brines--an example from central Pennsylvania (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 544-545. Author at U.S. Geol. Survey, 345 Middlefield Road, Menlo Park, CA 94025.

Mineralogic, textural, and fluid-inclusion features of lead-zinc occurrences within a 5000 km^2 region in central Pennsylvania are consistent with periodic influxes of saline basin brines as the sites of deposition opened tectonically during sulfide mineralization and with the mixing of these brines with less saline meteoric waters as the systems progressively sealed during nonsulfide mineralization. (From the author's abstract)

HOWSE, A.F. and MALONEY, J., 1984, 18. Barite deposits of the Avalon peninsula, in Mineral Deposits of Newfoundland - A 1984 Perspective: Newfoundland Min. Dev. Div. Report 84-3, p. 173-177.

Fluid inclusion and stable isotope studies are in progress. Quartz associated with the barite has Th of 100-200°C, but one sample from the Silver Cliff vein showed 300-360°C. (E.R.)

HUANG, Fusheng, MU, Zhiguo, CHEN, Chengyie and WANG, Zhifen, 1984, Isotopic composition of oxygen, hydrogen, and carbon in granites of tin deposits, Gejin (China): Yanshi Kuangwu Ji Ceshi, v. 3, no. 1, p. 241-247 (in Chinese) (also in CA: 101(14)114155p).

Indexed under Fluid Inclusions.

HUBBARD, N., LIVINGSTON, D. and FUKUI, L., 1984, The composition and stratigraphic distribution of materials in the Lower San Andres salt unit 4: Materials Research Soc. Symp. Proc., v. 26, p. 405-415. First author at Battelle Memorial Inst., Columbus, OH 43201.

The salt bed in depositional cycle 4 of the Permian Lower San Andres Formation, Palo Duro Basin, Deaf Smith County, Texas consists of massive salt interlayered with discrete bands and beds of anhydrite and claystone. The massive salt consists of about 90% halite, with 7% anhydrite and 3% clays disseminated in and among the halite crystals.

The halite in this salt bed contains fluid inclusions filled with a (Na, K, Mg) Cl brine, with an average Mg concentration of about 50,000 mg/liter. The anhydrite in the salt will saturate the brines in $CaSO_4$, which in turn may coat the waste package with anhydrite because of the retrograde solubility of $CaSO_4$. This may increase waste package lifetime to failure by corrosion. (Authors' abstract)

HUNT, J.M., 1984, Generation and migration of light hydrocarbons: Science, v. 226, p. 1265-1270. Author at Dept. Chem., Woods Hole Oceanographic Inst., Woods Hole, MA 02543.

Light hydrocarbons (containing from 1 to 14 carbon atoms) are formed from disseminated organic matter in sediments at the parts-per-billion level by biological and low-temperature (<50°C) chemical reactions and at the parts-per-million level by high-temperature (>50°C) cracking reactions. The cooler reactions produce mainly branched hydrocarbons, whereas the hotter reactions yield more straight chains. Hydrocarbon generation zones in the subsurface can be recognized on the basis of hydrocarbon distribution patterns. Hydrocarbons with tertiary carbon atoms form at lower temperatures than those with quaternary carbons. Methane and ethane migrate vertically through fine-grained shales by diffusion and solution, whereas many of the C_{3+} hydrocarbons show little or no vertical migration. Concentrations of light hydrocarbons, including methane, in fine-grained source rocks decrease to low values in deep, high-temperature (>200°C) sediments. This decrease may be one reason why no economic accumulation of gas has been found to date deeper than 8.2 kilometers (27,000 feet). (Author's abstract)

HUT, G., WEERKAMP, H.R. and POELHEKKEN, T., 1984, Stable isotope ratios in the natural gas components CH_4 and N_2 separated by gas chromatography: ZFI-Mitteilungen, "Isotope in der Natur," no. 84, p. 129-138: Leipzig, Akad. Wissen. der DDR (in English). Authors at Isotope Physics Lab., Univ. Groningen, Westersingel 34, 9718 CM Groningen, The Netherlands.

Stable isotope data of natural gas components can provide important information on origin, maturity of source material and migration of these gases. To determine the stable isotope ratios in CH_4 and N_2 a system is constructed to separate these components from milliliter quantities of natural gas by gas chromatography. Having passed the separation column and a catharometer detector the gas flow is distributed consecutively to two lines, one in which N_2 is trapped in a He-cryostat and one in which CH_4 is immediately combusted by CuO to CO_2 and H_2O which are trapped separately.

The δ^2H, $\delta^{13}C$ and $\delta^{15}N$ values are determined by conventional mass spectrometry. (Authors' abstract)

HUTCHINSON, R.W., 1984, Significance of evolutionary changes in base metal deposits through time (abst.): Terra cognita, v. 4, p. 84.

HYNDMAN, D.W. and ALT, David, 1984, Large-scale evidence for liquid immiscibility differentiation in Square Butte laccolith, central Montana alkaline province (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 547.

IANNACCHIONE, A.T., GRAU, R.H., SAINATO, A., KOHLER, T.M. and SCHATZEL, S.J., 1984, Assessment of methane hazards in an anomalous zone of a Gulf Coast salt dome: Bureau of Mines Report of Investigations, RI-8861, 26 pp.

IGNATOV, V.A. and STAKHANOV, I.P., 1984, Formation and absorption of atmosphere in a cavity due to gas diffusion, adsorbed in its walls: Akad. Nauk SSSR Doklady, v. 275, no. 2, p. 361-364 (in Russian). Authors at Moscow Inst. of Fine Chemical Technology, Moscow, USSR.

The paper describes the conditions of achieving equilibrium between gas present in the walls of a cavity and the cavity atmosphere; pertinent to formation of G bubbles and to the problem of volatile diffusion through crystal lattice from inclusion filling. (A.K.)

ILLICH, H.A., HANEY, F.R. and GRIZZLE, P.L., 1984, Geochemical significance of seep oil from the Subandino Norte, northwest Bolivia: Geochimica Cosmo. Acta, v. 48, p. 391-394. Authors at Sun Exploration, Div. Sun Exploration & Prod. Co., Irving, TX 75234.

This report presents an interpretation of the geochemical significance of a surface seep oil sample from the Subandino Norte of Bolivia. The oil from this seep is unusual because it contains a limited range of low molecular weight normal paraffins. Normal paraffins containing more than 12 carbons are absent from the oil, while normal paraffins having fewer than 12 carbons are conspicuous components of the oil. The compositional peculiarities of the oil are attributed to transport of hydrocarbons in water, with water playing an active role in the final composition of the seep. The composition of the seep oil is qualitatively consistent with that anticipated if the hydrocarbons were moved in molecular solution in water. (Authors' abstract)

IMEOKPARIA, E.G., 1984, Geochemistry of intrusive rocks associated with molybdenite mineralization (Kigom complex, northern Nigeria): Chem. Geol., v. 47, p. 261-283. Author at Dept. Geol., Univ. Benin, Benin City, Nigeria.

The Kigom igneous complex of northern Nigeria is a small intrusive complex made up of peralkaline arfvedsonite granite, riebeckite-biotite granite and riebeckite-aegirine granite. The granites show coherent major-element chemistry typical of that of the Nigerian Younger Granites, and are enriched in Rb, Li, Zr, Nb, Th, Y, F and REE, and depleted in Ba and Sr compared to the world average for rocks of similar composition.

The riebeckite-aegirine granite exhibits a two- to three-fold increase in the concentration of Zr, Nb, Li, F, Th, Zn and REE over comagmatic granites. Concentrations of the highly charged cations in these granites are believed to be the result of halogen-alkali-rich fluid activity during the fractionation of the magma. Corresponding trace-element increases in the granites in areas of alkali metasomatism (albitization) support this argument, and reflect the partial confinement of this alkali volatile phase within the high-level magma chambers.

It is important to recognize that the chemical signatures of this liquid state fractionation process may be explanatory mechanisms in the formation of some kinds of lithophile ore deposits. The degree of peralkalinity maintained miscibility in the residual fluid between silicate and aqueous phase to low temperatures so that mineralizing components continuously accumulated together. The interaction between this phase and early-formed minerals led to Mo mineralization.

The well-known classification of granites into sedimentary protolith (S-type); igneous protolith (I-type) and A-type indicates that the granites studied here have typical A-type features. An origin by partial melting of lower-crustal material (probably granulite facies) under a high flux of mantle-derived volatiles is suggested for these rocks. As a result of mixing of crustal and mantle-derived fluids a syenitic magma was produced which then experienced selective contamination as a result of further reaction melting during fractionation and ultimately produced a peralkaline differentiate. (Author's abstract)

INSHIN, P.V., ABAULINA, L.I. and TSAREV, V.V., 1983, Behavior of carbon during the formation of gold deposits in clastic "black shale" sequences: Dokl. Akad. Nauk SSSR, v. 269, no. 5, p. 1156-1158 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 79-80, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 117, 1983. (E.R.)