FLUID INCLUSION RESEARCH

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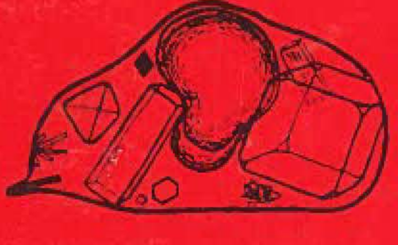

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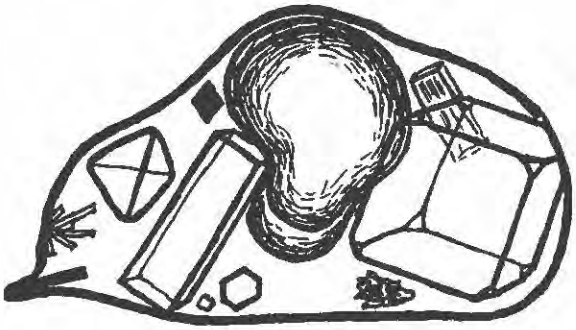

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PREFACE

The purpose of these volumes is to provide entrée into the world literature for the year with English abstracts or annotated citations of all items that either contain fluid inclusion data or are pertinent to some aspect of fluid inclusion work. This covers all types of fluid inclusions (aqueous, organic, silicate melt, sulfide melt, gas, etc.), causes and mechanisms of trapping (including various types of immiscibility), physical, chemical, and isotopic data, and data on experimental studies of systems pertinent to the interpretation of all types of phase changes occurring in inclusions, as well as to the sources and movement of such volatiles or fluids and their interactions with rocks. These data are generally given without editorial value judgments except in the case of obviously contradictory or obscure statements, where comments or "sic" are added in brackets. Language problems make extensive editing necessary on some abstracts, and may still leave the meaning obscure. The extent of coverage varies in part as an inverse function of the availability of the original text to the average Western reader and in part as a direct function of the usefulness of the data. Items that are difficult to obtain, such as theses, may be covered in more detail than scientifically more important publications from readily available journals. Pertinent meetings, and the resulting publications, are also listed.

This volume contains 1275 abstracts, citations, or annotated citations, of which 15 percent are from 13 non-English sources, mainly Chinese and Russian. Most items are from the current year, but a few that were not obtained before the necessary editorial cutoff for previous volumes are included. Some items cited as "Indexed under fluid inclusions" came from various computer searches but could not be looked up in time; they may involve only a trivial mention of fluid inclusions or they may be major items, since such distinctions are not normally made in computer databases. Compilation of the Subject Index is one of my most time-consuming chores. The choice of index entries is evolving with each volume, and I would much appreciate any feedback from the users.

To authors of pertinent articles that have been omitted or are misquoted here through haste, or through language difficulties, I extend my apologies and my request to have these things called to my attention; to authors whose original abstracts have been drastically shortened, often by as much as 90 percent, edited, or revised, I offer a reminder that the following "abstracts" are not intended to be abstracts of the whole paper, but only that part most pertinent to inclusion workers. I hope that these cuts have not resulted in erroneous, misleading or confusing statements. The obvious inconsistencies in citation, transliteration, abstracting, editing, cross-referencing, and indexing are strictly a result of lack of editorial time.

I will be glad to learn of unpublished translations of foreign language inclusion literature, and will also be glad to furnish photocopies of the original text of articles or abstracts that have not been translated, or back issues of *Fluid Inclusion Research*, in exchange for partial or full translations for use in future issues. I would particularly like to receive abstracts from pertinent graduate theses and dissertations, as these are exceedingly difficult to locate and represent important contributions that may not appear in the published literature for years.

I am deeply indebted to coeditor Belkin and Business Manager Bodnar for their hard work, and to the U.S. Geological Survey and Harvard University libraries for their cooperation. I also want to thank Margie Sentelle (Virginia Tech) for the excellent topography and editorial help.

April 18, 1997 Edwin Roedder, Editor

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CONTRIBUTORS, VOLUME 28

Many individuals contribute to the preparation of each volume of *Fluid Inclusion Research.* Previously we listed Regional Representatives who were asked to help in assuring complete coverage of the world literature by forwarding reprints or citations from their areas to the editors. This concept of regional representatives has outlived its usefulness. With the numerous international fluid inclusion meetings and Email, I receive much more material from people who are not regional representatives than from those who are. I am particularly grateful to those in the following listing who sent me rare volumes, or who translated abstracts, or wrote new abstracts, from the foreign literature.

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SUBSCRIPTION INFORMATION

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All correspondence concerning editorial matters, and particularly offers of help on abstracting or translation, should be addressed to the Editor:

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VOLUNTEERS NEEDED

The editors would appreciate any help that can be offered by the readers in issuing future volumes of *Fluid Inclusion Research*. Thus recent volumes have been missing a number of items from the French and German literature because some of our volunteer translators were not able to produce the translations promised. Help is particularly needed in translation and in preparing abstracts on a *regular* basis from various segments of the literature. These jobs can be partitioned into as small units as desired; please contact any one of the editors at the following addresses. On an informal basis, it would be most helpful if readers could send to the editors reprints or even just reference citations of pertinent literature. Such help is particularly useful to avoid missing obscure publications, such as theses, or ones in which the presence of inclusion data may not be obvious from title or abstract. If important papers have been missed in previous volumes, they also should be noted.

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EDITOR'S SPECIAL REQUEST TO USERS

A lot of volunteers put a lot of time into *Fluid Inclusion Research* each year, since Volume 1 was published 29 years ago. Many of these issues contained an editorial plea for feedback from the users concerning how it could be improved in text, format, coverage, or indexing. Unfortunately, I have received almost *no* such feedback. As the preparation is a volunteer operation and the printing is a non-profit operation, I cannot promise gross changes that will increase the load. But I believe I can speak for the whole crew when I say we want to make it useful, and hence *we need your input.*

Edwin Roedder, Editor
Department of Earth and Planetary Sciences
Harvard University, Cambridge, MA 02138, USA

April 18, 1997

NOTICES OF MEETINGS, SYMPOSIA, AND SPECIAL PUBLICATIONS

Edited versions of pertinent abstracts from these meetings will be found in the appropriate volume of *Fluid Inclusion Research*: 1994, v. 27; 1995, v. 28; 1996, v. 29.

The Society for Luminescent Microscopy and Spectroscopy continues to issue Newsletters (the latest is v. 7, no. 2, Fall 1996) that include excellent color reproductions of cathodoluminescence views, and news of interest to anyone using this technique, which is very pertinent to assigning origins to fluid inclusions. Membership information: Kula Misra, Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, USA. Telephone (423) 974-2366; Fax (423) 974-6020; Email kmisra@utk.edu.

The Commission on Ore Forming Fluids in Inclusions (COFFI) of IAGOD had a fluid inclusion symposium at the ninth quadrennial IAGOD meeting, August 12-18, 1994, at Beijing, China. The FI papers are on pp. 156-211 of the Abstracts Volume. A report of the COFFI business meeting was given in the IAGOD Newsletter, 1994, p. 10.

The 5th Goldschmidt International Conference was held at University Park, Pennsylvania, May 24-16, 1995.

ECROFI XIII was held at Sitges, Spain, June 21-23, 1995. Abstracts of the 151 papers were printed in Boletín de la Sociedad Española de Mineralogia, v. 18-1, 301 p., 1995 (ISSN 0210-6558). Address Sociedad Española de Mineralogia, Alenza 1, 28003, Spain.

The First Symposium on Fluid Inclusions in Brazil was held in April 1995; nine papers are abstracted in this volume.

The 8th Int'l Symposium on Water-Rock Interaction was held in Vladivostok, Russia, August 13-28, 1995.

APSCROFI I, Asian and Pacific Society on Current Research on Fluid Inclusions, was to be held August 1-4, 1995, in Blagoveshchensk, Russia, but was postponed.

EMPG-VI Sixth Int'l Symposium of Experimental Mineralogy, Petrology, and Geochemistry was held April 10-13, 1996, at Bayerisches Geoinstitut, Universität Bayreuth, D-95440 Bayreuth, Germany.

PACROFI VI was held at Madison, Wisconsin, May 30-June 1, 1996. *Chemical Geology* has agreed to publish a set of papers from the meeting.

ICAM '96, Int'l Congress on Applied Mineralogy, was held in Warsaw, Poland, June 2-5, 1996, at the Warsaw University of Technology.

The 30th Int'l Geological Congress was held August 4-14, 1996, in Beijing, China. A few papers pertinent to fluid inclusion studies are scattered through the three volumes of abstracts, but a large number are collected in a group from a session on FI.

Int'l Conference on Cathodoluminescence was held September 2-4, 1996, at Nancy, France.

The 7th Annual V.M. Goldschmidt Conference will be held June 2-6, 1997, in Tucson, Arizona. For information: M.J. Drake. Telephone (520) 621-6962; Email goldconf@lpl.arizona.edu.

ECROFI XIV will be held July 1-4, 1997, Nancy, France. Contact: L.W. Diamond, Bern. Email larryn@mpi.unibe.ch.

A 1997 Gordon Research Conference on Inorganic Geochemistry, to be held August 10-15, 1997, will include numerous items of interest to fluid inclusion studies. For information: Gordon Research Conference. Telephone (401) 783-4011; Email grc@grcmail.grc.uri.edu.

18th Int'l Meeting on Organic Geochemistry, Maastricht, The Netherlands, September 22-26, 1997. Contact: B. Horsfield. Telephone 49-2461-613670; Email b.horsfield@kfa-juelich.de.

The Chinese Society on Petrology, Mineralogy and Geochemistry will hold a conference on fluid inclusions in Wuhan, Hebei Province, China, October 6-8, 1997. Contact: Prof Wenhuai Zhang, Dept. Mineral Resources, Chinese University of Earth Sciences. Telephone 8627-780-2136 x2531. Abstracts due July 15, 1997.

A meeting on Structural Controls and Genesis of Economic Resources will be held November 8-9, 1997, Dublin, Ireland. Contact: Dr. Ken McCaffrey, Kingston University, Telephone +44 181 547 2000.

The 10th IAGOD Symposium, Australia, 1998. Contact: Prof. I.R. Plimer, University of Melbourne, Parkville, Victoria 3052, Australia. Fax (613) 344-7761.

Water-Rock Interaction-9, Taupo, New Zealand, March 30-April 4, 1998. Contact: B.W. Robinson. Fax 64-7-374-8199; Email wri-9@gns.cri.nz.

17th General Meeting of IMA, Toronto, Canada, August 9-15, 1998. Contact: A.J. Naldrett. Telephone (416) 978-3030; Email ima98@quartz-geology.utoronto.ca.

ABBREVIATIONS

The Cyrillic sequence, а,б,в,г,д,е, is converted to abcdef. Other than the normal scientific and reference abbreviations, we use mainly the following:

aq	aqueous
CL	cathodoluminescence
dm	daughter mineral[†]
dp	daughter phase[†]
dxl	daughter crystal
eq.	equivalent
F	fluid; degree of fill[§]
FI	fluid inclusion
FIP	fluid inclusion planes
FIR	<u>Fluid Inclusion Research</u>
G	gas
H	homogenization
I	inclusion
L	liquid
M	melt

Mt	metric tonnes
P	pressure; primary
PS	pseudosecondary
S	secondary
sal	salinity
t	tonne
T	temperature (°C)
Td	temperature of decrepitation*
Te	temperature of eutectic melting*
Th	temperature of homogenization*
Tm	temperature of melting*
Tn	temperature of nucleation*
Tt	temperature of trapping*
V	vapor

[†] Some authors include here crystalline phases formed on cooling in the laboratory, but this can lead to confusion.
[§] Ambiguous usage; F generally refers to *fluid.*

*For explanation, please see next page. The abbreviation "Tf" is exceedingly ambiguous and should be avoided. Some papers use "Tf" for "temperature of formation" (i.e., Tt), some use it as equivalent to Th, others use it for "temperature of freezing," meaning Tm ice (on heating), and still others mean Tn ice (on cooling). A few use "Te" for "temperature of crystallization," meaning either Tn (on cooling) or Tm (on heating).

A few authors in the following abstracts have used some of these *same* abbreviations but with new or ambiguous definitions, or new abbreviations *without definitions*. Caveat emptor!

The original author's usage has been followed on the following:

GLI	gas liquid inclusion
HC	hydrocarbon
F	degree of fill
ppb	parts per billion (10^9)
ppm	parts per million (10^6)
µg/g	parts per million (10^6)
‰	parts per thousand
ppt	parts per thousand
per mil	parts per thousand
per mille	parts per thousand
%	parts per hundred
percent	parts per hundred
Ka	thousand years

Ky	thousand years
Ma	million (10^6) years
My	million (10^6) years
mybp	million years before present
Ga	billion (10^9) years
XCO_2	mole fraction CO_2
K	temperature Kelvin
mg	milligram (10^{-3} g)
µg	microgram (10^{-6} g)
ng	nanogram (10^{-9} g)
J	joule
KJ	kilojoule

The original author's usage has also been followed on *pressure.* Most use bars ($\approx$ atm $\approx$ kg/cm^2), kilobars (kb or kbar), or megabars (Mbar), but others use pascals: 1 kPa = 10^3 Pa = 0.01 bar; 1 MPa = 10^6 Pa = 10 bar; 1 GPa = 10^9 Pa = 10^4 bar = 10 kbar. Still others use N/m^2 for newtons per square meter (10^5 N/m^2 = 1 bar).

MICROTHERMOMETRY ABBREVIATIONS

A consensus of fluid inclusion workers on usage of microthermometric terms was reached and first printed in Volume 10 (1977). It is suggested that if this terminology is used consistently in future papers, considerable ambiguity will be avoided. The details have been reprinted in each succeeding volume, and hence will be given here only in summary. For ease of typewriting and typesetting, it is suggested that subscripts not be used (the possibility of confusion with element symbols is almost nonexistent). Note that these terms are *not* adequate to cover some of the complex phase changes in gas-rich inclusions (see Kerkhov, A.M. van den, 1989, in Volume 22 of *Fluid Inclusion Research*).

Tt — The temperature of trapping, i.e., the temperature of formation of the inclusion. Thus Th = Tt if no pressure correction is needed.

Tf — The temperature of formation. Normally same as Tt.

Th — The temperature of homogenization. Unless otherwise indicated, this should refer to *total* homogenization (i.e., Th tot.). The phase into which homogenization occurs should also be stated as well (e.g., Th L or Th V). Where only the homogenization of a given pair of phases is meant, these should be designated, thus Th L-V, Th CO_2 L-V, etc. The phase into which such homogenization occurs should also be stated as well, thus Th CO_2 L-V (V), or Th H_2O-CO_2 (H_2O).

Tm — The temperature of melting. For ordinary water-rich inclusions, this may refer to the melting of ice, but ambiguity in this is all too common. The specific solid phase that melts (or dissolves) should *always* be designated. Thus Tm NaCl, Tm ice, Tm dms, Tm CO_2.

Te — The temperature of eutectic. This is the first *recognizable* formation of liquid on warming a completely crystalline inclusion; it is only an approximate or "practical" value at best, as traces of other components will always result in undectable traces of melting at lower temperatures.

Tn — The temperature of nucleation of a given phase. This generally refers to nucleation on cooling, normally from a supercooled, metastable fluid. Thus, Tn for an aqueous inclusion would be Tn ice, and formation of a bubble in a previously homogenized L-V inclusion would be Tn V.

Td — The temperature of decrepitation. This is used differently by various authors and cannot be defined exactly. Specific details on how such a temperature is determined, e.g., the start of decrepitation, the most rapid rise of decrepitation rate, the maximum number of impulses per unit increase in temperature, etc., will vary with the technique used and should be specified in each paper.

eq. wt % NaCl — That quantity of NaCl that would yield the same Tm ice value. Sometimes also used for a rough estimate, on NaCl dm-bearing inclusions, to signify total *apparent* NaCl content obtained by combining measurements of size (or Tm) of NaCl dm and an assumption as to NaCl concentration of solution at room temperature.

ABSTRACTS AND CITATIONS, 1995
Editorial Notes and Caveats

Some items from previous years that were not available earlier are included; there will be more of such back date items in this and future issues as a result of the faster publication schedule. Items for which a full English translation has become available during the year are included, even if the item was previously abstracted from the original foreign language. The first author's address is given as of the publication date only. Given names or only initials are listed as in the original. Differences in the transliteration procedures that are used in various Western journals for Cyrillic author's or place names have resulted in different spellings of what is probably the same name (e.g., Tsaryeva vs. Tsareva; Petersil'e, Petersilie, and Petersilje; Ye vs. E; ...iy vs. ...ii., etc.). To avoid problems in the use of various bibliographic databases, I have maintained such spellings *as they appeared in the original publications.* Similar problems occur with diacritical marks in author's names. (In alphabetizing here, these marks are ignored. Note, however, that some journals delete all umlauts, and others delete the umlaut but add an "e" to the author's name (e.g., "ö" becomes "oe"), so the *same* author could appear at *three* different places in the following alphabetized listing.) Names starting with "van," "Van," "de," "De," etc., are alphabetized under V (or D), in part with a cross-reference entry under the family name, except when the author's preferences are known; names starting with "Mc" or "St" are alphabetized exactly as spelled. The differences in custom between Spanish and Portuguese peoples in the sequence of listing (and hence alphabetization) of double surnames presents numerous possibilities for error in alphabetization. Even worse problems exist for Chinese names, which have been alphabetized here according to what I *believe* is the family name, regardless of the order of printing in the original.

In a few abstracts, the use of "temperature of formation" is *assumed* to refer to FI temperatures. Also, in a few items, cross references are made to other items in this volume or to particularly pertinent items in previous volumes that have been recognized, but most such have probably been missed. In numerous cases, two (or even three) similar abstracts by the same author (or authors) are printed here, even though they may be nearly duplicates; this is done because differences in data or interpretation may be present. *Complete* duplicates are merely cited. The software used in preparing these abstracts results in some changes in alphabetization from the normal sequence used in scientific bibliographies. To avoid missing items, please note the following examples: O'Hara comes before Oban; Le Guern comes before Leaman.

ABART, R., EPPEL, H. and POZZORINI, D., 1995, Examples of kinetically controlled oxygen isotope mineral/fluid exchange from regional- and contact metamorphic environments (abst.): Mitt. Österr. Miner. Ges., v. 140, p. 402-403 (in English). First author at Inst. Mineralogie-Kristallographie und Petrologie, Univ. Graz, A-8010, Austria.

Due to the effects of finite transport- and exchange rates, isotopic fractionations may vary as a function of space and time, even if the T is constant throughout the system. A 10 to 400 m wide ophicarbonate layer within massive serpentinites shows O isotope compositions of calcite, antigorite and diopside become successively depleted towards the lithologic contacts, from the interaction of the ophicarbonate rocks with an isotopically light F derived from serpentine dehydration during contact metamorphism. If the pattern of calcite-antigorite and calcite-diopside fractionations were interpreted in terms of local equilibrium, this would indicate a T increase from 450°C in the center of the ophicarbonate zone to 600°C at the lithologic contacts. The orientation of the profile and the lack of petrographic evidence for such T variation across the ophiocarbonate zone indicates grain-scale isotopic disequilibrium during F/rock interaction resulting from differences in mineral/F exchange rates of the constituent minerals with the rates decreasing in the order calcite > antigorite > diopside.

Another occurrence of pelagic limestones interbedded with shales has experienced lower greenschist facies metamorphic overprint. The isotope signature also suggests grain-scale isotopic disequilibrium during F/rock interaction that resulted from differential calcite/F and quartz/F isotopic exchange rates. In both cases, the observed isotope signature suggests that isotopic mineral/F exchange was slow relative to isotope transport and that the isotope pattern was significantly influenced by the kinetics of mineral/F exchange. (From authors' abstract by E.R.)

ABDALLA, Hamdy, MATSUEDA, Hiroharu, ISHIHARA, Shunso and MIURA, Hiroyuki, 1995, Mineral chemistry of albite-enriched granitoids at Um Ara, southeastern Desert, Egypt: Int'l Geol. Rev., v. 36, no. 11, p. 1067-1077.

Indexed under FI. (E.R.)

ABDULAGATOV, I.M. and DVORJANCHIKOV, V.I., 1995, Thermodynamical properties of the geothermal fluids: Geokhimiya 1995, no. 5, p. 612-620 (in Russian, English abstract).

New experimental data on C_v values of the geothermal F of different mineralisation in monophase and two phase field including phase equilibrium line were obtained. The measurements were carried out for three F samples with mineralisation being 6.30, 12.23 and 22.10 g/l, respectively, within 20-250°C T range. Based on experimental data obtained for C_V, p, T the values of C_S, C_p, ΔS, ΔH, W at the equilibrium line is calculated. The measurement errors are as following: $C_V \pm 1.5\%$, density 0.1%, T ± 0.01 K. (Authors' abstract)

AFANAS'EVA, Z.B., IVANOVA, G.F. and RAIMBAULT, L., 1995, Scheelite as an indicator of formation-conditions of gold-sulphide mineralization: The Olimpiada Au-(Sb-W) contact metamorphic deposit, Russia, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 835-838. First author at Vernadsky Inst. Geochemistry and Analytical Chemistry of the Russian Acad. Sci., Moscow, Russia.

By evaluating T, P, fO_2, and fS_2 associated with W-Au-Sb deposition, and the distribution of REE, Au and Sb in scheelite, the conditions of formation of the Olimpiada Au-(Sb-W) contact metamorphic deposit, in Proterozoic metamorphic rocks (including the carbonaceous metasediments) in Russia, have been determined. (From authors' abstract by E.R.)

FI data for quartz of pre-ore silicification and ore mineralization suggest P-T conditions of 490-240°C and 3.9-1.2 kb and 430-110°C and 1.2-0.8 kb, respectively (Prokof'ev et al., 1994, FIR, v. 27, p. 115). Scheelite exhibits two groups of Th: 410-370°C (scheelite I) and 200°C (scheelite II). It was also shown by Prokof'ev et al. (1994) that the Olimpiada deposit formed from a F involving the system C-H-O-N-S as a result of the interaction between hydrothermal ore-bearing solutions and carbonaceous rocks. (From authors' text by E.R.)

See also FIR, v. 27, p. 1. (E.R.)

AFANAS'YEVA, Z.B., IVANOVA, G.F., MIKLISHANSKIY, A.Z., ROMASHOVA, T.V. and KOLESOV, G.M., 1995, Geochemical characteristics of the tungsten mineralization at the Olimpiada gold-sulfide deposit, Yenisey Ridge: Geokhimiya, no. 1, p. 29-47 (in Russian; translated in Geochem. Int'l, v. 32, no. 8, p. 118-136, 1995).

See previous item. (E.R.)

AGUE, J.J., 1995, Deep crustal growth of quartz, kyanite and garnet into large-aperture, fluid-filled fractures, north-eastern Connecticut, USA: J. Meta. Geol., 13, 299-314. Author at Dept. Geology and Geophysics, Yale Univ., PO Box 208109, New Haven, CT 06520.

Quantitative thermobarometry results from vein mineral assemblages indicate that the fractures formed at P and corresponding crustal depths of c. 0.8 GPa and c. 30 km, and T of 550-600°C. The formation of large-aperture fractures could increase significantly the transient permeability of the deep crust, and therefore influence metamorphic heat and mass transfer. (From authors' abstract by E.R.)

AHMAD, M., 1995, Genesis of tin and tantalum mineralization in pegmatites from the Bynoe area, Pine Creek Geosyncline, Northern Territory: Australian J. Earth Sci., 42, 519-534. Author at Dept. Mines and Energy, Northern Territory Geol. Surv., PO Box 2901 Darwin, NT 0801, Australia.

The Sn- and Ta-bearing pegmatites of the Bynoe area are located in the western Pine Creek Geosyncline. They are emplaced within psammopelitic rocks in the contact aureole of the Two Sisters Granite. The latter is a Palaeoproterozoic, fractionated, granite with S-type characteristics and comprises a syn- to late-orogenic, variably foliated, medium-grained biotite granite and a post-orogenic, coarse-grained biotite-muscovite granite. The pegmatites comprise a border zone of fine muscovite + quartz followed inward by a wall zone of coarse grained muscovite + quartz which is in turn followed by an intermediate zone of quartz + feldspar + muscovite. A core zone of massive quartz is present in some occurrences. Feldspars in the intermediate zone are almost completely altered to kaolinite. This zone contains the bulk of cassiterite, tantalite and columbite mineralization. FI in pegmatitic quartz indicate that early Type A ($CO_2 + H_2O \pm CH_4$) I were trapped at the H_2O-CO_2 solvus at P ~100 MPa, T ~300°C (range 240-328°C) and salinity ~6 wt % eq. NaCl. P-salinity corrected T on Type B (H_2O + ~20% V), C (H_2O + <15% V) and D (H_2O + halite + V) I also fall within the range of Type A I. O and H isotope data show that kaolin was either formed in isotopic equilibrium with meteoric waters or subsequent to its formation, from hydrothermal F, [and] underwent isotopic exchange with meteoric waters. FI waters from core zone quartz show enrichment in deuterium suggesting metamorphic influence. Isotope values on muscovite are consistent with a magmatic origin. It is suggested that the pegmatites were derived from the post-orogenic phase of the Two Sisters Granite. Precipitation of cassiterite took place at ~300°C from an aqueous F largely as a result of increase in pH due to feldspar alteration. (Authors' abstract)

See also Ahmad, 1994, FIR, v. 27, p. 2. (E.R.)

AICHLER, Jaroslav, DURISOVÁ, Jana, HLADÍKOVÁ, Jana and FOJT, Bohuslav, 1995, Metamorphosed Cu-Mo mineralization at Vidly pod Pradedem, the Hruby Jeseník Mts, Czech Republic, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 839-842. First author at Czech Geol. Surv., Jeseník, Czech Republic.

The Cu-Mo mineralization at Vidly is presented by disseminated sulphides in the blastomylonites and in secretory quartz veins. The structural features of the ores, the character of quartz veins and FI composition in quartz reflect the Variscan polyphase metamorphic and tectonic history of the host rocks. The primary character of the mineralization remain unclear. The deep-seated origin of S, the precursors of the host rocks, their geochemistry and some features of the ore mineralization are similar to those of the porphyry type deposits. The extent of the mineralization and the absence of other typical symptoms do not support this hypothesis. (Authors' abstract)

AIRES-BARROS, L., MARQUES, J.M. and GRAÇA, R.C., 1995, Elemental and isotopic geochemistry in the hydrothermal area of Chaves, Vila Pouca de Aguiar (northern Portugal): Environmental Geol., 25, p. 232-238.

AISSA, Mohammed, BENY, Claire and RAMBOZ, Claire, 1994, The Sn-W-B skarn fluids at the El Hamman deposit (Central Morocco): First results (abst.): 15th Reunion Sci. de la Terre, p. 71 (in French).

The skarns of El Hamman (Central Morocco) developed within stripped "cornéennes" which resulted from the metamorphism of a series of Visean calc-silicates by the emplacement of the buried granite of Achmeche. Work undertaken on the FI trapped in the skarn minerals has yielded the following preliminary results:

(1) In the scheelite skarns (Stage 1): The observed I in pyroxene show an early H_2O-CO_2 L, weakly saline, and with V phase homogenization between 380°C and 400°C. Raman analyses reveal the presence of CH_4, and the clathrate melting fixes pCH_4 = 25-30 bars at 25°C. The pyroxenes also contain aqueous F with homogenization decreasing from 420°C to 130°C with a correlative increase in salinity (2 to 8% eq. NaCl). Finally noted was the presence of very large FI with complex forms which homogenize in the L phase between 260 and 300°C, and have variable salinities between 3 and 18% eq. NaCl (reequilibrated FI?).

(2) In the stanniferous skarn (Stage 2) [there are two types]: (2a) Garnet zone I. The first F trapped, characteristically in the core of the mineral, are dense brines (40% eq. NaCl) which homogenize between 450 and 510°C. In the later zones, one finds I of a complex form containing an aqueous F of constant salinity (3% eq. NaCl) which homogenize between 230 and 400°C [reequilibration?]. (2b) Pyroxene I (stage 2). The F are concentrated brines with many salts as dms (40 to 55% eq. NaCl), which homogenize between 400 and >560°C. They indicate a thermal stage much hotter than that indicated by the primary F in the garnet cores.

(3) In the carbonatization calcite (late stage): One finds two types of F—one, H_2O-CO_2 with CH_4 traces, of moderate salinity (5% eq. NaCl) and which homogenize in the L phase towards 280°C; the other is an aqueous F of variable salinity with final melting at ~-52°C, with very low Te (~-84°C) and which homogenize between 300 and 120°C. The correlation between final melting and homogenization suggests episodic trapping of aqueous F more and more cool, necessarily containing salts other than NaCl. This study shows that the F in the early stages of skarns are hot and strongly concentrated in salts and can be a carbonated phase (W metasomatism). (Authors' abstract; translation courtesy of Dr. A.P. Gize)

AISSA, M., RAMBOZ, C., BENY, C. and PASCAL, M.L., 1995, Genesis of Sn-W skarns at high temperature, low fO_2 and hypogene conditions, and late boron metasomatism at El Hammam (Central Morocco) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 1-3. First author at CRSCM, la rue de la Férollerie, 45071 Orléans Cedex 02, France.

The El Hammam district contains major fluorite. FI in pyroxenes, garnets, axinite, quartz and calcite were examined.

Scheelite-bearing skarns: FI in metamorphic grossularite are CH_4 and G-rich, H_2O-poor; Th V 370-410°C or Th L 425°C. Those in pyroxene have 25-30 bars CH_4, 1.5% NaCl, and Th V 380-400°C. Also in pyroxene, H_2O-rich, lower Th, 2-8% NaCl.

Malayaite-bearing skarns: Three types of minerals are studied: FI in diopside from Sn-garnet skarns contain 40-55% sal., 5-6 dms, Th L 400->570°C. Zoned Sn garnets show 40% NaCl, Th L 450-510°C (core), but 3% NaCl, Th L or V 400-230°C. Hedenbergite has low-salinity, Th L or V 375-400°C.

Boron-bearing skarns only contain aqueous FI, 6-13 wt % sal., Th L or V 330-380°C.

Sn-W stage. The trapping of low density aquo-carbonaceous F contemporaneous with dense hypersaline brines fixed a lithostatic P regime for the Sn-W stages. A lithostatic P ≈1 kb and a T of 500°C are inferred for the W mineralization. At P ≈1 kb, the Sn-skarn formed between 570° and 630°C. The Sn F was a dense multicationic brine, trapping P ≤1 kb and fO_2 ≈Ni-NiO.

Retrograde evolution. Late-stage features suggest a transition from lithostatic to hydrostatic P, with a drop of both P and T to ≈250-280 bar and 370-420°C, respectively. (From authors' abstract by E.R.)

AKANDE, S.O. and ERDTMANN, B.-D., 1995a, Organic matter and clay minerals as thermal maturation indicators in the Benue Trough lead-zinc deposits, Nigeria, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 715-718.

Cites literature data on FI. See also next item. (E.R.)

AKANDE, S.O. and ERDTMANN, B.D., 1995b, Studies of burial metamorphism in the Cretaceous sediments of the southern Benue Trough and Anambra Basin, Nigeria (abst.): AAPG Bull., v. 79, no. 8, p. 1192-1193.

See also previous item. (E.R.)

AKÇAY, M., MOON, C.J. and SCOTT, B.C., 1995, Fluid inclusions and chemistry of tourmalines from the Gümsüsler Sb-Hg ± W deposits of the Nigde massif (Central Turkey): Chem. Erde, v. 55, p. 225-236. First author at Dept. Geology, Karadeniz Teknik Univ., Trabzon, Turkey.

Sb-bearing mineral deposits of the Gümüsler area in the Nigde massif (Central Turkey) have varying mineralogical association including veins of stibnite, stibnite-cinnabar, stibnite-cinnabar-scheelite ± baryte ± Au. All these vein type occurrences are also associated with disseminated type mineralisation. These mineral occurrences and the nearby felsic dikes are spatially and genetically related.

Tourmalinisation is a characteristic feature of the mineral occurrences and is also found in granite and associated felsic dikes. Tourmalines from the latter have a schorl composition and plot in the granite field whilst those of mineralised zones have intermediate compositions between schorl and dravite and plot between the fields of granites and metasediments. The differing compositions of tourmalines are not due to a difference in their genesis but to interaction of tourmaline-forming F with host lithologies. The salinity measurements of 8 ± 2.5 wt % eq. NaCl for the I in tourmalines from the mineralised zones compare well with those obtained from tourmalines in pegmatites elsewhere, and may indicate a magmatic origin for tourmalinisation associated with mineral occurrences. (Authors' abstract)

AKINFIEV, N.N., 1995, Algorythms for *ab initio* calculation of ion association in the supercritical H_2O fluids: 1:1 electrolytes: Geokhimiya 1995, no. 3, p. 426-440 (in Russian, English abstract; translated in Geochem. Int'l, v. 32, no. 11, p. 116-131).

The algorithms for prediction of association in 1:1 electrolytes without individual adjusting parameters are presented. The method involves algorythms both for calculation of nonelectrostatic and solvatation properties of ion pairs. The expressions for Born parameter values of a complex consisting of two nonpolarised hydrated ions are deduced. The proposed model is joined with Helgeson-Kirkham-Flowers equation of state for aqueous species; thus, the method could be applied for calculation of any thermodynamic properties of the ion pair. The comparison of the modeling calculations and available experimental data showed good agreement for the 1:1 electrolyte behavior description in the wide range of supercritical parameters (400-800°C, 0.5-4.0 kb). (Authors' abstract)

See also FIR, v. 27, p. 2. (E.R.)

AKINFIYEV, N.N., 1994, A model for ore deposition from a boiling fluid: Incorporating the dielectric constant: Geokhimiya, no. 10, p. 1465-1478 (in Russian, translated in Geochem. Int'l, v. 32, no. 6, p. 35-50, 1995).

Abstract in FIR, v. 27, p. 2. (E.R.)

AL-AASM, I.S. and WHITE, T., 1995, Mississippian hydrothermal dolomitization of the Upper Debolt Formation, Sikanni gas Field, Northeastern British Columbia (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-1. Authors at Dept. Geology, Univ. Windsor, Windsor, Ontario N9B 3P4, Canada.

The Mississippian carbonates of the Upper Debolt Formation, Sikanni Field, British Columbia, are gas producing, fractured and brecciated, dolomitized rocks. Reservoir porosity is represented by secondary, fracture, vuggy and intercrystalline porosity. Five types of dolomite have been identified: early dolomite, pseudomorphic dolomite, coarse crystalline dolomite, and saddle dolomite.

Preliminary FI data show Th of 90 to 218°C (avg. 135°C) for the last two dolomite types and salinity of ca 8 eq. wt. % NaCl. These data infer hot, slightly saline F were responsible for their formation. The radiogenetic ^{87}Sr/^{86}Sr ratios for coarse crystalline dolomite (0.7086 to 0.7091) and for saddle dolomite (0.7087 to 0.7099) are atypical for Mississippian seawater suggesting an extraformational F. The geochemical and petrographic data, combined with the proximity of both dolomite types in relation to the thrust faults suggest that basinal F, somehow affected by meteoric waters, enriched in Mg, radiogenic ^{87}Sr/^{86}Sr and depleted δ^{18}O values were funneled upwards along faults and fractures developed during Late Jurassic to Early Cretaceous time. (From authors' abstract by E.R.)

AL-AASM, I.S., WHITE, T. and DUROCHER, S., 1995a, Divergent dolomitization models from Shoal Mississippian carbonate reservoirs, NE British Columbia (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-1. First author at Dept. Geology, Univ. Windsor, Windsor, Ontario N9B 3P4, Canada.

Large hydrocarbon accumulations from several pools in NE British Columbia occur in pervasively dolomitized carbonates in the Mississippian Upper Debolt Formation. Reservoir dolomites were produced through very divergent processes. Two case studies, the Blueberry oil play and the Sikanni gas play, illustrate P-T and F compositional extremes for dolomitization. FI data on dolomites from the Sikanni gas play (Th 90-218°C, sal. ca. 8 eq. wt % NaCl) are combined to suggest that these dolomites formed from hot, slightly saline, basinal F that moved upward along faults and fractures developed during Late Jurassic to Early Cretaceous time. (From authors' abstract by E.R.)

AL-AASM, I.S., WHITE, T. and DUROCHER, S., 1995b, Dolomitization of Mississippian carbonate reservoirs, NE British Columbia, Canada: Divergent porewater evolution and chemistry (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 202-203.

The reservoir dolomite of the U. Debolt carbonates of the Sikanni Field is dominated by fractured and brecciated units. Early matrix dolomite formed at shallow burial. The main reservoir porosity occurs in later coarse crystalline dolomite and saddle dolomite. Stable (δ^{18}O values: -7.82 to -10.8‰ PDB) and radiogenetic isotopes (^{87}Sr/^{86}Sr; 0.7086 to 0.7099), FI (Th = 90-218°C; and Tm of ca. 8 eq. wt % NaCl) and petrographic examination of these dolomites suggest that these dolomites formed from hot, slightly saline, basinal F that moved upward along faults and fractures developed during Late Jurassic to Early Cretaceous time. (From authors' abstract by H.E.B.)

ALBINO, G.V., JALAL, Sameh and CHRISTENSEN, Kurt, 1995, Neoproterozoic mesothermal gold mineralization at Sukhaybarat East Mine, Saudi Arabia; Trans. Inst. Min. Metall. (Sect. B, Appl. Earth Sci.) v. 104, p. B157-210.

The geological setting, ore mineralogy and geochemistry, together with the style of veining and alteration, indicate that the deposit is a mesothermal Au deposit similar to those in Archaean to Mesozoic orogenic belts elsewhere in the world. The presence of L CO_2 in FI is consistent with such a classification. (From authors' abstract by E.R.)

ALFONSO, P. and MELGAREJO, J.C., 1995, The Cap de Creus rare element pegmatite field (Catalonia, Spain): Model of cristallization (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 4-6. Authors at Dept. Cristallografia, Mineralogia I Diposits Minerals, Univ. Barcelona, C/Martí I Franquès s/n, 08028 Barcelona, Spain.

In the Cap de Creus a pegmatitic field occurs within medium to high-grade metamorphic rocks. In addition to microcline-rich, barren pegmatites (type I), three pegmatitite types occur: according to the classification of Cerny (1992), based on beryl-columbite type (type II), beryl columbite-phosphate type (type III), and albite type (type IV). All these types are genetically related. FI have been studied in all the types and zones. Host minerals were quartz, beryl, albite, montebrasite and berlinite.

Type I. Only S FI have been observed.

Type II contain two groups of FI: (1) H_2O-salts-CO_2-N_2 and (2) H_2O-salts. The first coexist with MI in beryl from the intermediate zones, suggesting that they were formed during an unmixing stage between granitic magma and hydrothermal F. The isochores, combined with the Al_2SiO_5 polymorphs, indicate that the beryl formed between 570-600°C and 3-3,4 Kb. Group (2) occur in the replaced units, and represent late hydrothermal F that replaced the above units between 210-290°C and produced beryl and chrysoberyl replacement for herderite.

Type III contain the following kinds of inclusions: (1) H_2O-salts- CO_2-(N_2), (2) H_2O- CO_2, (3) H_2O-salts, (4) H_2O-salts- CO_2-(N_2), (5) H_2O-salts-other vapours, (6) CO_2-(N_2)-(CH_4).

FI (1) occur in the intermediate zones. Associated MI have been observed in one sample. Th L-V ranges between 380° and >550°C. They are hypersaline (≤46 wt % NaCl eq.), and contain muscovite, $FeCl_2$, calcite and, probably, kutnohorite. Hence, this zone formed similarly as above. The hydrothermal F (1) unmixed [to form F 2 and 3.] FI (2) is CO_2-rich, salts-poor (3-6 wt % NaCl eq.), occurs in the quartz core, and contains calcite, barite, siderite, and muscovite. They homogenize to V, calculated to occur at 380°C. This F probably generated the quartz core. The other F (3) is aqueous saline (23-35 wt % NaCl eq.), very rich in trapped solids: muscovite, calcite, foordite, apatite and, possibly, kutnohorite. Th L V 230-300°C. This F generated the cleavelandite veins and the related albitizations, as well as the replacement of beryl for hurlbutite. Moreover, this saline F concentrated all the rare elements, alternatively to that which formed the quartz core: Nb-Ta oxide minerals are highly concentrated in albite veins, and practically absent in the quartz core.

Later, a hydraulic decompression resulted in forming quartz-muscovite veins from stage (4) F. These are more saline (37-39% wt NaCl eq.). Trapped solids includes muscovite and sparse carbonates. Th L-V is 280-290°C. These F produced a little cassiterite.

Finally, I (5) occur in replaced units, and contain the highest salinities: ≤43 wt % NaCl eq, and sylvite crystals are widespread, indicating K enrichment in these late F. Th L-V is 160-200°C. The V phase contains CO_2 and probably organic compounds. These are solid-rich I: muscovite, calcite, ferrian calcite, sphalerite, apatite. They represent the F responsible of the formation of the late hydrothermal veins: sulphide veins, quartz-adularia veins, and late apatite veins.

Moreover, an ubiquitous group of apparently monophasic FI (6) exists, with different characteristics depending on the zone: in the intermediate zones, Th is 15-18°C; in the core, 10-12.5°C; in the albitization replacements, 1-7°C; and, in the quartz muscovite veins, -5 to 1°C. These I are related to the continuous aqueous and CO_2-rich V unmixing phenomena along the pegmatite crystallization.

Type IV display four kinds of I: (1) H_2O-salts, (2) CO_2-(N_2)-(CH_4), (3) H_2O-salts- CO_2-(N_2)-(CH_4), (4) CO_2.

The first (1) formed the intermediate zones; MI were not found. The salinity is 35-39 wt % eq. Th is 270-350°C. Trapped solids are muscovite, calcite, kutnohorite and $FeCl_2$.

FI (2) occur in the quartz core and in the quartz muscovite veins. They are CO_2-rich (H_2O<10% vol), also N_2 (10-15%) and CH_4 (2-4%) are present. CO_2 homogenizes into L from 9 to 12°C. Carbonates sparsely occur as trapped solids. In some quartz-muscovite veins these FI have graphite as a trapped solid.

FI (3) are saline, ≤40 wt %. Graphite also have been found within them, other trapped solids are muscovite, calcite, and ferrian calcite; TH from 280-290°C.

In the quartz-muscovite veins, I (2) coexist with I (3). The presence of graphite indicates reduction conditions at this stage. According to the coexistence of I (2) and (3), a T between 280-290°C and P of 1,5-1,8 kb were obtained for the formation of the quartz muscovite veins. These veins contain the highest concentration in Sn, Ta, and REE minerals in all the pegmatitic field.

FI (4) also occur in quartz-muscovite veins. They are dense (Th -12 to -4°C). They are probably related to late trapping of metamorphic F. (From authors' abstract by E.R.)

ALLIBONE, A.H., CORDERY, G.R., MORRISON, G.W., JAIRETH, Subhash and LINDHORST, J.W., 1995, Synchronous advanced argillic alteration and deformation in a shear zone-hosted magmatic hydrothermal Au-Ag deposit at the Temora (Gidginbung) Mine, New South Wales: Econ. Geol., v. 90, p. 1570-1603. First author at Dept. Geology, James Cook Univ. North Queensland, Townsville, Queensland 4811, Australia.

In the Temora mine, economic Au grades are associated with barite-sulfide veins that are generally confined to the silica-pyrite core of the earlier quartz-rich advanced argillic alteration. Cu-Au mineralization at the Dam prospect is associated with sericite-clay-chlorite alteration inferred to be the deeper level equivalent of quartz-absent advanced argillic alteration in the Temora mine. O and D/H isotope and FI data indicate a dominantly magmatic F focused through the host shear zone, possibly at depths >~4.5 km. Mineral stability relations and S isotope data indicate magmatic S input. (From authors' abstract by E.R.)

ALTAMURA, R.J., 1995, Pressure temperature and kinematic history of fault zone: The Lantern Hill fault, Connecticut (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-283.

The Lantern Hill fault (LHF) is a 10-mile long, N-S trending zone that transgresses metaigneous and meta-sedimentary units of the Proterozoic Z Avalonian terrane in southeastern Connecticut. The fault zone is massively silicified along its trace, and especially at its northern end, at the intersection with the Honey Hill fault, the terrane boundary between Avalonian and Gander terranes, where a quartz vein complex of economic importance for industrial silica was deposited. This silicified zone is 1 mi long and 200 ft thick and is comprised of quartz-filled fractures, faults, and metasomatically altered wall rock.

Earliest LHF deformation may be recorded in wall rocks as metamorphic foliation that shows evidence of ductile folding along steep fold axes. Ductile folding was followed by faulting and emplacement of quartz-filled fractures in the brittle regime. Eight sets of quartz-filled fractures are grouped into an early stage of stockwork veins that dissect wall rock, followed by main- and late-stage sets. Veins are cut by faults and are in turn cut by other veins. P FI in hydrothermal quartz suggest that the fault was active at rising structural levels. Faulting accompanying main-stage silicification occurred at 238.6±1.8 Ma, and using P-T-t paths for the area, at ~6 km depth. Faulting occurred at 265°C and F P of ~60 MPa (assuming hydrostatic conditions). Faulting accompanying emplacement of early stockwork veins probably occurred at similar depths. F in late-stage quartz-filled fractures in the fault zone indicate activity at 205°C and ~5 km depth. Last faulting associated with silica-saturated solutions appears to have been at this depth. F may have had some effect in reducing stresses necessary for rock failure.

F salinities determined from FI in hydrothermal quartz of all stages were ≤0.35 wt % eq. NaCl. These low salinities suggest that these F may have been dominantly from meteoric waters. Indeed, late-stage F from P FI have yielded $\delta^{18}O$ and δD values, +10.8‰ and -27.5‰, respectively, values that are similar to meteoric water, suggesting that meteoric water composed late-stage fault F. (Authors' abstract)

ALTHAUS, Egon, WALTHER, Johannes and HOLL, Albert, 1995, The Continental Deep Drilling Program and fluid research: The KTB as a tool in the investigation of fluids in the crust and their processes: Die Geowissenschaften (Weinheim, Zeitschrift), v. 13, no. 4, p. 147-153 (in German, English summary).

Indexed under FI. (E.R.)

ANDERSEN, T. and BURKE, E.A.J., 1995, Hydrocarbon inclusions in shocked quartz from Gardnos impact breccia, South Norway (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 7. First author at Mineralogical-Geological Museum, Sars Gate 1, N-0562 Oslo, Norway.

The Gardnos breccia in the Hallingdal area, South Norway, has recently been recognized as a meteorite impact structure of latest Proterozoic or early Phanerozoic age. The meteorite is thought to have hit in a shallow sea, penetrating through a thin layer of C-rich sediment.

Shocked quartzite from the central part of the Gardnos breccia is impregnated by fine-grained carbonaceous material, giving a nearly black colour in hand specimen. Micro Raman spectroscopy shows this material to consist of poorly crystalline graphite. Planar fractures, typical of shocked quartz, are outlined by graphite I and by trails of S FI. The FI consist of CH_4, with minor CO_2 ($XCH_4 \geq$ 96 mol %). The I show H1 and S2 type of microthermometric behaviour, H1 I showing a peak of Th to L at -100°C., which corresponds to isochore P of ca. 2.5 kb at 500°C and ca. 4.3 kb at 1000°C. Such trapping conditions cannot be related to the extreme P encountered during the impact. On the other hand, PT conditions along the CH_4 isochore can easily have been attained during Caledonian metamorphism, presumably at T <500°C. In this process, CH_4 was formed *in situ* by reaction between graphite and H_2O, and was trapped as the partly open planar fractures healed.

The hydrocarbon-rich FI in shocked quartz from the Gardnos breccia are thus only indirectly related to processes during the meteorite impact, and not at all to hydrocarbons of a deep (mantle) origin. (From authors' abstract by E.R.)

ANDERSEN, T., BURKE, E.A.J. and NEUMANN, E.-R., 1995, Nitrogen-rich fluid in the upper mantle: Fluid inclusions in spinel dunite from Lanzarote, Canary Islands: Contrib. Mineral. Petrol., v. 120, p. 20-28. First author at Mineralogical-Geological Museum, Sars Gate 1, N-0562 Oslo, Norway.

FI, ranging from pure N_2 to pure CO_2, occur in olivine porphyroclasts in spinel dunite xenoliths (chrome-diopside suite) from two localities in Canary Islands. This is the first report of FI containing major amounts of N_2 in mantle xenoliths. The nitrogen-rich FI predate at least one generation of nitrogen-free CO_2 I; textural evidence indicates that the I were trapped within the upper mantle. Some of the nitrogen-rich FI are intimately associated with solid I of spinel. The nitrogen-rich F was most likely produced *in situ*, by oxidation-dehydration reactions destabilizing ammonium-bearing silicate minerals (phlogopite, amphibole), increasing O fugacity or, possibly, increasing T of the mantle. This process could be related to an event of CO_2 and silicate M injection at 6-8 kb or to some earlier event in the evolution of the mantle beneath Lanzarote. The existence of a N_2-rich F phase in at least some mantle lithology(ies) at certain conditions is demonstrated by these data. This discovery has consequences for the understanding of the evolution of the mantle below the Canary Islands, as well as for the global nitrogen budget. (From authors' abstract by E.R.)

ANDERSON, A.J., MAYANOVIC, R.A. and BAJT, Sasa, 1995a, Determination of the structure and speciation of zinc complexes in individual fluid inclusions by micro-XAFS (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-2. First author at Dept. Geology, PO Box 5000 St. Francis Xavier Univ., Antigonish, Nova Scotia, B2G 2W5, Canada.

See next item. (E.R.).

ANDERSON, A.J., MAYANOVIC, R.A. and BAJT, Sasa, 1995b, Determination of the local structure and speciation of zinc in individual hypersaline fluid inclusions by micro-XAFS: Canadian Mineral., v. 33, p. 499-508. First author at Dept. Geology, St. Francis Xavier Univ., PO Box 5000, Antigonish, Nova Scotia B2G 2W5, Canada.

X-ray absorption fine structure (XAFS) spectra were obtained for the first time from metal complexes in individual FI in quartz using the synchrotron X-ray microprobe (X26A) at the Nat'l Synchrotron Light Source (NSLS), Brookhaven Nat'l Laboratory. Analysis of Zn *K*-edge absorption spectra obtained from hypersaline FI in quartz indicate that the dominant complex of Zn in these I at room T is having a Zn-Cl bond length of 2.33 Å, coordination number of 4.2 atoms and a mean-square relative displacement of the atoms of 0.004 $Å^2$. XAFS spectra obtained from zinc chloride test solutions having a Cl/Zn ratio of 8 closely match the spectra derived from the I. The presence of $ZnCl_4^{2-}$ is consistent with results of previous spectroscopic studies of zinc chloride solutions having high Cl/Zn ratios and with solubility studies of zinc compounds in chloride solutions. Our results demonstrate the potential of micro-XAFS as a tool for direct measurement of the structure of aqueous metallic species in FI. The sensitivity of the method will improve as brighter and more focused X-ray beams become available. (Authors' abstract)

ANDERSON, A.T., 1995, CO_2 and the eruptibility of picrite and komatiite: Lithos, v. 34, p. 19-25. Author at Dept. Geophysical Sciences, Univ. Chicago, 5734 S. Ellis Ave., Chicago, IL 60637.

A tholeiitic picrite erupted from the summit region of Kilauea volcano, Hawaii, in 1959. Work by Wright, Helz and Schwindinger and Anderson shows that the 1959 magma was a mixture of new, hot, MgO-rich magma that rose through and mixed with cooler stored magma causing crystallization of abundant olivine phenocrysts. CO_2 dissolved in MI in olivine phenocrysts from the eruption of 1959 reveals that most of the olivines grew at P <1 kb (100 MPa). Therefore, the new magma probably was buoyant relative to stored magma at 1 kb. The MgO-rich magma is characterized by a relatively dense M and could only be buoyant, if it contained more G than the stored magma. Compositions of I indicate that the G was rich in CO_2. Because G is highly compressible, the mass fraction of CO_2-rich G that is required for magma buoyancy increases at greater P. A critical P is that at which gassy, MgO-rich, parental magma has the same density as stored magma. Because G-free komatiitic magma is relatively dense, it too is expected to be trapped beneath stored magma. Komatiitic magmas containing more than ~0.6 wt % of CO_2, however, would be buoyant relative to stored, degassed basalt M even at the base of magma storage reservoirs. The common occurrence of komatiitic lavas in Archaean times may reflect a greater CO_2 content of mantle-derived Archean parental magmas. (From author's abstract by E.R.)

ANDRAS, P., WAGNER, R., RAGAN, M., FRIEDL, J., MARCOUX, E., CANO, F. and NAGY, G., 1995, Gold in arsenopyrites from the Pezinok deposit (Western Carpathians, Slovakia): Geol. Carpathica, v. 46, no. 6, p. 335-342 (in English). First author at Geological Inst., Slovak Acad. Sci., Severna 5, 974 01 Banska Bystrica, Slovakia.

Two types of arsenopyrite are found in the Pezinok deposit: fine-grained Au-bearing arsenopyrite I with average Au content 110 ppm (max. 378 ppm) and younger coarse-grained arsenopyrite II with low Au content (on the average 0.17 ppm). Arsenopyrite I is the most significant Au-bearing mineral in the Pezinok-Kolarsky Vrch Mt. Sb-Au deposit. A Mossbauer study of ^{97}Au in two arsenopyrite separates showed that Au is present exclusively in a chemically bound state with isomer shift values of 3.25 $mm \cdot s^{-1}$ and 3.62 $mm \cdot s^{-1}$, respectively. The Au-bearing arsenopyrites exhibit generally two extreme types of growth zones. The first zone has Sb, S and As contents ~0.6-1.0 wt % and 40-41 wt %, respectively. The following second zone has As and S contents ~43-45 wt % and 19-21 wt %, respectively. Sb contents are 0.2 wt % within the second zone, which is considered to be the most probable carrier of chemically bound Au. The Th derived from FI in quartz-bearing arsenopyrite I ranges from 140 to 275°C (avg. 225°C). These aqueous H_2O-NaCl F have low salinities, from 4 to 8 wt % NaCl eq. The Th of FI in black quartz paragenetically related to arsenopyrite II range between 150 and 200°C, and the salinities of the aqueous H_2O-NaCl F range from 5 to 9 wt % NaCl eq. (Authors' abstract)

ANGELL, C.A., 1995, Formation of glasses from liquids and biopolymers: Science, v. 267, p. 1924-1935.

Pertinent to understanding the behavior of many FI on cooling, e.g., Ca-rich aqueous solutions, and some organic F. (E.R.)

ANOVITZ, L.M., JOYCE, D.B., BLENCOE, J.G. and HORITA, J., 1995, New, more precise data on activity/composition relations of H_2O/N_2 and H_2O/CO_2 fluids (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-431.

Accurate, precise activity/composition relations for mixed-species supercritical F are critical for a wide range of geological and industrial applications. Recent improvements in our procedures for measuring the PTX relations of C-O-H-N F yield far greater precision than previously achievable, especially for water-poor compositions. (From authors' abstract by H.E.B.)

APPOLD, M.S., KESLER, S.E. and ALT, J.C., 1995, Sulfur isotope and fluid inclusion constraints on the genesis of Mississippi Valley-type mineralization in the central Appalachians: Econ. Geol., v. 90, p. 902-919. First author at Dept. Geological Sciences, Univ. Michigan, Ann Arbor, MI 48109.

MVT mineralization from two major host formations in the central Appalachians was studied in order to gain a better understanding of depositional conditions, sources of ore constituents, and the distribution of mineralizing F in the region. S isotope data show that mineralization in each formation acquired S from sources of similar isotopic composition.

New FI data were also obtained from the Timberville district and reveal the presence of at least two distinct F involved in mineralization—a more saline or Ca-rich F with final Tm between -42° and -29°C, and a less saline or more Ca-poor F with final Tm of -24° to -12°C. Th of both I types ranged for the most part between

100° and 170°C.

Geologic evidence suggests that the Beekmantown Group and Tuscarora-Shawangunk Formations were part of distinct paleoaquifers, and together with the S isotope data, also suggests that the source of S for MVT deposits in each paleoaquifer was connate (formational) F derived from seawater, or alternatively in the case of the Beekmantown Group, intraformational evaporites. Furthermore, evidence of mixing and a temporal increase in the oxidation state of mineralizing conditions in at least two of the districts suggests that much of the MVT mineralization in the central Appalachian region may be the result of mixing of oxidizing tectonically driven Zn-Pb or Ba-rich F with S-rich formation F. (From authors' abstract by E.R.)

ARANOVICH, L.Y. and NEWTON, R.C., 1995, Experimental determination of H_2O activity in concentrated aqueous sodium chloride solutions at high P and T (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-155.

The activity of H_2O in NaCl solutions was measured in the ranges 500-900°C, 2-15 kb and at NaCl concentrations up to salt saturation, using the equilibrium $Mg(OH)_2$ (brucite) = MgO (periclase) + H_2O. (From authors' abstract by H.E.B.)

ARCOS, D., SOLER, A. and DELGADO, J., 1995, Fluid behavior in the gold-skarn deposit of Carlés (NW Spain) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 8-9. First author at Dept. Cristallografia, Mineralogia i Dipòsits Minerals. Univ. Barcelona, Martí i Franquès s/n, 08028 Barcelona, Spain.

The Au-bearing skarn is related to a granodiorite intrusion. There are four different types of mineralization, two of them developed on the granodiorite itself and the other two on the host marbles.

FI in quartz crystals of each type of mineralization have been studied. Inclusions in quartz from K-feldspar alteration and skarn-type mineralization contain L, V and a halite crystal; some also have a K-feldspar crystal, trapped during their formation [i.e., dxl?].

Tm NaCl = 265-410°C, Th total = 265-500°C. The good correlation between halite dissolution and total Th indicates that this F is nearly saturated in NaCl at the T range of total homogenization. This means that salinity is ~48 wt % eq. NaCl between 500°C and 375°C and decrease along the NaCl saturation curve to 35 wt % eq. NaCl at 265°C. No CO_2 phases were detected in these high salinity FI.

CO_2-bearing FI have CO_2 Tm ranging from -57°C to -66°C, which are lower than that for pure CO_2, indicating the presence of other gases such as CH_4 and N_2. CO_2 homogenization is to the V phase in a range from +26°C to +20°C. These data together with the CO_2 volume fraction observed in these FI (between 0.25 and 0.55), suggest an XCO_2 between 0.03 and 0.15, assuming that these FI belong to the H_2O-CO_2-NaCl system. Total Th range from 390°C to 340°C to V and from ~340°C to 320°C to L, whereas some FI homogenize by meniscus disappearance ~345°C, indicating a critical behavior of the F. This evolution suggests that small variations in the composition of the system could have an important effect on the locus of the critical point and therefore on the type of total homogenization of these FI, i.e., the addition of small quantities of CH_4.

From Raman spectroscopy we have detected no CO_2 in high salinity FI, suggesting a very low XCO_2, whereas analyses of CO_2-bearing FI show that gases are mainly CO_2, with minor CH_4 and N_2, ranging from 1 to 12% and from 0 to 8% of the total gases, respectively.

All these data suggest that a high salinity F with very low XCO_2 has suffered an unmixing process by which a F, mainly water with small amounts of CO_2 and CH_4, was separated from it. This process took place in an open system, where the high salinity F was responsible for the formation of the ore in the skarn and K-feldspar alteration, whereas the CO_2-CH_4-bearing F formed the ore in the greisen and in the ferro-actinolite-arsenopyrite replacement. (From authors' abstract by E.R.)

ARNAUD, F., BOULLIER, A.M. and BURG, J.P., 1995, Fluid circulation within thrusting shear zones in a schist sequence (Cevennes, SE French Massif Central): A fluid inclusion study in quartz lenses (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 10. First author at CRPG 15 rue Notre Dame des Pauvres, 54501 Vandoeuvre-les-nancy CEDEX, France.

In most zones of imbricate schists shear zones are underlined by quartz lenses that result from circulation of SiO_2-rich F during deformation. According to the type of FI, the orientation of FI planes and the microthermometric and Raman data, different types of FI have been identified [summarized on Figure on p. 297]:

- primary CO_2-CH_4-N_2-H_2O I in albite and CO_2-H_2O I in apatite
- Lc1: CO_2-N_2-$H_2O \pm CH_4$ FI planes sub-parallel to S1 slaty cleavage and to l stretching lineation
- Lc2: CO_2-N_2-$H_2O \pm CH_4$ FI planes sub-perpendicular to S1 with variable orientations to l.
- L1: $H_2O \pm N_2 \pm CH_4$ FI planes sub-perpendicular to S1 with variable orientations to l.
- FI planes sub-perpendicular to S1 and to l which have different compositions: Vc1: CO_2-$N_2 \pm CH_4 \pm H_2O$; Vc2: CH_4-$N_2 \pm H_2O \pm CO_2$ and L2: $H_2O \pm N_2 \pm CH_4$.

The geometric relationship between the different types of FI indicate a relative chronology as follows: (1) P FI in apatite and albite, (2) Lc1 which may be contemporaneous with lens opening, (3) Lc2 (4) L1 and (5) Vc1, Vc2 and L2 which have the same orientation.

These preliminary results show variations in FI compositions which may be interpreted as resulting from the evolution of the metamorphic F during the shear event. The large variation in composition of the Vc1-Vc2-L2 FI could be interpreted as an heterogeneous trapping of a single H_2O-CO_2-N_2-CH_4 parent F. (From authors' abstract by E.R.)

ARRIBAS, Antonio, Jr., 1995, Characteristics of high-sulfidation epithermal deposits, and their relation to magmatic fluid: Mineral. Assoc. Can. Short Course, v. 23, p. 419-454.

Results of recent detailed FI and stable isotopic studies reveal much about the composition, T and sources of hydrothermal F in HS deposits. Combination of these data with geological and mineralogical observations mentioned above allows the nature of the altering and ore-forming F to be determined. The framework for the interpretation has benefited from information on the composition and fluxes of volcanic discharges and active magmatic-hydrothermal systems. (From author's text by H.E.B.)

ARRIBAS, Antonio, Jr., CUNNINGHAM, C.G., McKEE, E.H., RYE, R.O., RYTUBA, J.J., TOSDAL, R.M., WASSERMAN, M.D. and AOKI, Masahiro, 1995, Compilation of sample preparation and analytical methods and results of chemical, isotope, and fluid inclusion analyses, Rodalquilar gold-alunite deposit, Spain: U.S. Geol. Surv., Open-File Report 950221, 33 p.

See also next item. (E.R.)

ARRIBAS, Antonio, Jr., CUNNINGHAM, C.G., RYTUBA, J.J., RYE, R.O., KELLY, W.C., PODWYSOCKI, M.H., McKEE, E.H. and TOSDAL, R.M., 1995, Geology, geochronology, fluid inclusions, and isotope geochemistry of the Rodalquilar gold alunite deposit, Spain: Econ. Geol., v. 90, p. 795-822.

The Rodalquilar epithermal alunite deposit formed by hydrothermal circulation associated with the emplacement of shallow hornblende andesitic intrusions late in the evolution of a caldera. Ore deposits within the Rodalquilar caldera complex consist of low-sulfidation Pb-Zn-(Cu-Ag-Au) quartz veins and the economically most important high-sulfidation Au-(Cu-Te-Sn) ores. The latter are enclosed in areas of acid sulfate alteration present on the east margin of the Lomilla caldera.

The results of paragenetic, FI, and stable isotope studies indicate an evolution of the hydrothermal system, consisting of an early period of acidic wall-rock alteration and a late period of Au mineralization. A significant magmatic F component was present throughout, contributing acidity in the form of H_2SO_4 and HCl. Salinities in some samples of deep, hot (>400°C) F exceeded 40 wt % NaCl eq., consistent with the presence of a magmatic brine. In addition, the O and H isotope ratios of hypogene alteration minerals indicate that hydrothermal F during the main period of wall-rock alteration were dominantly magmatic in origin. The $\delta^{34}S$ values reflect isotopic equilibrium between sulfate and sulfide at T = 220° to 330°C, with the lower values corresponding with present-day surface samples. Textural and O isotope relations suggest that black chalcedony ($\delta^{18}O_{fluid}$ = ≤3‰) precipitated originally as amorphous silica, at T <180°C from a mixture of O-exchanged meteoric and

magmatic waters. (From authors' abstract by E.R.)
See also previous item. (E.R.)

ARRIBAS, Antonio, Jr., HEDENQUIST, J.W., ITAYA, Tetsumaru, OKADA, Toshinori, CONCEPCÍON, R.A. and GARCIA, J.S., Jr., 1995, Contemporaneous formation of adjacent porphyry and epithermal Cu-Au deposits over 300 ka in northern Luzon, Philippines: Geology, v. 23, no. 4, p. 337-340.
Literature FI data are used. (E.R.)

ASAVIN, A.M. and KOROLEV, J.K., 1995, The liquid immiscibility in the rock dragged from the Vinogradov Seamount (Philippine Sea) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 304-305.

Ultrabasic foudite dredged from the Vinogradov rise (Philippine Sea) contain rounded I of brown glass in the groundmass plus olivine and pyroxene megacrysts. The traces of melting and reaction relationship can be seen in the thin section of the rocks. The compositions of the I glass falls in the range: SiO_2 20.86-7.48, Al_2O_3 9.31-3.24, FeO 11.36-3.73, CaO 47.79-27.7, F 3.24-1.39, P_2O_5 29.09-17.27; these compositions lay near the border of the phosphatic L immiscibility field. Origin of the I seems to be connected with the accumulation process of the basaltic high-T melts intruded into the P_2O_5-rich soft sediment accumulating on the ocean bottom. This is a unique appearance of phosphatic L immiscibility in nature. The similar process can, however, lead to phosphatic ore formation in the regions where accumulation process is common (zones of subduction). (From authors' abstract by E.R.)

ASHLEY, P.M. and CRAW, D., 1995, Carrick Range Au and Sb mineralisation in Caples Terrane, Otago Schist, central Otago, New Zealand: New Zealand J. Geology and Geophys., v. 38, no. 2, p. 137-149.

Mineralised zones of the Carrick Range, bearing Au and stibnite veins, constitute one of the rare economically significant mineralised fields in the Caples Terrane. The mineralised zones have a polyphase hydrothermal history. FI in early milky quartz homogenise mainly between 145° and 210°C, with some higher Th ≤300°C. Late prismatic quartz has I that homogenise at 150°-170°C, and Tm(ice) suggest low salinity (2.4-4.8 wt % NaCl eq.). O isotopic ratios of early milky quartz range from $\delta^{18}O = 15.4$ to 17.6‰, whereas fine-grained late quartz ranges from 13.4 to 22.8‰. Vein carbonates have $\delta^{18}O$ between 13.8 and 19.9‰, and $\delta^{13}C$ between -1.6 and -3.6‰. The isotopic data, combined with other geological and mineralogical evidence, imply that mineralisation occurred over a wide range of T (140°-400°C) with a F of constant isotopic composition similar to typical Otago Schist metamorphic F. Sulphide S isotopic ratios fall in a narrow range of $\delta^{34}S = -1.6$ to +2.6‰, consistent with a homogenised crustal S source. (From authors' abstract by E.R.)

ASLUND, T., OLIVER, N.H.S. and CARTWRIGHT, I., 1995, Metasomatism of the Revenue Granite and aureole rocks, Mt. Isa Inlier, Queensland: Syndeformational fluid flow and fluid-rock interaction: Australian J. Earth Sci., v. 42, p. 291-299.

ATTIA, O.E., LOWENSTEIN, T.K. and WALI, A.M.A., 1995, Middle Miocene gypsum, Gulf of Suez: Marine or nonmarine?: J. Sed. Res., Sect. A, v. 65, p. 614-626.
Indexed under FI. (E.R.)

AUDET, D.M., 1995, Mathematical modeling of gravitational compaction and clay dehydration in thick sediment layers: Geophys. J. Int'l, v. 122, no. 1, p. 283-298.
Indexed under FI. (E.R.)

AUGUSTITHIS, S.-S.P., 1995, Atlas of the Textural Patterns of Ore Minerals and Metallogenic Processes: de Gruyter, Berlin, 659 p.

In Chapter 36, "Fluid Inclusions," the author briefly discusses the relevance of FI research to metallogenic processes. He also presents published FI data to amplify various metallogenic paragenesis in other chapters. (H.E.B.)

AUSBURN, K.E., 1995, Ore petrogenesis of Tertiary volcanic hosted epithermal gold mineralization at the Hart mining district, Castle Mountains, northeast San Bernardino County, California: Unpub. PhD thesis, Univ. North Carolina, Chapel Hill, North Carolina, 121 p.
Indexed under FI. (E.R.)

AYAN, Zeynep and ÖZGENÇ, Ismet, 1995, Fluid inclusion studies and rare earth elements geochemistry of fluorite from Vaysal village (Lalapasa-Edirne): Geol. Bull. Turkey [English version], v. 38, no. 1, p. 67-72.

Fluorites were collected from a F-Pb vein related with hypabyssal granodiorite porphyry intrusions of Santonian-Campanian age within Istranca massif. In this vein type mineralization the fluorite and galena are the dominant ore minerals. Paragenesis consists of fluorite + quartz + galena + pyrite + calcite. The host rock is represented by polymetamorphic crystalline basement of Precambrian age.

Microthermometric measurements on ~100 two-phase (L+V) I yield mean Th of 275°C for fluorites. Salinities range from 5 to 10 wt % NaCl eq., with mean of 7.5%. Microthermometric measurements on quartz reveal mean Th of 235°C. No FI have been observed in calcites.

The REE contents of the fluorite are quite variable, ranging from 0.03 to 0.9 ppm and Ce/Yb ratios reflect the dominant trend of light REE (LREE) enrichment. The similarity in the Tb/La ratios of dark purple, light purple and white fluorite indicates crystallization at about the same time. Chondrite normalized plot and REE ratios of fluorite reveal persistent positive Ce anomalies, indicating low O fugacities at the source area, and negative Eu anomalies indicate the presence of the same conditions at the deposition site. Tb/La and Tb/Ca ratios confirm a hydrothermal origin for fluorites. (Authors' abstract)

AYERS, J.C. and EGGLER, E.H., 1995, Partitioning of elements between silicate melt and H_2O-NaCl fluids at 1.5 and 2.0 GPa pressure: Implications for mantle metasomatism: Geochim. Cosmochim. Acta, v. 59, p. 4237-4246. Authors at Dept. Geosciences, Pennsylvania State Univ., University Park, PA 16802.

Partition coefficients between a synthetic andesite M and 1.5 and 3.0 molal (*m*) NaCl-H_2O F have been measured at 1.5-2.0 GPa and 1250°C. Concentrations of alkalis in the F positively correlate with total Cl concentration, suggesting that Cl complexes with alkalis in the F. Results imply that NaCl-bearing aqueous F can dissolve large amounts of silicate material, but do not strongly fractionate elements in equilibrium with silicate M. Thus, the geochemical signature left by metasomatic H_2O-NaCl F will not be distinctly different from that of silicate M. (From authors' abstract by E.R.)

AYORA, C., GARCIA-VEIGAS, J., ORTI, F. and ROSELL, L., 1995, The chemical composition of the Miocene Ocean: The interpretation of fluid inclusion in salt from Lorca basin (SE Spain) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 11-12. First author at Inst.. Ciències de la Terra, CSIC, Martí I Franquès s/n, E-08028 Barcelona, Spain.

The chemical composition of the ocean in the Phaneroic is assumed to be very close to present seawater. However, detailed compilation of marine evaporites show that the sequences following the expected evaporation path of present seawater are the exception rather than the rule. Indeed, most of the fossil evaporites do not contain Mg-K sulfates and belong to the so-called "sulfate-depleted" trend (Hardie, 1990). Based on the accurate chemical analysis of individual FI in halite Kovalevich (1990) confirms that the differences in the mineral sequences are due to variations in the mother brine, which are in turn attributed to differences in Ca and SO_4-content of the ocean water.

The Lorca basin is a representative example of a Miocene western Mediterranean basin. P FI trapped in halite have been analyzed by Cryo-SEM-EDS. According to solute proportions in FI from drillcore #5, the halite was precipitated in an open basin with a major inflow very close in composition to present day seawater. However, the FI from drillcore #4 shows SO_4-contents distinctly lower than expected from the simple evaporation of present day seawater. The inflow of a $CaCl_2$-bearing brine is to the basin is a more likely process to account for sulfate depletion, as suggested by the solute proportions analyzed in FI.

The P FI, in the Messinian basin of Lorca, suggests that rather than a different chemical composition of the past ocean, the differences found in mineralogical record and in FI are due to chemical changes within the evaporite basin. (From authors' abstract by E.R.)

AYUSO, R.A., MESSINA, Antonia, DE VIVO, Benedetto, RUSSO, Selma, WOODRUFF, L.G., SUTTER, J.F. and BELKIN, H.E., 1994, Geochemistry and argon thermochronology of the Variscan Sila Batholith, southern Italy: Source rocks and magma evolution: Contrib. Mineral. Petrol., v. 117, p. 87-109.

AYT OUGOUGDAL, M., CATHELINEAU, M., PIRONON, J., BOIRON, M.C., BANKS, D. and YARDLEY, B., 1995a, Diagenetic salt-rich and organic-rich fluid migration in the Rhine graben Triassic sandstones (Soultz deep drilling) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 198.

Microscopic observations and microthermometric studies have demonstrated the presence of two types of F related to the recent to modern circulations:

- biphase (sometimes three phase, with bitumen) hydrocarbon I in barite veinlets, and sometimes in quartz FIP. Tm is ~-70°C indicating that hydrocarbons are mostly nonaneoctane species. Th are relatively high (≤200°C). Infra-red spectroscopy confirms the presence of hydrocarbon chains formed by six to eight carbons, traces of CO_2, CH_4 and aromatic CH. G chromatography indicates that the most abundant species in bitumens are composed of 13 to 16 carbons (tridecane to hexadecane).

- aqueous F which have been observed as P FI in barite associated with hydrocarbon I and as FI planes in quartz overgrowths or in quartz grains. Several F types have been distinguished with salinity of 7-10, 17-20, and 25 wt % eq. NaCl, with Th of 150-190, 120-130, and 100°C respectively, depending on the location of the I (healed microcracks, barite veins and quartz overgrowth). The large variations of salinities suggest a mixing process between convected low salinity F (<5 wt % eq NaCl) and brines, indicating active F movements between the sedimentary formation, the basement, and the surface. (From authors' abstract by E.R.)

AYT OUGOUGDAL, M., CATHELINEAU, M., PIRONON, J., BOIRON, M.C., BANKS, D. and YARDLEY, B.W.D., 1995b, Salt-rich and organic-rich fluid migration in the Rhine graben Triassic sandstones (Soultz deep drilling) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 13-14. First author at CREGU, BP 23, 54501 Vandoeuvre-lès-Nancy, France.

Microscopic observations and microthermometric studies have demonstrated the presence of two types of F related to the recent to modern circulations in the Rhine basin:

Hydrocarbon fluids

UV-fluorescent P FI occur in barite from crosscutting veins. They are biphase and sometimes contain bitumen. V phase is highly variable in the 40-80 vol % range.

Tm of hydrocarbon phase is ~-70°C which indicate that hydrocarbons are mostly nonane-octane species. Th are relatively high (≤200°C) but problems of leakage prevent any Th measurements.

Infra-red spectroscopy confirms the presence of 6-8 aliphatic hydrocarbons, based on calculation of the CH2/CH3 area ratio. Traces of CH_4 have been detected in V phase. IR spectra of solid phase show the presence of aliphatic CH (corresponding to alkyl chains with 8 to 16 carbons), aromatic CH and OH groups. CO_2 is detected in all I phases.

G chromatography performed on organic matter from microfissures has shown that the most abundant species are composed of 13 to 16 carbons (tridecane to hexadecane).

Aqueous fluids

Three groups of F, with salinities of 7-10, 17-20, and ~25 wt % eq., have been distinguished. Th ranges from 100-190°C. The large variations of salinities suggest a mixing process between convected low salinity F and brines and is confirmed by the study of Br/Cl ratios in trapped F by using crush-leach procedures. Result show that the barite F are characterized by a relatively wide range of Br/Cl ratios from 0.03 to 0.08 indicating the contribution of a Br enriched end-member in F percolating the sediments. Such values are higher [than that of] mixed F from the present day reservoir, or trapped within the granite.

The overall data indicate that the movements of the saline and HC bearing F were limited to specific episodes of F circulation. This stage may correspond to the main stage of oil production, and happened later than the cementation of the sandstones, but prior to the recent hydrothermal circulation.

However, the lack of high salinity F and HC I in the deep granite levels indicate that F movements were limited at that stage to the Trias formations and to the fractured top part of the granite basement. (From authors' abstract by E.R.)

AYT OUGOUGDAL, M., CATHELINEAU, M., PIRONON, J., LANDAIS, P., BOIRON, M.C., DUBOIS, M., BANKS, D. and YARDLEY, B.W.D., 1995, Study of migration of aqueous fluids and hydrocarbons in Triassic sandstone and the Soultz-Sous-Forets granite (Rhine graben, Alsace) (abst.): Soc. Geol. de France, Meeting, Nov. 1995, Abstracts, p. 137 (in French) First author at CREGU, BP 23, 54501 Vandoeuvre-lès-Nancy, France.

F migration events at the interface between sedimentary formations and granitic basement are represented by: (a) P FI in quartz overgrowths; (b) S FI in quartz overgrowths; (c) P and PS FI in vein barite cutting sandstone and granite. Two main types of F are associated with 10-15 Ma geothermal activity.

(1) Hydrocarbon-rich F, P two-phase FI in barite, associated with aqueous FI, some containing bitumen; 40-80 vol % V. Tm (hydrocarbons) is ~-70°C, between Tm of n-heptane and n-octane. IR spectroscopy of solid, L and V phases indicates C6-C8 aliphatic chains. The solid phase contains C8-C16 aliphatic chains, and aromatic and OH groups. CH_4 is present in V, and CO_2 in all phases. Bitumen in vein barite contains abundant C13-C16 chains, and the presence of C26 to C32 indicates T <= 150°C.

(2) Aqueous F. P FI in quartz overgrowths contain 7-10 eq. wt % NaCl and have Th of 120-130°C, typical of diagenetic F. P or PS FI in vein barite have salinities 1-6.5 eq. wt % NaCl, and Th of 120-130°C. FI in quartz and barite veins in granite have more variable salinity, Tm(ice) from -1 to -29°C, and slightly higher Th. S FI in quartz overgrowths resemble the latest FI in barite veins, indicating fracture-controlled permeability after cementation of the sandstone. The large salinity range indicates mixing between low-salinity F and brine from Oligocene and Triassic formations. F released by crushing barite has Br/Cl of 0.03 to 0.08, greater than in seawater or in F now present in granite, indicating a contribution of Br, probably from sediments. Migration of brines and hydrocarbons was limited to Triassic sandstone and the upper fractured part of the granite. (Abridged from authors' abstract and translated by C.J. Eastoe)

BABANSKIY, A.D., ASHIKHMINA, N.A., KOVALENKO, V.I., LYATIFOVA, Ye.N. and KONONKOVA, N.N., 1995, Inclusions in minerals and the initial magma for the Upper Chegem caldera complex, North Caucasus: : Dokl. Ross. Akad. Nauk, v. 344, no. 2, p. 226-228 (in Russian).

Th of I in quartz and plagioclase range from 1120 to 1295°C. Fluorine, Cl and H_2O values are low. Dm amphibole, biotite, magnetite, and pyroxene analyzed, as well as MI glass. (E.R.)

BACH, W. and ERZINGER, J., 1995a, A vesicle gas study of oceanic basalts: preliminary results (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 149.

BACH, Wolfgang and ERZINGER, Jörg, 1995b, Volatile components in basalts and basaltic glasses from the EPR at 9°30'N, *in* R. Batiza, M.A. Storms and J.F. Allan, eds., Proceedings of the Ocean Drilling Program, Scientific Results, v. 142, p. 23-29. First author at Geo Forschungs Zentrum Potsdam, Projektbereich 4.2, Telegrafenberg A50, 14473 Potsdam, Germany.

Major and minor volatile concentrations and ferric/ferrous ratios of basaltic glasses, microcrystalline basalts, and fine-grained basalts from Hole 864A at the East Pacific Rise, 9°30'N, are presented. The average concentrations of volatile components in the basaltic glasses are 0.27 wt % H_2O, 0.04 wt % CO_2, 0.085 wt % S, 0.3 ppm N_2, and 1.2×10^{-5} cm^3 STP/g He. These are typical volatile concentrations of N-MORBs. CO and CH_4 are subordinate G species, of which the total is $<10^{-4}$ cm^3/g. $Fe^{3+}/\Sigma Fe$ ratios are ~0.11 in the glasses, which corresponds to O fugacities of >1 log unit below the fayalite-magnetite-quartz buffer. $Fe^{3+}/\Sigma Fe$ ratios are slightly higher in the basalts, indicating that the inner parts of the volcanic flows are more oxidized than the glassy rinds. Concentrations of S appear to be slightly higher in the basalts than in the glass, which is the opposite of what one would expect.

Vacuum-crushing of the glasses yielded virtually pure CO_2 in the vesicles, followed by N_2, H_2, H_2O, He, Ar and CH_4. The glasses are supersaturated with respect to CO_2 (290 ppm dissolved CO_2) as a result of incomplete degassing upon rapid ascent of the basaltic liquids. About 100 ppm CO_2 are trapped in vesicles, which corresponds to a vesicularity of 0.2%. (Authors' abstract)

BAJWAH, Z.U., WHITE, A.J.R., KWAK, T.A.P. and PRICE, R.C., 1995, The Renison granite, northwestern Tasmania: A petrological, geochemical and fluid inclusion study of hydrothermal alteration: Econ. Geol., v. 90, p. 1663-1675. Authors at Geology Dept., La Trobe Univ., Bundoora, Vic. 3083, Australia.

The Renison granite in NW Tasmania is genetically related to cassiterite sulfide mineralization (carbonate replacement) at Renison Bell, one of the largest Sn deposits in the world. The magmatic hydrothermal system responsible for the mineralization in the roof sediments is also responsible for the development of three zones of extensive hydrothermal alteration in the granite. The tourmaline zone is in part surrounded by a sericite zone, followed by an albite zone.

There are at least three sets of FI in the Renison granite. The earliest (type I) is characterized by high salinities ranging from 30.0 to 38.4 wt % NaCl eq., a second type (type II) has lower salinities (8.8-22.5 wt % NaCl eq.), and a third generation (type III) is marked by low salinities (4.5-12.3 wt % NaCl eq.) and the presence of CO_2. Hydrothermal activity represented by type II inclusions appears to be widespread, whereas type I and III inclusions are mainly restricted to the tourmaline zone. Tt recorded from type I and II inclusions are essentially in the same range (343°-455°C) in the tourmaline zone. A substantial overlap in the T and salinity of F recorded from all the alteration zones suggests a continuous flow of F. Decreases in T and salinities are thought to be responsible for changing F compositions which led to the formation of the three zones of alteration in the Renison granite. (From authors' abstract by E.R.)

BAKKER, R.J., 1995, The application of a computerised and optimised clathrate stability model to fluid inclusion studies (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 15-17. Author at CREGU, BP 23, 54500 Vandoeuvre-lès-Nancy, France.

A new modified clathrate stability model eliminates the defects in previous models. It gives a complete and accurate description of the H_2O-CO_2-CH_4-N_2-NaCl-KCl-$CaCl_2$ F system between 253-293 K and 0-200 MPa. A computer program in C++ language has been developed to handle the complex calculation method, which includes several numerical approximations. (From author's abstract by E.R.)

BALLHAUS, Chris and ULMER, P., 1995, Platinum-group elements in the Merensky Reef: II. Experimental solubilities of platinum and palladium in $Fe_{1-x}S$ from 950 to 450°C under controlled fS_2 and fH_2: Geochim. Cosmochim. Acta, v. 59, p. 4881-4888.

BANERJEE, A., 1995, Investigation of fluid inclusion in emeralds of different geological origins by microchemical analysis and IR-reflexion-spectroscopy (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 18-19. Author at Inst. Geowissenschaften-Edelsteinforschung, Johannes Gutenberg-Univ. Mainz, D 55099 Mainz, Germany.

Fourteen samples of emeralds [~10 mg each] from different sources were analysed for H_2O according to a method developed by Dindorf (1995), based on the thermal conductivity of the gases produced by the combustion of the samples. Wt % H_2O varied from ~0.6 to 2.7. (From author's abstract by E.R.)

BANKS, D.A., GIULIANI, G., CHEILLETZ, A. and RUEDA, F., 1995, Chemistry and source of the fluids in the Colombian emerald deposits (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 20-21. First author at Dept. Earth Sciences, Univ. Leeds, Leeds, UK.

The crush-leach technique detailed in Yardley et al. (1993) [FIR, v. 26, p. 203-204] has been used on single emerald crystals and bulk samples of between 0.5 and 1 g from both the eastern and western zones. There is no systematic difference between samples from the eastern or western zones, but I in quartz do have greater concentrations of Ca, Ba, Li, Fe, Mn, Pb, Zn, Cu and Br, whereas the emeralds have greater Na, Mg and SO_4. There is a large range in Cl/Br ratios (~15,000 to 700), while the salinity remains almost constant. The halogen analyses suggest that there were two distinct F present: Fluid E (I in emerald and fluorite) was relatively oxidising, and Fluid Q (I in quartz) was more reduced. Mixing appears to have taken place during mineral precipitation. We suggest that these two F had different sources but were both derived from dissolution of evaporite sequences. The constancy of element ratios from deposits that are c. 80 km apart indicates that the hydrothermal system was widespread. (From authors' abstract by E.R.)

BANKS, D.A., YARDLEY, B.W.D., CHEILLETZ, A., GIULIANI, G. And RUEDA, F., 1995, Chemistry and source of the high temperature brines in the Colombian emerald deposits: *in* Pasava, Křibek and Žák, eds., Mineral Deposits: Balkema, Rotterdam, p. 557-560. First author at Dept. Earth Sciences, Univ. Leeds, UK.

See previous item. (E.R.)

BARAKAT, A., BOIRON, M.C., CATHELINEAU, M., DURISOVA, J. and MORAVEK, P., 1995, Microfissure permeability and fluid migration in gold bearing Mokrsko granodiorite (Bohemia) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 187.

The Mokrsko deposit represents the largest Au deposit in Bohemian massif. It is located on the contact of upper Proterozoic volcano-sedimentary unit and granitic rock of the central Bohemian pluton of Variscan age. Au input is related to a dense network of parallel millimeter thick quartz veinlets (regular spacing of ~0.5 to 1 cm). Study of 3D geometry characteristics of each microstructure (quartz veins and fluid inclusion planes (FIP)) have been carried out using a systematic and statistical analysis in horizontal oriented planes.

FI study was carried out on P and SI in the quartz veinlets and FIP in the granodiorite where the following succession of F has been determined:

(i) F with CO_2-CH_4 ± N_2-H_2O-NaCl composition linked to the first mineralizing event (quartz-arsenopyrite Au)). The quantity of CH_4 is higher in the host granodiorite. Minimal T are 340°C, and density ranges indicate a strong P decrease during the veinlet network formation.

(ii) low salinity aqueous F circulated in the later stage related to the crystallization of the Au-Bi, Bi minerals. Minimal Tt (Th) is in the range of 140 to 300°C (modes at 200°C, 290°C) and salinities in the range of 1 to 9 wt. % eq. NaCl.

Thus, the granodiorite has been submitted to several stages of F migration and microfissure sealing due to a succession of intense brittle deformation assisted by F. (From authors' abstract by H.E.B.)

BARAKAT, A., CATHELINEAU, M., CANALS, M., BOIRON, M.C., DURISOVA, J. and BANKS, D., 1995, 3D reconstruction and PVTX conditions of microfissural fluid migration and extensional vein formation: Examples of Mokrsko (Bohemia) and Malpica-Tuy shear zone granites (Galicia) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 22-23. First author at GS CNRS-CREGU, BP 23, 54501 Vandoeuvre-les-Nancy, France.

New methodological developments concern the estimation of migration parameters using a probabilistic approach of the connectivity between FI planes, and a fractal description of microfracture populations. Systematic 3D measurements are carried out using a Universal stage and an Image Analyser, after a detailed study of FI. Characterization of P-T-V-X features of percolating F is then obtained through a multidisciplinary study of FI (microthermometry, Raman spectroscopy, bulk ion chemistry using crush-leach procedures).

Example of Mokrsko-Celina

Using this approach, the Mokrsko-Celina Au ore zone is characterized by the following succession of F events:

(i) Formation of the EW macroscopic extensional fractures filled by quartz. PI (CO_2-CH_4 ± N_2-H_2O-NaCl F linked to the first stage of veinlet infilling (Au-mineralizing event with quartz-arsenopyrite) at Th ~330 ± 20°C.

(ii) Formation and healing of EW and NS-N30°E FI plane networks.

These I display lower densities than the early F. The study of FI, plane by plane, shows clearly an evolution of the Th-Tm ice pairs, attesting of a progressive decrease in salinity and minimal Tt. Each crack exhibits well-defined features, but the successive healing of the cracks give the record of progressive evolution.

The study of Au concentrations at Tomino and Corcoesto (Galicia) shows that F migration in syntectonic Hercynian granites were similar to the above. C-H-O-(N) metamorphic F show in the 2-4 kb range and T of 350° to 450°C. They may be extremely enriched in CH4 and N2, indicating mixing with F produced by the devolatilization of nearby C-rich units. (From authors' abstract by E.R.)

BARANOVA, N.N., VOLYNSKY*, A.B., KOZERENKO, S.V., KOVALENKER, V.A., KOLOTOV, V. and KOLPAKOVA, N.N., 1995, Contents and chemical forms of Au, Te, Sb and As in mineral-forming solutions gold-sulfide-telluride epithermal deposits: Geokhimiya, 1995, no. 12, p. 1786-1799 (in Russian; English abstract).

FI in quartz samples taken as representative in respect of main mineral assemblages of three Au-sulfide/telluride epithermal ore deposits were studied. Au, As, Sb and Te content were determined by use of neutron activation and atomic absorption analysis, the corresponding values being as follows: 10^{-6}-$10^{-4.5}$, $10^{-2.5}$-$10^{-1.2}$, $10^{-2.2}$-$10^{-0.5}$, 10^{-6}-10^{-4} M. The complex ions $Au(HS)_2^-$, $H_3AsO_3^0$, $HSb_2S_4^-$ and HTe were found as predominant chemical forms of Au, As, Sb and Te in ore-forming solutions. Covariative character of Au distribution in relation to that of As and Sb in FI is interpreted as indicative of the probable Au transport in the form of S-bearing complex compounds with As and/or Sb in the sulfide ore-forming processes. The reciprocal correlation of Au and Te content could be considered as an evidence of Te ore-concentrator role in the Au-Te mineralisation. (Authors' abstract)

*Editor's note: The last author's initials are given as "N.N." in one place and "B.P." in another. (E.R.)

BARGAR, K.E., 1995, Some fluid inclusion measurements for geothermal drill holes in California, Nevada, El Salvador, and Russia: U.S. Geol. Surv. Open-File Report 95-9826, 14 p.

BARGAR, K.E., KEITH, T.C. and TRUSDELL, F.A., 1995, Fluid-inclusion evidence for past temperature fluctuations in the Kilauea East Rift Zone geothermal area, Hawaii: Geothermics, v. 24, p. 639-659.

BARKER, A.J., 1995a, Post-entrapment modification of fluid inclusions due to overpressure: Evidence from natural samples: J. Meta. Geol., v. 13, p. 737-750.

Effects of post-entrapment FI modification are examined with reference to retrogression-related quartz veins from the Caledonian, Øse Thrust, northern Norway. The I occur in secondary trails, and contain high-density hypersaline aqueous F. On morphological characteristics, they are subdivided into Type A, elongate, ellipsoidal and/or irregular I, and Type B, more equant, regular, and/or negative crystal form. With reference to previous research on post-entrapment modification of I in quartz, it is proposed that Type A I experienced little or no post-entrapment modification, whereas Type B I show features characteristic of post-entrapment permanent inelastic stretching and/or leakage. This produces increased Th, associated with increased I volume and lowering of density, whilst maintaining constant salinity. The similarity of data for degree of fill and salinity between Type A and Type B I indicates that Type B I have primarily modified by stretch rather than leakage. However, the spread towards slightly larger volume of V in Type B I suggests that some leakage has also occurred. Because stretched and/or partially leaked I have increased Th, isochore projections significantly underestimate Pt relative to unmodified I. Therefore, recognition of post-entrapment I modification due to overpressure is crucial to avoid misinterpretation of data, but has considerable potential for constraining the detail of P-T trajectories of individual rocks. On this basis, rocks from the Øse Thrust zone, north Norway, are shown to have experienced rapid uplift on a "clockwise" P-T-t path during the final stages of Caledonian (Scandian) orogenesis. (Authors' abstract)

BARKER, A.J., 1995b, Diachronous fluid release and veining associated with out-of-sequence thrusts in the north Scandinavian Caledonides: Australian J. Earth Sci., v. 42, p. 311-320. Author at Dept. Geology, The University, Southampton, SO17 1BJ, UK.

The Øse Thrust of northern Norway represents a major late Caledonian out-of-sequence thrust which duplicates a previously assembled nappe stack with inverted metamorphic gradient. F flow along this thrust gave rise to retrogression of peak metamorphic porphyroblastic phases in both footwall and hangingwall. Chlorite pseudomorphs after garnet are not smeared out, suggesting that retrogression largely postdates thrust movement. Dominated by vein quartz, the Øse Thrust and adjacent footwall and hangingwall rocks record three stages of veining in a protracted history of F flow; schistosity-parallel, prograde and peak metamorphic veins (V_A-V_B), and retrogression-related (post-D_3) veins which crosscut the regional S_2 schistosity (V_C). V_C veins contain similar highly saline FI to those associated with early ductile thrusts from the region. This indicates that various thrusts in the north Scandinavian Caledonides acted passively as important F conduits for late-stage F flow and retrogression during uplift. The proportion and composition of different vein types varies considerably between footwall and hangingwall rocks, largely as a function of bulk rock composition and tectonometamorphic evolution. Contoured maps of veining intensity have been produced by image-processing and visual analysis of photographs from 80 localities along the Øse Thrust zone. Footwall gneisses typically contain 15-30% vein material (most of which is peak metamorphic), whereas hangingwall rocks generally contain <1% veins. Integration of new data on veining and F production with existing radiometric dates and P-T data has shown that during Scandian collisional orogenesis F events occurred as discrete pulses. These pulses were diachronous between nappes, some units experiencing prograde devolatilization coeval with others experiencing retrogression. (Author's abstract)

BARKER, C.E. and BONE, Yvonne, 1995, The minimal response to contact metamorphism by the Devonian Buchan Caves Limestone, Buchan Rift, Victoria, Australia: Org. Geochem., v. 22, p. 151-164.

Peak T from solid bitumen reflectance values are in good agreement with FI Th measures (from literature). (E.R.)

BARKER, D.S., 1995, Crystallization and alteration of quartz monzonite, Iron Springs mining district, Utah: Relation to associated iron deposits: Econ. Geol., v. 90, p. 2197-2217. Author at Dept. Geological Sciences, Univ. Texas at Austin, Austin, TX 78712.

The Iron Springs mining district of SW Utah contains the largest Fe deposits in the western U.S. These are related to emplacement, at minimum depths of 1 to 2.3 km, of three Miocene laccoliths of porphyritic quartz monzonite. When emplaced, the magma was nearly half crystallized, on the verge of brittle behavior, and contained phenocrysts of plagioclase, amphibole, biotite, and clinopyroxene. Granophyric dikes in quartz monzonite formed from residual L, but miarolitic cavities in these dikes are lined with alpha quartz, indicating that deposition continued from a volatile-rich phase below the solidus. Pervasive high-T alteration led to: replacement of augite by diopside; oxidation of magnetite and ilmenite; replacement of amphibole (completely) and biotite (partially) by aggregates of diopside, alkali feldspars, smectite-chlorite, magnetite, ilmenite, and calcite; albitization of groundmass alkali feldspar; exchange of Mg for Fe and of F for OH in biotite; and exchange of F and OH for Cl in apatite. This alteration produced whole-rock enrichment in Fe^{3+}, Na, and H_2O, and losses in Fe^{2+}, Ca, and K. Total Fe was effectively unchanged. (From author's abstract by E.R.)

BARRETT, T.J. and SHERLOCK, R.L., 1995, Volcanic stratigraphy and lithogeochemistry at the H-W massive sulfide deposit, Myra Falls, Southern British Columbia (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-5. Authors at Mineral Deposit Research Unit, Dept. Geological Sciences, Univ. British Columbia, Vancouver, B.C. V6T 1Z4, Canada.

The footwall to the ores consists of >300 m of massive to pillowed mafic flows and local hyaloclastites. Lithogeochemical data indicate that these are of mainly basaltic andesite composition, and of island-arc tholeitic affinity. The ores are directly underlain by strongly altered sericite-quartz-pyrite rock that extends 25-30 m into the footwall. Immobile element plots for these sericitized rock yield linear alteration trends that indicate very large additions of K, near-total loss of Ca and Na, and variable changes in Si. Whole rock δ^{18}O values range from 8‰ in the lower mafic footwall to 11‰ in the sericite-quartz-pyrite feeder zone. Taken together with preliminary FI data, this indicates that T in the feeder pipes were relatively low, in the order of 200-250°C. (From authors' abstract by H.E.B.)

BATANOVA, V.G and SOBOLEV, A.V., 1995, New data on the origin of intrusive complex of Troodos ofiolites [sic]: Evidence from melt inclusions study (abst.): Eos, v. 76, no. 17, p. S268. Authors at Vernadsky Inst. Geochemistry, Kosigin St. 19, Moscow 117975, Russia.

Trace elements contents of Cpx from oceanic and ophiolitic cumulates potentially indicate the geochemistry of primitive melts (Ross and Elthon, Nature, 365, 1993). However, major assumption that Cpx from intrusive rocks was in equilibrium with primitive melt has not been yet confirmed by direct data. Here we present the comparison of the parental melts: (1) calculated from Cpx composition, using Cpx/L partition coefficients and (2) obtained directly by study of MI. Cpx grains and MI trapped in associated Pl were studied from sample of typical olivine gabbro from the central plutonic complex of Troodos ophiolite, Cyprus. P MI were found in Pl cores (An 93) and quenched after heating ≤1190°C using optical heating stage (Sobolev et al., Proc. 11th LPSC, 1980). The trace element composition of Cpx and MI were analysed by Cameca IMS 4f ion microprobe. The data show that observed Cpx compositions correspond to depleted varieties similar or even more depleted in LREE than those reported for MAR cumulates. The composition of MI is reasonably close to predicted equilibrium L and similar to ultra-depleted MORB melts. Compared to magmas from Troodos volcanic complex studied melt shows no connection to boninite suites from upper pillow lavas (types II-III after Cameron, Contrib. Mineral. Petrol., 89, 1985) but could be similar to island-arc tholeiite from lower pillow lavas or type I from upper magmatic suites. However, the supra-subduction affinity of melts parental for intrusive complex should be additionally proved by measuring H_2O contents in MI. (Authors' abstract)

BATTLES, D.A. and BARTON, M.D., 1995, Arc-related sodic hydrothermal alteration in the western United States: Geology, v. 23, p. 913-916.

Na-rich hydrothermal alteration is widely developed in Permian to Jurassic arc igneous rocks of the western U.S., but it is rare in younger rocks. Na-rich alteration reflects a paleogeographic control on development. Two varieties, NaCa and Na, can be defined by mineralogic and compositional changes. Both are common in Permian to Jurassic arc plutonic and volcanic rocks and are accompanied by Fe and Cu + Zn mineralization. Geologic relations and mineralogic, stable isotopic, and FI data indicate that the F responsible for Na-rich alteration were isotopically heavy, moderately to highly saline F of marine, formation, and/or meteoric origin, with or without a magmatic component. The transition away from widespread Na + Ca-rich alteration in the late Mesozoic corresponds to and is consistent with the change from an early Mesozoic marine and/or and rifted arc setting to a fully emergent, continental arc environment in the Cretaceous. (Authors' abstract)

BAU, Michael and DULSKI, Peter, 1995, Comparative study of yttrium and rare-earth element behaviours in fluorine-rich hydrothermal fluids: Contrib. Mineral. Petrol., v. 119, p. 213-223.

BEANE, R.E. and BODNAR, R.J., 1995, Hydrothermal fluids and hydrothermal alteration in porphyry copper deposits, *in* F.W. Pierce and J.G. Bolm, eds., Porphyry Copper Deposits of the American Cordillera: Arizona Geol. Soc. Digest 20, p. 83-93.

Porphyry Cu deposits contain large volumes of rock which have undergone alteration as a result of circulation of hydrothermal F. Several workers have attempted to systematize the characteristics of such alteration by defining groups of minerals which commonly occur together and placing these in a spatial relationship to Cu mineralization. Mineral paragenetic sequences are recognized to be an important aspect of alteration studies. Information regarding the thermochemical nature of the F responsible for alteration and mineralization are obtained through study of FI. FI characteristics vary as a function of time and position in porphyry Cu systems. Accumulating knowledge has enabled correlation between FI characteristics and the timing and location of alteration phenomena. Such information aids not only in understanding the genesis of porphyry Cu deposits but also in interpretation of such environments by exploration geologists. This paper reviews the current state of knowledge concerning hydrothermal F and the alteration minerals they produce. (Authors' abstract)

BEBEJ, J. and DUBAJ, D., 1993, Volatile components in hydrothermal systems. Part 2: Practical interpretation in the case of Kremnica deposit, Central Slovakia. Mineralia Slovaca, v. 25, p. 301-312 (in Slovak with Eng. extended abstract).

The epithermal Au-Ag deposit Kremnica (NW part of the Slovakian neovolcanics) belongs to the adularia-sericite type. The mineralization process took place in three stages. The first stage was connected with the development of the Zlata Studna intrusive complex of Badenian age (andesite, diorite, gabbrodiorite), believed to be genetically linked with Cu-Pb-Zn ± Au ± Ag mineralization and wall-rock alterations resulting in secondary quartzite facies rocks (sillimanite-cordierite-topaz-fluorite ± pyrophylite). The second stage was activated by rhyolitic volcanism of Sarmatian age. The high-T substage was connected with K-metasomatism ("trachytisation") of andesites and with formation of secondary quartzites with andalusite. Low-T substage was connected with formation of the Au-Ag ± Sb vein epithermal mineralization.

Most recent microthermometric study revealed dominant two-phase aqueous I with variable L/V ratios. These I occur in vein as well as in metasomatic ores. Te between -35 and -38°C indicate presence of divalent cations in the mineral-forming solutions—a characteristic feature of the base metal deposits (Nash, 1976). T-salinity diagrams display severe changes in salinity at fixed Th, as is typical of high-gas epithermal systems (Hedenquist and Henley, 1985). Polyphase high-salinity aqueous I with halite dxls are also sporadic. Salinity of these I is 36-54 wt % NaCl eq. and Th range from 420-450°C. Analogous I have been observed in quartz-sanidine rhyolites, as well as in metasomatites around Schrámer and Hlavna veins. This leads to the conclusion that the hypersaline F were linked with a higher T stage of the mineral-forming process. Origin of these brines may be due to "secondary boiling" of silicate melts injected towards earth's surface in the form of rhyolitic dikes of the quartz-sanidine type. (Authors' abstract)

BEGEMANN, F., 1994, Indigenous and extraneous noble gases in terrestrial diamonds, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 217-227. Author at Max-Planck-Inst. Chemie (Otto-Hahn-Inst.), 55020 Mainz, Germany.

The original hope that mantle diamonds should contain isotopically unadulterated ambient G from the location and time of their formation has turned out to be overly simplistic. First, the basic question has been raised (but not yet been satisfactorily answered) whether diamonds have been able to retain any primary noble G signature. Secondly, changes due to implantation of various nuclides have in many cases completely obliterated the primary noble G signature.

Ingenious models have been invented, and a perhaps seemingly contrived one is presented here in connection with Kokchetav crustal diamonds, to account for the various implanted noble G species. Aside from the intellectual satisfaction, however, that solutions have been found for complicated problems these models have not contributed in any substantial way to further our knowledge about geological problems in general. It remains to be seen whether the noble G record of I in diamonds will fare any better in the future. (From author's abstract by E.R.)

BELKIN, H.E., 1995, Pt-group element (PGE) paragenesis in Mesozoic intrusive rocks: Abstracts of Papers, Part 1, 210th Am. Chem. Soc. Nat'l Mtg., Chicago, Illinois, 20-24 Aug. 1995, Division of Geochemistry abst. no. 025, unpaginated.

PGE anomalous zones (Pd ~200 ppb, Pt ~35 ppb) occur in a ferrogabbro zone in high-Ti quartz-normative diabase sheets of the Gettysburg (PA) and the Culpeper basin (VA). The ferrogabbro zones are enriched in FeO, TiO_2, P_2O_5, REE and Zr. Pervasive hydrothermal alteration replaced clinopyroxene with Fe- and Cl-rich amphiboles, biotite, and chlorite. Primary oxides are replaced by ilmenite and later low-Ti magnetite. Intimately associated with late-stage chalcopyrite and various base-metal sulfides are micrometer-size grains of Pd-Bi-antimonide and less commonly electrum. Textural, FI, and isotopic evidence suggests that late-stage magmatic, high-salinity (≥40 wt % NaCl eq.), Fe-bearing aqueous F altered partially crystallized magma and deposited the PGE and related phases. Various geothermometers record processes from ~700° to 300°C; geologic constraints suggest $P \leq 1$ kb. (Author's abstract)

BELKIN, H.E., DE VIVO, B., TOROK, K., and WEBSTER, J.D., 1995, Silicate melt inclusions in Vesuvius Lavas (pre-1631 A.D.): microthermometry and analytical chemistry (abst.): Eos, v. 76, no. 46, p. F672.

Lavas and pyroclastics from pre-1631 A.D. Somma-Vesuvius eruptions contain phenocrysts of clinopyroxene, olivine, leucite, and plagioclase. Silicate-MI are abundant in most phenocrysts, and have been studied by microthermometry and electron microprobe and SIMS analytical techniques in order to examine magma evolution and paragenesis. The MI are small, usually <60 µm and show a range of pre-and post-entrapment magma evolution. Petrographically the I fit into three general types; (1) transparent glass, bubble, ± a small opaque phase, (2) transparent glass, dxls (usually pyroxene and oxide), bubble, and (3) I containing a variety of accidentally trapped solid crystals (usually apatite or oxide). Some I appear to be completely devitrified. Clinopyroxene hosted I yield Th from 1170 to 1260°C with the majority between 1220 to 1240°C. Plagioclase-hosted I have Th from 1210 to 1230°C. Inclusions hosted by olivine darkened during heating, obscuring homogenization at ~1000°C, and those in leucite decrepitated and/or stretched. The included bubble(s) is usually larger than that resulting from pure shrinkage and indicates the presence of volatiles. Preliminary chemistry from unhomogenized I show a range of compositions reflecting pre- and post-entrapment processes. (Authors' abstract)

BENCHEKROUN, Fouad, 1994, Fluids associated with auriferous sulphide mineralization at Salsigne (Black Mountain, France) (abst.): 15th Reunion Sci. de la Terre, p. 71 (in French). Author at Lab. de Mineralogies, U.A. 67 du CNRS, 38 Allees J. Guesde Toulouse, France.

In the Salsigne deposit, the superimposition of several deformation stages, both ductile and brittle, renders identification and microthermometric interpretation of the varied FI types somewhat difficult. In a detailed study of quartz I related to shales (or schists) Lescuyer et al. (1993, Chr. Rech. Min., 513, 3) has completed our previous studies. Three main families are recognized (I-III), which contain eight I generations.

(I) H_2O-CO_2 I, relatively abundant (1-20% NaCl); (II) weakly saline FI (1-8% NaCl), intermediate age; (III) very saline FI (10-26% NaCl), late and probably related to Lias tectonic events.

Generation I inclusions show the greatest variations in the proportions of H_2O and CO_2 and total densities. Those highest in H_2O ($0.1 < XCO_2 < 0.4$) are the most abundant and densest. Their minimal P-T trapping conditions are 300-400°C at 1.6-3 kb (Nesplie) and 4-6 kb (vein generation "3a-2x"). These elevated P before sulphide precipitation are supported by other regional studies (Boiron et al., 1990, Mineral. Mag., 54, 231; Cathelineau, 1993, Eur. J. Mineral. 5, 107). The evolution towards less dense F, CO_2-rich (XCO_2 ~1), together with others H_2O-rich (XH_2O ~1) is probably due to an unmixing process (with or without heterogeneous trapping) related to a lowering of the P-T conditions. The F P variations related to tectonic events have been previously noted in the region (ibid.). The interpretations are in accord with two F, containing H_2O and CO_2, but with different densities.

The Type II have Th 200-280°C. They are often obviously later than Type I, and often occur alone (no Type I observed in the vicinity) in quartz veins later than earliest sulphides. As the Au is present in very low grades in the sulphides, it is probable that the Au was transported by the Type II F, and deposited in a preexisting sulphide deposit. This deposition occurred at ~250°C. The mechanism of precipitation from a S species complex ($Au(HS)^-_2$ ...) is not understood as interaction with the sulphide ores tends to augment the Au solubility [sic]. Apart from a lowering of T (unverified), the role of boiling is speculated upon, based on local observations of Type II FI. (Author's abstract; translation courtesy of Dr. A.P. Gize)

BENCHEKROUN, F. and MOINE, B., 1995, Fluid inclusions and process of gold precipitation in the Salsigne deposit (Montagne Noire, France) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 24-25. Author at Laboratoire de Minéralogie, URA 67 du CNRS, 39 Allées Jules-Guesde, 31000 Toulouse, France.

Three main successive families of F of contrasted features have been observed:

(I) An early family of H_2O-CO_2-NaCl (CH_4, N_2) FI trapped under different P-T conditions (Fig.).

(II) The second family of H_2O-NaCl F of relatively low salinity (5 wt % NaCl) is connected with the late Bi-Au paragenesis.

(III) Very late H_2O-NaCl-$CaCl_2$ F of intermediate to high salinity, trapped along several families of sealed microfractures are probably connected with the Trias-Lias distension. (From authors' abstract by E.R.)

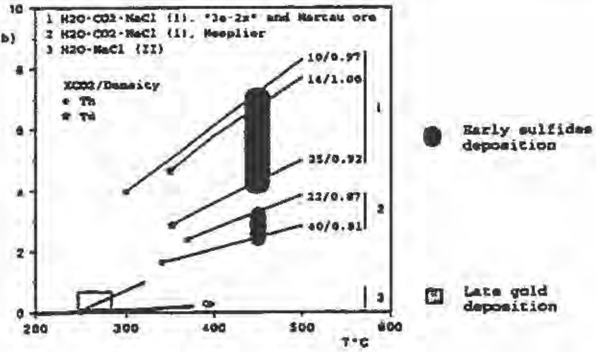


Figure 1. Isochores for the F related to sulfides and Au deposition, respectively (Th: homogenization T; Td: decrepitation T; Cp: critical point).

BENVENUTI, M., LATTANZI, P., COSTAGLIOLA, P. and TANELLI, G., 1995, The metamorphic-hosted siderite-Cu deposit of Frigido: Structural setting and isotopic data: *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 843-846. First author at Dipt. Scienze della Terra, Firenze, Italy.

The Palaeozoic basement of Apuane Alps core complex contains siderite veins, hosted by metamorphosed schist and rhyolites. C-O isotope composition of siderite indicates a mineralising F equilibrated with basement rocks. The basements appear to be chemically heterogeneous but, at the same scale, isotopically homogeneous. Metamorphic (mineralising) F inherited their chemical composition in response to local scale features. (From authors' abstract by E.R.)

Uses literature FI data. (E.R.)

BERGMANN, B.J. and LUCZAJ, J.A., 1995, Preliminary fluid inclusion evidence for the mechanism of dolomitization in the Lower Permian Chase Group, Hugoton Embayment, southwest Kansas (abst): AAPG Bull., v. 79, no. 9, p. 1400. Authors at Univ. Kansas, Lawrence, KS.

P FI in dolomite from the lower Krider Limestone of the Mobil Nix #1 Unit #3 well and the base of the Winfield Limestone of the Mobil Clair Curry Unit #3 well in SW Kansas were analyzed to determine the salinity, T, major ions, and G content of F responsible for dolomitization.

Dolomite rhombs show growth zonation with I-rich cores and clear, I-free rims. Both one-phase and two-phase aqueous FI are present in the I-rich cores. Tm ice range from -17.5°C to -22.8°C (20.6 to 24.2 wt % NaCl eq.). Th range from 56.9°C to 128°C, with 85% between 75°C and 95°C. Te were observed at -57°C for the Nix well and -52°C for the Clair Curry well, indicating model compositions of Na-Ca-Mg-Cl-rich and Na-Ca-Cl-rich F, respectively. Intermediate Tm between ~-42° and -38°C were observed but were not interpretable. Crushing runs reveal the V phase contains an exsolved G of unknown composition at P between 5 to 35 bars at room T.

Cathodoluminescence petrography reveals three growth zones that are especially well developed in dolomite of the Clair Curry well. Zone 1 (I-rich core) is dull but contains some bright areas suggestive of recrystallization of an originally dull rhomb. Zone 2 (inner zone of clear rim) is bright and exhibits polyhedral crystal growth. Zone 3 (outer zone of clear rim) is dull and rhombic.

The presence of one-phase and two-phase I within the cores of dolomite crystals suggests that highly saline F were entrapped below ~50°C and subsequently reequilibrated (by leakage and refilling or by recrystallization). A possible model responsible for the dolomitization involves refluxing of brines followed by reequilibration of I by warm brines migrating crationward from the Anadarko Basin. (Authors' abstract)

BERGSTRÖM, S.M., HUFF, W.D., KOLATA, D.R. and BAUERT, H., 1995, Nomenclature, stratigraphy, chemical fingerprinting, and areal distribution of some Middle Ordovician K-bentonites in Baltoscandia: GFF, v. 117 (part 1, March), p. 1-13.

Thus far, only one of the many Baltoscandic ash beds, the Kinnekulle K-bentonite, has been correlated to North America, but investigation of MI chemistry in quartz phenocrysts may lead to trans-Atlantic recognition of additional beds. (From authors' abstract by H.E.B.)

BETTISON, V.L., SCHIFFMAN, Peter and JANECKY, D.R., 1995, Fluid-rock interaction in the hydrothermal upflow zone of the Solea Graben, Troodos Ophiolite, Cyprus: Geol. Soc. Am., Spec. Paper 296, p. 81-100.

Indexed under FI. (E.R.)

BEURLEN, Hartmut, SAMPAIO, Adriana and da SILVA, M.R.R., 1995, Estudo de inclusões fluidas do pegmatito berilífero do Sítio Exu, Altinho-PE, Brasil: Rev. Esc. de Minas, Ouro Preto, v. 49, no. 2, p. 142-145 (in Portuguese, English abstract).

Microthermometric measurements were carried out on FI in quartz of different zones and aquamarine of the Sítio Exu pegmatite, Altinho County in the State of Pernambuco, Brazil. The freezing and heating behaviour of the supposedly P FI revealed it to be statistically the same for different host minerals and for the different zones of the pegmatite and the same as observed in clearly SI disposed along sealed fractures, diagonal to the C-axis of the beryl. It is thus supposed that all P FI reequilibrated with the F that formed the S FI in beryl, during the cooling of the already crystallized pegmatite and/or its deformation.

A density of 0.72 (homogenization at ±294°C), low salinity of 5.5 wt % NaCl eq. and 25 to 39 mol % CO_2 characterize this F. Up to seven different dms may occur in the beryl-hosted P FI, but all of them remained insoluble ≤450°C, indicating an origin as crystallized melt rather than as true dms. (Authors' abstract)

BICKLE, M.J., CHAPMAN, H.J., WICKHAM, S.M. and PETERS, M.T., 1995, Strontium and oxygen isotope profiles across marble-silicate contacts, Lizzies Basin, east Humboldt Range, Nevada: Constraints on metamorphic permeability contrasts and fluid flow: Contrib. Mineral. Petrol., v. 121, p. 400-413.

BIERLEIN, F.P., PLIMER, I.R. and ASHLEY, P.M., 1995, An integrated model for sulphide mineralisation in the Willyama Supergroup, South Australia: *in* Pasava, Křìbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 31-34. First author at School of Earth Sciences, Univ. Melbourne, Vic., Australia.

Metasediments of the multi-deformed Proterozoic Willyama Supergroup in the Olary Block, South Australia, are host to a diversity of syndepositional, diagenetic, metamorphic and epigenetic sulphide deposits. Combined petrographic, structural and geochemical evidence suggest that intermittent tectonic disturbances induced seismic pumping and subsequent mobilisation of ore components from a deep-seated crustal reservoir since the Mid-Proterozoic. Whilst the Olary Block, which is contiguous with the Broken Hill Block, does not appear to host significant stratiform Pb-Zn-Ag mineralisation, it might have considerable potential for high-grade veined Cu-Au deposits and Mt. Isa-style epigenetic Cu mineralisation. (Authors' abstract)

Mineral assemblages, sulphide-wallrock reaction textures, REE patterns, trace element geochemistry and FI point to multi-stage deposition of epigenetic sulphides at 225°-375°C from hypersaline CO_2-CH_4-bearing F characterised by near-neutral pH values and variable fO_2 and aS_2. (From authors' text by E.R.)

BIERMAN, Paul, GILLESPIE, Alan, CAFFEE, Marc and ELMORE, David, 1995, Estimating erosion rates and exposure ages with ^{36}Cl produced by neutron activation: Geochim. Cosmochim. Acta, v. 59, p. 3779-3798. First author at Dept. Geology, Univ. Vermont, Burlington, VT 05401.

The isotopic composition of water-soluble Cl, extracted from mineral grains in granitic rocks, appears to reflect the relative age of debris-flow fan surfaces and the erosion rate of bedrock outcrops. Our data indicate that some granitic landforms are stable landscape elements eroding on the order of meters to tens of meters per million years. Samples collected from debris-flow fan surfaces of three distinct relative ages show the expected increase of model age with time but the ^{36}Cl-exposure ages for boulders on any particular surface vary by a factor >5.

The method we used for extracting Cl was designed to isolate the $^{35}\mathrm{Cl}\ (n, \gamma)\ ^{36}\mathrm{Cl}$ production pathway and to simplify the chemical preparation of samples. Such isolation from FI allows direct interpretation of measured ^{36}Cl/Cl ratios but requires a model to predict the thermal-neutron production and absorption profile below the rock surface. Using such a model, we find good agreement between ^{36}Cl/Cl for eight samples collected below the ground surface as well as consistency between several groups of samples collected near one another. Using elemental abundance data for 129 granitic rocks, we modeled ^{36}Cl/Cl supported by radiogenic neutrons and find that it varies from 4 to 125×10^{-15} (mean — 21 ± 18, 1σ). However, from the surface to a depth of 10 m, thermal neutrons resulting from muon interactions have the potential to generate more ^{36}Cl than do radiogenic neutrons. The production of ^{36}Cl in the subsurface has important implications for surface-exposure dating of young, low-altitude samples collected from moraines and debris-flow or alluvial fans, especially at ages where erosion of the boulder surface is significant or where the source area for boulders is at altitudes much higher than the landform to be dated. (Authors' abstract)

BJERG, E.A., LABUDIA, C.H., VARELA, M.E. and CESARETTI, N.N., 1995, Fluid inclusions in olivine crystals from spinel lherzolite nodules, Somoncura Massif: Revista de la Assoc. Geol. Argentina, v. 50, p. 257-261 (in Spanish). Authors at Consejo Nacional de Investigaciones Cientificas y Técnicas, Univ. Nacional del Sur, San Juan 670, 8000 Bahía Blanca, Argentina.

This paper presents the preliminary results of petrographic and microthermometric studies on spinel lherzolites from Lenzaniyeu area, Somoncura Massif, Argentina. (From authors' text by E.R.)

BJØRLYKKE, A. and ETTNER, D.C., 1995, Geology, fluid geochemistry, and genesis of gold and copper mineralization at the Bidjovagge deposit, Finnmark, northern Norway (abst.), *in* P.M. Ihlen, M. Pedersen and H. Stendal, eds., Gold Mineralization in the Nordic Countries and Greenland, Symp. held at Geological Inst., Univ. Copenhagen, 19-20 Oct. 1995, Volume of Extended Abstracts: Geol. Surv. Greenland Open File Series 95/10, p. 16-19.

BJØRLYKKE, Knut, 1994, Fluid-flow processes and diagenesis in sedimentary basins, *in* J. Parnell, ed., Geofluids: Origin, Migration and Evolution of Fluids in Sedimentary Basins: Geol. Soc. (London) Spec. Publ. No. 78, p. 127-140. Author at Dept. Geology, Univ. Oslo, 0316 Oslo 3, Norway.

Flow of F in sedimentary basins causes transport of heat and dissolved mass and is therefore potentially important in relation to diagenetic reactions. Rather large F fluxes are required, however, for this type of transport to be significant in terms of dissolution and precipitation of minerals. Before diagenetic processes are attributed to pore water flow, semi-quantitative calculation of flow rates and duration of flow should be attempted.

Heat flow in sedimentary basins is normally dominated by conduction, except on a local scale. The upwards pore water flux due to compaction is on average smaller than the subsidence rate, and the thermal anomalies caused by compaction are moderate in modern basins. Dissolution and precipitation of minerals which are in equilibrium with the pore water occur when the flow is oblique relative to the isotherms. Due to the low solubility/T gradient of the common silicate and carbonate minerals, very large fluxes of pore water are required to transport significant volumes of mass in solution. The greatest potential for transporting solids and creating secondary porosity is during meteoric water flow, because the flow rate then may be several orders of magnitude higher than what is typical for compaction-driven flow. Quartz overgrowth corresponding to 3% of the rock volume requires a total flow of 10^8 cm^3 cm^{-2} if the silica is introduced by vertical compaction-driven flow from a source outside the sandstone. Pore water flow precipitating quartz due to cooling will dissolve carbonate cement at a much higher rate. An external import of silica through the flow of water would be expected to cement up the most permeable pathways, such as fractures and well-sorted permeable sand beds. In the case of carbonate cement the solubility gradient is negative and upwards flowing and cooling pore water would cause dissolution rather than precipitation. Also in the case of carbonate rocks, large-scale mass transfer such as dolomitization is easier to explain as occurring at relatively shallow depths rather than during deeper burial.

Ore minerals like galena have a steep solubility/T gradient, but concentrated precipitation requires rapid cooling of hot water. Such conditions are most likely to be met when hot F are cooled near the surface. (Author's abstract)

BLACKWELL, Singoyi and KHIN, Zaw, 1994, Mineral paragenesis, fluid inclusion and oxygen isotope studies of the magnetite-scheelite skarn deposit, Kara, northwestern Tasmania (abst.), *in* D.R. Cooke and P.A. Kitto, eds., Contentious Issues in Tasmanian Geology: A Symposium: Geol. Soc. Australia, Tasmania Div., Abstracts, no. 39, p. 119-120. Authors at CODES Key Centre, Univ. Tasmania, GPO Box 252C, Hobart 7001, Australia.

FI microthermometric measurements have been undertaken for garnet, vesuvianite, quartz, calcite, fluorite and scheelite. Four major I types in the skarn minerals are recorded. Type I: P L-V inclusions with low L/V ratios; Type II: P L-V inclusions with high L/V ratios; Type III: P L-V-unidentified dms; and Type IV; S L-V inclusions with variable L/V ratios. The measurements reported for the different stages of skarn formation are from Type I-III FI. Stage I had Th of 464°-585°C (mode 525°C) from garnet and clinopyroxene. Stage II gave Th ranging from 349° to 600°C (mode 500°C) from vesuvianite and early scheelite. stage III minerals formed at T of 326°-359°C (mode 350°C) from quartz. Th for Stage IV (as revealed by scheelite, fluorite and calcite) varied from 233° to 342°C (mode 300°C) with a corresponding salinity of 10.0-11.0 eq. wt % NaCl. Quartz in the granite reveal Th >565°C.

O isotope measurements on Stage II scheelite (n = 2) yielded $\delta^{18}O$ values of 5.6‰ while those of the stage IV scheelite (n = 1) had a $\delta^{18}O$ value of 5.8‰. The Stage II and IV magnetite grains (n = 2) had $\delta^{18}O$ values of 3.5‰ and 4.7‰, respectively. O isotopic composition of ore F calculated using a theoretical scheelite-H_2O fractionation equation of Wesolowski et al. (1986) gave $\delta^{18}O$ value = 9.6‰ (500°C) and $\delta^{18}O$ value = 7.2‰ (300°C) for the Stage II and IV ore F, respectively. The ore $\delta^{18}O_{fluid}$ values of 7.2 to 9.6‰ from scheelite compare well with scheelite ore $\delta^{18}O_{fluid}$ values of 6 to 10‰ for the King Island scheelite deposit (Wesolowski et al., 1986) and 7 to 10 for the Glenorchy Au-W-Sb mineralisation, New Zealand (Paterson, 1982). These $\delta^{18}O$ values are consistent with a magmatic source for the ore F.

Mineral paragenesis, FI and O isotope studies indicate that magnetite-scheelite mineralisation at Kara was formed as a proximal skarn assemblage in carbonate host rocks from magmatic hydrothermal F derived from the nearby granitoid source. Skarn formation and ore deposition occurred in stages. The garnet-clinopyroxene skarn assemblages deposited at >525°C, representing early anhydrous prograde metasomatism, and were overprinted by hydrous mineral assemblages containing magnetite and scheelite at T of 500°-300°C and sal. of 10.0-14.0 eq wt % NaCl. (From authors' abstract by H.E.B.)

BLIZNAKOV, L.B., 1995, Types of geological environments and physico-chemical conditions of gold-ore and gold-bearing endogenic deposits formation in the East Rhodope ore region: Geol. Soc. Greece, Sp. Publ., No. 4, p. 671-676.

FI data are presented and related to ore paragenesis. (H.E.B.)

BOBIS, R.E., JAIRETH, Subhash and MORRISON, G.W., 1995, The anatomy of a Carboniferous epithermal ore shoot at Pajingo, Queensland: Setting, zoning, alteration, and fluid conditions: Econ. Geol., v. 90, p. 1776-1798. Authors at Gold Research Group, Geology Dept., James Cook Univ. North Queensland, Townsville, Queensland 4811, Australia.

The Paleozoic Scott lode Au-Ag epithermal deposit shows six principal types of alteration assemblages which are zoned with respect to the main vein structure: propylitic, potassic (adularia), intermediate argillic, silicic, kaolinitic, and ferroan carbonate.

Economic mineralization at the Scott Lode deposit was laid down from dilute F (0.7-2.5 wt % NaCl eq.) with a very low concentration of CO_2. Th of 170° to 315°C exhibit vertical variation with higher T at greater depth. The presence of coexisting L- and G-rich I in mineralized quartz, together with adularia, vein brecciation, and pronounced crustiform-colloform banding, indicates hydrothermal boiling as the principal precipitation mechanism for Au and Ag deposition. Thermodynamic modeling of adiabatic boiling of a F with an initial concentration of 2 to 5 ppb Au at 300°C indicates that such a F can deposit ores containing 10 ppm Au and 260 ppm Ag at the T intervals recorded by the FI work.

The $\delta^{18}O$ values of the F in equilibrium with the vein quartz, calculated from the quartz $\delta^{18}O$ values and median Th lie within the range -7.0 to -1.0‰. The δD values of F extracted from PI in quartz range between -59.5 and -64.9‰. The compositions of altered rocks show significant depletion in O and deuterium which can be attributed to isotopic reactions with meteoric water. Isotopic calculations indicate that meteoric water of a composition $\delta^{18}O$ = -12‰ and δD = -86‰ alone cannot explain the observed values. It is suggested that the epithermal F in Pajingo was the result of mixing between meteoric water and isotopically magmatic water. (From authors' abstract by E.R.)

BODNAR, R.J., 1995a, Experimental determination of the PVTX properties of aqueous solutions at elevated temperatures and pressures using synthetic fluid inclusions: H_2O-NaCl as an example: Pure and Appl. Chem., v. 67, no. 6, p. 873-880.

An excellent review of the application of the Synthetic Fluid Inclusion Technique to determine isochores, critical properties, freezing-point depression, NaCl solubility, and L-V and L-solid phase equilibria in the H_2O-NaCl system over a wide range of PTX conditions. (From author's abstract by E.R.)

BODNAR, R.J., 1995b, Fluid-inclusion evidence for a magmatic source for metals in porphyry copper deposits: Mineral. Assoc. Canada Short Course, v. 23, p. 139-152. Author at Fluids Research Laboratory, Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

The characteristics of magmatic FI in porphyry Cu deposits show great variation in composition (salinity) and Th, depending on the depth of emplacement of the magma and the stage during crystallization at which the F are trapped. Consequently, it is not always possible to identify FI as being of magmatic origin solely on the basis of I characteristics. Although economic mineralization in porphyry Cu deposits is generally not associated with early alteration, FI in the early veins contain significant amounts of ore metals. As these veins were formed from magmatic F before the incursion of wallrock-sourced meteoric F into the pluton, the metals in the I could not have been derived by leaching of wallrocks by meteoric F. Thus, although the wallrock-derived F play an important role in the genesis of porphyry Cu deposits by cooling and diluting the magmatic F, the wallrock-derived F may not have contributed metals to the ore systems. (Author's summary)

BODNAR, R.J., 1995c, Synthetic fluid inclusion studies of phase equilibria and PVT properties in the H_2O-CO_2-NaCl system (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 26-27. Author at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Recent experimental data obtained using the synthetic FI technique are summarized and the differences rationalized. (E.R.)

BOER, R.H., MEYER, F.M., ROBB, L.J., GRANEY, J.R., VENNEMANN, T.W. and KESLER, S.E., 1995, Mesothermal-type mineralization in the Sabie-Pilgrim's Rest gold field, South Africa: Econ. Geol., v. 90, p. 860-876. First author at Economic Geology Res. Unit, Univ. Witwatersrand, Johannesburg 2050, South Africa.

We describe here a different class of mesothermal Au deposit at Sabie-Pilgrim's Rest which is probably associated with the Bushveld igneous event in South Africa. P and T estimates estimate that the ore F of the Sabie-Pilgrim's Rest Au field were similar to those of mesothermal Au deposits. However, a number of features distinguish the Sabie-Pilgrim's Rest ores from typical mesothermal deposits: (1) the presence of ubiquitous Cu and Bi in addition to Au, Ag, As, and Sb; (2) high salinities (mean ≈12 wt % NaCl eq.); (3) low mean bulk CO_2 content (≈5 mol %); (4) veins largely hosted within a platform carbonate sequence; and (5) mineralization along both vertical and horizontal (stratiform) veins, showing a clear genetic link. Characteristic features of the Sabie-Pilgrim's Rest Au field that correspond to those within the above spectrum of mesothermal Au deposits include: (1) comparable light stable isotope (δD, $\delta^{18}O$, $\delta^{34}S$) ranges, together with a lack of isotopic evidence for meteoric water involvement; (2) high Au/Ag ratios; (3) presence of ore shoot structures, which are highly characteristic of mesothermal Au deposits; (4) variably deformed structures within individual sheeted veins which point toward cyclic opening and quartz accretion events separated by episodes of deformation; and (5) FI properties which indicate high F P during entrapment. (From authors' abstract by E.R.)

Includes many Th CO_2 determinations for various mines, ranging from 0 to 29°C, and 20 quadrupole MS analyses of gases, from crushing, for nine components. H_2S = 0.003 to 0.025, and SO_2 0.0005 to 0.009 mol %. Gases decrepitated from with Au grains yielded widely variable CO_2/H_2O ratios, presumably indicating F immiscibility during Au precipitation. (E.R.)

BOER, R.H., REIMOLD, W.U. and KESLER, S.E., 1995, Conditions of gold remobilization in the Ventersdorp Contact Reef, Witwatersrand Basin: Proc. Symp. Economic Significance of Metamorphism and Fluid Movement within the Witwatersrand Basin, Econ. Geol. Research Unit Info. Circ. 296, p. 3-8. First author at Dept. Geology, Univ. Witwatersrand, Johannesburg, South Africa.

Detailed analysis of the F preserved in the auriferous and uraniferous Precambrian oligomictic conglomerates of the Ventersdorp Contact Reef (VCR) provide a unique insight into the conditions under which the ores formed. This investigation deals with FI occurring within footwall and hanging-wall quartzites, hydrothermal quartz and quartz-carbonate veins, the matrix of VCR conglomerate, and pseudotachylite samples from the VCR fault zone on Vaal Reefs and Elandsrand Mines in the Klerksdorp and West Wits Line Au fields. No attempt was made to characterize the numerous FI populations within the quartz pebbles. (From authors' abstract by E.R.)

BOIRON, M.C., BARAKAT, A., CATHELINEAU, M., DURISOVÁ, J. and MORÁVEK, P., 1995, Microfissural ore fluid migration: The example of a granodiorite hosted gold deposit (Mokrsko, Bohemia): *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 97-100. First author at GS CNRS-CREGU, Vandoeuvre-les-Nancy, France.

Study of 3D geometry characteristics and PVTX conditions of ore F migration in the Mokrsko deposit which represents the largest Au deposit in the Bohemian Massif shows that ores result from the superimposition of three main stages of fissural F migration through dense and regular networks of extensional structures (veinlets and microfissure networks). (Authors' abstract)

FI study was carried out on P and SI in the quartz veinlets and granodiorite ["FIP" presumably refers to "fluid inclusion planes," but the distinction between secondary inclusions and "FIP" is unclear] where the following succession of F has been determined:

(i) CO_2-CH_4 ± N_2-H_2O-NaCl F linked to the first stage of veinlet infilling (mineralizing event with quartz-arsenopyrite (Au)). They are found as PI in the veinlet quartz and in secondary S FI in FIP from the granodiorite (healed microfissures affecting the magmatic quartz grains). Tm CO_2 are in the range of -56.6° to -58.1°C (mode ~-57.5°C). Tm cl in the range of 6 to 9°C (mode ~7.5°C) and Th CO_2 in the range of 16 to 30°C (mode ~28°C). Minimal Tt (Th) are ~330 ± 20°C. There is very little difference between the data obtained on similar F generations from the Mokrsko and Celina deposit. Bulk composition obtained from microthermometry and Raman data show that CO_2 is the major volatile component.

(ii) Less dense CO_2-CH_4 ± N_2-H_2O-NaCl F in sub-EW FIP networks affecting both quartz veinlets and quartz grains from the granodiorite. Water content is significantly lower than in type (i).

(iii) Low salinity aqueous F: they are trapped in NS-N30°E FIP networks. Minimal Tt (Th) is in the range of 140 to 300°C (modes at 200°C, 290°C) and Tm(ice) range from -0.5 to -6.0°C (mode ~-1.5 and -4.5°C) corresponding to salinities in the range of 1 to 9 wt % NaCl eq.

The study of FI shows clearly a progressive decrease in salinity and Tt. (From authors' text by E.R.)

BOIRON, M.C., DUBESSY, J., MOISSETTE, A., GEERTSEN, C., BANKS, D.A., PRIETO, A.C., LACOUR, J.L. and MAUCHIEN, P., 1995, Elemental analysis of individual aqueous inclusions. Part I: New developments using micro laser ablation optical emission spectroscopy (MLA-OES) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 28-29. First author at CREGU, BP 23 - 54501 Vandoeuvre-lès-Nancy Cedex, France.

Recent developments using a prototype apparatus shows that accurate estimations of ratios between major ions will soon be possible. LA-OES is based on a time-resolved analysis of the emission from atoms present in a plasma produced by a laser pulse. Synthetic FI containing Na, K, Ca, Mg and Li have been prepared; the crushleach procedure (Banks and Yardley, 1992) was used for control. The limits of detection are estimated to be ~20 ppm for Na and 100 ppm for K. The ablation is strongly localized, and does not vaporize the F of the opened I since it was possible to record spectra even after 20 laser shots in the same I. MLA-OES appears to be a powerful localized analytical method for trace elements at the ppm level. Alkaline, calco-alkaline elements, metal elements and REE are good candidates for this method but Cl, S bearing species and O cannot be identified. MLA-OES will complement LA-ICP-MS and vice versa, since they give the best accuracy for complementary elements. (From authors' abstract by E.R.)

BOROVIKOV, A.A., 1995, Physical-chemical conditions and chief factors affecting silver-antimony and tin-tungsten ore formation in the Bazardarinsk deposit of SE Pamir: Unpubl. dissertation, 233 p. plus 20 tables, 46 figures, and 134 reference. Abstracted by David A. Vanko from 23-page dissertation précis, in Russian, published by Geol. Inst. SO RAN, Novosibirsk, CIS.

The Bazardarinsk deposit is located in SE Pamir, a region that is part of the Alpine-Himalayan tectonic belt. The deposit is typical of Ag-Sb and Sn-W deposits that occur worldwide. Nearly 1500 m of erosional relief allow sampling of the ore as well as the underlying and overlying hydrothermal deposits, leading to a broad genetic model for this type of mineralization. The focus of the study is the chemical composition of FI occurring in quartz, carbonates, fluorite, barite, and others. X-ray microanalysis of selected I involves decrepitation (by heating) of near-surface I and subsequent microprobe analysis of salt residues left on the sample surface.

Results indicate that (1) Ag-Sb ores formed from 220°C to 150°C from a highly concentrated (10-34 wt % NaCl + KCl + $CaCl_2$ + $FeCl_2$) solution containing CH_4, N and CO_2; (2) Sn-W ores formed at 350-280°C from 1.5-19 wt % NaCl + KCl + $CaCl_2$ + $FeCl_2$ solution containing CH_4, N and CO_2; (3) Ag-Sb ore F contained Fe ≤62 g/kg and Ag, Mn and Cu ≤1 g/kg each; (4) Sn-W ore F contained ≤19 g/kg Fe, 1.5 g/kg W and 2.6 g/kg Cu; (5) Ag-Sb ores formed during a decrease in T and Cl content of the F; (6) Sn-W ores formed during a T decrease and O fugacity increase; (7) the conditions for ore formation indicate mixing of concentrated metal-rich solutions with low-salinity F of external origin.

BORTNIKOV, N.S., 1995, Mineralogy, geochemistry, and origin of the black shale hosted gold deposits of the former Soviet Union: *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 935-937. Author at IGEM, Russian Acad. Sci., Moscow, Russia.

Common geological, mineralogical, and geochemical characteristics of the principal mesothermal Au deposits of ex-USSR (Charmitan, Nezhdaninskoye, Sentachan, Olympiada, etc.) are considered. The results of the mineral paragenesis, FI and stable isotope studies support the concept on dual origin of mineral-forming F related to magmatism and contact metamorphism events. (Author's abstract)

Minerals generally contain H_2O-rich and CO_2-rich gaseous I with Th in a range or 450 to 170°C. Salinity span a range of 1.5 to 28.7 wt % NaCl eq. Mole percentages of CO_2 are estimated to range ≤30%. Minor amount of CH_4 and N_2 have been identified. P estimates indicate the values of 0.8 to 2.7 kb, generally 1.2 kb. Late mineral assemblages contain the H_2O-NaCl I with salinity ≤15 wt % NaCl eq. [Only literature data cited.] (From authors' text by E.R.)

BORTNIKOV, N.S., DOBROVOL'SKAYA, M.G. and GENKIN, A.D., 1995, Sphalerite-galena geothermometers: Distribution of cadmium, manganese, and the fractionation of sulfur isotopes: Econ. Geol., v. 90, p. 155-180. First author at Inst. Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Russian Acad. Sci., 35 Staromonenty per., Moscow 109017, Russia.

Distribution of Cd and Mn, fractionation of S isotopes between coexisting galena and sphalerite, and filling T [of FI] in sphalerite have been studied as a test of sphalerite-galena geothermometers in samples from >30 deposits.

The Tf of a large number of sphalerite-galena pairs, estimated on the basis of the Cd distribution, range from 320° to 370°C. These values tend to be ~40° to 100°C higher then the filling T. The observed differences are considered to lie within the P correction values for FI, and a reasonable assumption is that there is good agreement between galena-sphalerite Cd T and filling T of FI for the studied samples. The Cd galena-sphalerite geothermometer gives reliable T for high-T assemblages (>250°C). Its applicability for low-T deposits is doubtful. The assumption that coexisting sphalerite and galena equilibrated with respect to Cd distribution at the majority of deposits studied seems to be reasonable.

Several samples studied gave a good agreement between T based on Mn distribution and those estimated from filling and the Cd galena-sphalerite geothermometer. However, most of the samples gave rather unreliable T. From these results it is concluded that geothermometry based on Mn distribution between galena and sphalerite is not useful.

The isotopic sphalerite-galena geothermometer yielded T ranges from 90° to 690°C. Approximately 30% of the samples gave unrealistic values. (From authors' abstract by E.R.)

BOUDREAU, A.E., 1995, Fluid evolution in layered intrusions: Evidence from the chemistry of the halogen-bearing minerals: Mineral. Assoc. Canada Short Course, v. 23, p. 25-45.

Shows a plot of literature data on Cl-F-OH of apatites from many localities (Fig. 2), indicating major differences between localities. Pertinent to the composition of residual F. (E.R.)

BOYCE, A.J., FALLICK, A.E., MUNOZ, M., TOLLON, F., COURJAULT-RADÉ, P. and BANKS, D., 1995, Fluid studies of the base-metal and fluorite deposits in the Montagne Noire, SW France: Evidence for the genetic influence of basinal brines: *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 337-340. First author at Isotope Geosciences Unit, SURRC, East Kilbride, Glasgow, UK.

The Saint-Salvy Zn, Peyrebrune Zn+F and Mont Roc F deposits represent a spectrum of vein mineralization hosted in the Palaeozoic basement of the SW Massif Central. Paragenetically these deposits are linked, and our F chemistry studies emphasise this connection. In all deposits there is a history of multi-stage F incursion, but the F responsible for mainstage mineralisations were high salinity (20-25 wt % NaCl eq.) and low-moderate T (Th ranging 100-170°C). All were $CaCl_2$-bearing. In addition, ore F have halogen contents indicative of F in equilibrium with evaporites. $\delta^{18}O$ and δD analyses indicate that the F were variably evolved meteoric waters, and, in the case of the Saint Salvy and Peyrebrune deposits, an organic H contribution is suggested by very low δD (~-95‰). Ore F were probably meteoric waters which interacted with evaporite- and hydrocarbon-bearing sequences in the adjacent Mesozoic Aquitain Basin. (Authors' abstract)

BRANDRISS, M.E., NEVLE, R.J., BIRD, D.K. and O'NEIL, J.R., 1995, Imprint of meteoric water on the stable isotope compositions of igneous and secondary minerals, Kap Edvard Holm Complex, East Greenland: Contrib. Mineral. Petrol., v. 121, p. 74-86.

BRANNON, J.C., COLE, S.C., PODOSEK, F.A. and MISRA, K.C., 1995, Radiometric dating of ancient calcite: Th-Pb and U-Pb isochrons for ore-stage and late-stage calcite from the central Tennessee zinc district, an Appalachian-Ouachita age MVT deposit (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 118.

Indexed under FI. (E.R.)

BRATHWAITE, R.L. and BLATTNER, P., 1995, The Waihi epithermal gold-silver-quartz vein system, New Zealand: A high-throughput geothermal system of Late Miocene age: PACRIM '95, p. 75-80. Authors at Inst. Geological and Nuclear Sciences, Lower Hutt, New Zealand.

The Late Miocene Au-Ag bearing epithermal system at Waihi has some close similarities in its paleo-thermal and -geochemical structure with modern, volcanic-hosted geothermal systems such as Ohaaki-Broadlands. FI studies indicate that the main stage quartz was deposited at 189°-273°C from dilute (Tm of -0.1 to -1.0°C) F that were locally boiling. Th versus Tm data points lie within the field enveloped by dilution and boiling/G loss paths determined for the Ohaaki geothermal field, and indicates that the parent hydrothermal F for the Waihi epithermal system had a similar composition to that at Ohaaki, i.e., 0.2 wt % eq. NaCl and 3.3 wt % eq. CO_2. The hydrothermal alteration mineralogy and the isotopic composition of vein calcite indicate that the hydrothermal F contained relatively high concentrations of CO_2, as at Ohaaki. O isotope analyses of main stage quartz range from 6.1 to 11.6‰ and of vein calcite from 2.29 to 9.4‰. Calculated $\delta^{18}O_{water}$ values for the hydrothermal F that deposited the main stage quartz range from -2.0 to -5.7‰, with a trend to less negative values with depth. They are similar to those in the deep chloride F in active geothermal systems with a substantial F throughput. A high F throughput at Waihi system is also evident from the extensive high intensity hydrothermal alteration and large volume of quartz deposited in the vein system. (From authors' abstract by E.R.)

BROMAN, C., BERGSTRÖM, U. and LINDBLOM, S., 1995, Fluid evolution in gold-bearing quartz veins associated with feldspar porphyry dikes at Vinliden in the Skellefte District, northern Sweden: GFF, v. 117 (part 4, Dec.), p. 233-244. First author at Dept. Geology and Geochemistry, Stockholm Univ., S-106 91 Stockholm, Sweden.

The Vinliden Au mineralization is located in the NW part of the Skellefte District in northern Sweden. The mineralization consists of a number of Au-bearing quartz veinlets in a greywacke sequence. The quartz veins have been emplaced in small-scale second order fault and shear zones within one of the major fault structures, which transects the folded supracrustal pile in the Skellefte District. The Vinliden Au occurrence is spatially related to feldspar porphyry dikes which have intruded the greywackes. Alteration zones with albite or sericite surround the quartz veinlets. The mineralization also includes a sulfide assemblage dominated by arsenopyrite and pyrrhotite.

Aqueous and carbonic (CO_2-CH_4) FI in the quartz veinlets indicate initial deposition of quartz and an early generation of arsenopyrite >400°C in association with a P drop from 5 to 1 kb. Secondary fracturing opened passageways and allowed F P to adjust to hydrostatic conditions of c. 0.5 kb, and subsequent sulfide and Au deposition occurred from a low salinity H_2O-NaCl-CO_2-CH_4 F at ~350-400°C, accompanied by phase separation (boiling).

In a post-mineralizing stage, and after further fracturing of the quartz vein system, large volumes of a N_2-CH_4 F (generated in the greywacke sediments) were introduced together with a brine with a complex $CaCl_2$-rich salt composition. Finally, a low to moderately saline aqueous solution filled larger cracks with calcite. The proposed F evolution X-P-T model at the Vinliden Au mineralization appears to be of regional significance and may be a distinct parameter for further comparisons in the Skellefte Districts as a whole. (Authors' abstract)

BROOKER, Murray and JAIRETH, Subhash, 1995, Mount Rawdon, southeast Queensland, Australia—A diatreme-hosted gold-silver deposit: Econ. Geol., v. 90, p. 1799-1817. Authors at James Cook Univ.., Townsville, Queensland 4810, Australia.

A high tonnage-low grade Au deposit is hosted by a diatreme emplaced into metasediments and bodies of Briggs Creek Granodiorite. Premineralization alteration within the diatreme is associated with intrusions and consists of phyllic and propylitic assemblages generated by dacite porphyries, crosscut by trachyandesites with propylitic alteration and trachytes with weak illite-smectite alteration. Sericitic alteration is centered on a sparsely porphyritic dacite plug forming an apophysis to the central dacite and overprints propylitic alteration in it and in the fragmental units. Sericitic alteration is overprinted by silica-pyrite and chlorite alterations. The chloritic alteration is intimately associated with mineralization.

FI in calcite indicate that mineralization took place from low- to moderate-salinity F (0.2-12 wt % NaCl eq.) which were undergoing boiling between 220° and 370°C. A limited number $\delta^{18}O$ and D analyses of the altered rocks and the vein carbonate suggest that the ore-forming F had seen some mixing of magmatic and meteoric waters. (From authors' abstract by E.R.)

BROWN, P.E. and HAGEMANN, S.G., 1995a, MacFlinCor and its application to fluids in Archean lode-gold deposits: Geochim. Cosmochim. Acta, v. 59, p. 3943-3952. Authors at Dept. Geology and Geophysics, Univ. Wisconsin, Madison, WI 53706.

MacFlinCor was developed to process laboratory data gathered on FI and to calculate isochores for geologically important F composed of H_2O, CO_2, CH_4, NaCl and N_2. Within the program, interactive diagrams are available to describe those chemical systems which cannot be adequately constrained numerically. The user can choose from various published equations of state describing F behavior and can easily compare the results obtained by using different equations.

The program, once the basic F parameters have been established, allows the data to be used to determine the P-T trapping conditions, to evaluate possible P corrections and to compare different depths of formation based on the P calculations and given geothermal gradients.

For illustrative purposes, MacFlinCor has been utilized here to constrain different physical-chemical parameters of FI trapped in ore-related quartz veins and breccias of Archean lode-Au deposits in Western Australia. Inferred P from individual deposits show a wide range of values which may be due to post-entrapment modifications and/or observational uncertainties including estimation of L-V ratios. (Authors' abstract)

See also next item and FIR, v. 27, p. 17.

BROWN, P.E. and HAGEMANN, S.G., 1995b, Fluid inclusion data reduction and interpretation using MacFlinCor on the Macintosh (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 32-33. Authors at Dept. Geology and Geophysics, Univ. Wisconsin-Madison, Madison, WI 53706.

MacFlinCor was developed to process laboratory data gathered on FI and to calculate P-T isochores for geologically important F composed of H_2O, CO_2, CH_4, N_2, and salts (Brown and Hagemann 1994; 1995). Within the program, interactive diagrams are available to describe those chemical systems which cannot be adequately constrained numerically. The user can choose from among multiple published equations of state describing F behavior and can easily compare the results obtained by using different equations. Once the basic F parameters are established, the pro-gram allows the data to be manipulated to permit the determination of, for example, P-T conditions or the evaluation of P corrections.

The most complicated system that can be approximately modeled using experimental phase equilibria is (H_2O-CO_2-CH_4-NaCl). It is not possible to calculate numerically the CH_4 content of the carbonic phase in an I—this must be done graphically. (From authors' abstract by E.R.)

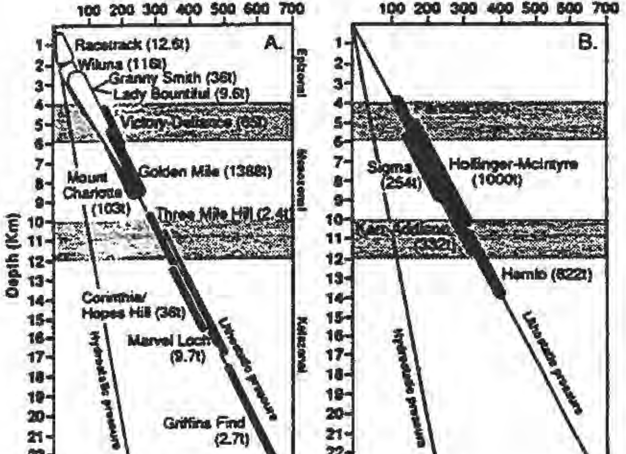


Figure 1. P-depth conditions of Archean epi- meso- and katazonal lode-Au deposits from the Western Australian Yilgarn Craton (A) and Superior Province in Canada (B). Depths for deposits were estimated using ranges of P from isochores. Lithostatic and hydrostatic lines assume P gradients of 33 and 100 m/MPa. Note that for the epizonal Au deposits, P may vary between litho- and hydrostatic values; for meso- and katazonal deposits constant lithostatic P are assumed. The ranges given indicate the uncertainties of estimation. The gray bands indicate the assumed transition zone between the different crustal levels.

See also previous items. (E.R.)

BROWN, P.E. and HAGEMANN, S.G., 1995c, Geobarometry and depth relations in Archean lode-gold deposits (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 30-31. Authors at Dept. Geology and Geophysics, Univ. Wisconsin-Madison, Madison, WI 53706.

The depth of mineralization for Archean lode-Au deposits from the Yilgarn Craton in Australia and the Superior Province in Canada has been estimated from published data and new FI measurements (Fig.).

This study confirms that Archean lode-Au deposits in Western Australia formed over a remarkable range of crustal depths. One reason for the apparent disparity between the two Archean terrains might be the lack of detailed FI studies, hence lack of geobarometric data, conducted in deep and shallow level deposits. The apparent lack of giant lode-Au deposits at epi- and katazonal depth levels could be related to a variety of factors. (From authors' abstract by E.R.)

See also previous item. (E.R.)

BROWN, W.L. and OHNENSTETTER, D., 1995, Compositional zoning in pyroxenes in glassy boninites (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-11. Authors at CRPG-CNRS, BP 20, 54501 Vandœuvre-lés-Nancy Cedex, France.

During ideal fractional crystallization, chemical zoning in minerals develops through epitaxial overgrowth of successive zones in some or all of the minerals. Local equilibrium is assumed to exist at the crystal/L interface and also within the L, but not in the zoned crystals, because cooling is assumed to be fast enough to avoid significant diffusion in the crystals. No account is taken of the size or disposition of the crystal interfaces nor of the time required for diffusional homogenization of the L, especially at progressively lower T. Ideal fractional crystallization thus operates in chemographic space and not in real space. Chemical zoning in minerals of volcanic rocks, on the other hand, is produced by more or less disequilibrium growth and can always be considered to be preserved, at least on the µm scale of interest to igneous petrologists, if not on the nm scale. At T drops, diffusion in the L does not remain fast enough to maintain chemical homogeneity in the L, so that the detailed geometry of crystal shapes and textures become important. Thus the L in contact with one face of a mineral may differ in composition from that in contact with another face and a fortiori, with a different mineral or in MI in minerals.

Zoning is best studied in fresh glassy volcanic rock, such as boninites, because fast cooling ensures preservation of zoning in minerals and the presence of glass enables one to determine compositional variation in the quenched L. We describe details of major- and minor-element zoning in olivine, clinoenstatite, orthopyroxene and pigeonite-augite-ferroaugite phenocrysts and microphenocryst in boninites from New Caledonia, the Mariana Trench, Cape Vogel and Chichi-jima in relation to crystal growth and dissolution morphologies as the function of cooling history. In the early stages the L is rapidly depleted in elements, such as Ni in olivine or Cr in pyroxene which are preferentially incorporated in crystals (compatible elements), in areas close to the growing crystals which are strongly zoned. In the later stages before growth stops, the growing crystals incorporate the elements which are at hand, in the order of crystal-chemical affinity, so that extreme enrichment of certain elements is found. The composition of the adjacent L and the nearby nucleation or not of other phases has a strong influence on zoning, especially in MI. (Authors' abstract).

BRUDER, B., BUCHER, K. and HÄNNI, H., 1995, Characterization of rubies and sapphires on the basis of fluid inclusions (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 288.

Samples from 10 different locations in Asia and east Africa were studied. The FI show a generally high concentration of CO_2 and could be split in four different types:

(1) pure high-density, mono- to multi-phase CO_2-I which give a PT-range of 500°-700°C and 3-6 kb at the time of trapping. This type of I commonly appears in sapphires from India (Kashmir), Sri Lanka and Madagascar.

(2) impure low-density, two-phase CO_2 I (probably CO_2-CH_4 (-N_2) mixtures) are correlated with rubies in amphibolite to granite-facies metamorphosed dolomitic marbles. These marbles occur in Pakistan, Burma and Vietnam. The FI have a very dark or opaque appearance and are at least partially decrepitated. No water compound could be observed.

(3) CO_2-H_2S-(CH_4) bearing I of similar appearance could be detected in rubies from Afghanistan.

(4) CO_2 and H_2O FI which occur in sapphires from Rwanda are associated with a specific alkali-basalt flow.

On the basis of the available data precise correlation with geographic provinces is not yet possible, but as the FI database for corundum expands, such a correlation may be possible. (From authors' abstract by E.R.)

BRUECKNER, H.K., ELHADDAD, M.A., HAMELIN, B., HEMMING, S., KRÖNER, A., REISBERG, L. and SEYLER, M., 1995, A Pan African origin and uplift for the peridotites and gneisses of Zabargad Island: J. Geophys. Res., v. 100, no. B11, p. 22,283-22,297. First author at Dept. Geology, Queens College, Flushing, NY 11367.

A Sr, Nd, Pb and Os isotopic study of peridotites and granulite-facies gneisses from Zabargad island in the Red Sea. Only one post-Pan African event had a significant effect on the geochemistry of the gneiss/peridotite complex: shallow-level metasomatism by ultra-hot (750-900°C), hypersaline solutions with high $^{87}Sr/^{86}Sr$ (≈0.710) ratio led to the development of gem-quality olivine crystals as well as low P mineral assemblages in the peridotites, gneisses and younger rocks. Plagioclase-rich assemblages with apparent igneous textures ("troctolites") that are typical of the southern peridotite body may have formed by interaction of these F with peridotite (i.e., are "pseudo-troctolites"). (From authors' abstract by E.R.)

BÜHN, B, OKRUSCH, M., WOERMANN, E., LEHNERT, K. and HOERNES, S., 1995, Metamorphic evolution of Neoproterozoic manganese formations and their country rocks at Otjosondu, Namibia: J. Petrol., v. 36, no. 2, p. 463-496. First author at Inst. Geowissenschaften und Lithosphärenforschung, Sneckenbergstrasse 3, D-35390 Giessen, Germany.

Manganiferous chemical sediments of Neoproterozoic age in Namibia were subjected to high-T-low-P metamorphism during the Damara Orogeny and display unique phase assemblages. An early H_2O-rich generation of FI is interpreted as a manifestation of prograde dehydration reactions in the ore horizons. The uplift path of the sequence can be constrained using different decrepitation patterns of H_2O FI and a syn- to late-metamorphic CO_2-rich FI population, which indicate high geothermal gradients of 70°C/km and more. (From authors' abstract by E.R.)

BUICK, I.S. and CARTWRIGHT, I., 1995, Fluid-rock interaction during early contact metamorphism of the Reynolds Range group, central Australia: Australian J. Earth Sci., v. 42, p. 301-310.

BÜKER, C., LITTKE, R., WELTE, D.H. and LEISCHNER, K., 1995, Numerical simulations of complex temperature, burial, and erosion histories for sedimentary basins and their calibration; examples from western Germany (abst): AAPG Bull., v. 79, no. 8, p. 1201.

The detailed and reliable reconstruction of the geological and thermal evolution of sedimentary basins forms the indispensable basis of any simulation of generation, migration and accumulation of hydrocarbons. Utilising 1-D and 2-D forward modeling approaches resulted in important and new quantitative information on basin T, subsidence and erosion histories which are of fundamental geological interest. The basin evolution models were calibrated using vitrinite reflectance data, FI T, and apatite and zircon fission track data. (From authors' abstract by E.R.)

BURGESS, R. and TURNER, G., 1995, Halogen geochemistry of mantle fluids in diamond, *in* K.A. Farley, ed., Volatiles in the Earth and Solar System: AIP Conf. Proc. 341, p. 91-98. Author at Dept. Earth Sciences, Univ. Manchester, Oxford Rd., Manchester, M13 9PL, UK.

Ar and halogens (Cl, Br and I) have been measured, using the $^{40}Ar/^{39}Ar$ stepped heating method, in diamonds from Jwaneng, Orapa (both in Botswana) and Zaire. The samples analysed included cubic (coated) stones and polycrystalline diamonds of eclogitic association. Both these types of diamond contain H_2O, CO_2, carbonate and silicate I. Coated stones have relatively constant $^{40}Ar^*/Cl$ and Br/Cl, show limited variation in I/Cl, and have normal mantle $\delta^{13}C$ values (-5 to -7‰). This contrasts with polycrystalline diamonds which, although having similar Br/Cl values to coated stones, possess significantly higher and more variable $^{40}Ar^*/Cl$ and I/Cl values coupled with lower $\delta^{13}C$ values (≤-20‰). The origin of polycrystalline diamonds with high I/Cl-low $\delta^{13}C$ is tentatively considered in terms of the subduction of organic carbon and iodine in pelagic sediment. Coated stones have Br/Cl, I/Cl and $\delta^{13}C$ values that are similar to depleted upper mantle (MORB source). Mantle F trapped in the coated stones is enriched in halogens and ^{40}Ar by about a factor of 5000 relative to present-day upper mantle values. However, the estimated halogen content of the source from which the F derived is 7 ppm Cl, 25 ppb Br and 0.1-2.5 ppb I. These values are strikingly similar to those estimated previously for the source of MORB and therefore indicates that the halogens, like other volatile elements (e.g., noble gases, C and N), are homogeneously distributed throughout large portions of the upper mantle. (Authors' abstract)

BURNARD, P.G., CLAYTON, R., BURGESS, R. and TURNER, G., 1995, Inclusion-specific noble gases and CO_2 abundances from a lithospheric xenolith, Australia (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 135.

Using techniques described in Burnard et al, (Earth Planet. Sci. Lett., 128, 243, 1994) the He, Ar and CO_2 abundances of specific FI trapped in an Australian wehrlite xenolith have been determined. FI morphologies and thermobarometry are described elsewhere (Clayton and Burnard, this volume). Preliminary results suggest that $^4He/^{40}Ar$ (where ^{40}Ar represents radiogenetic Ar) of P FI are lower than in "PS-SI" (0.31 to 1.74 and 1.50 to 2.31 respectively). $^{40}Ar/^{36}Ar$ compositions are in the range 500-3000 and $CO_2/^4He$ range from 1 to 54×10^4. Particular $^{40}Ar/^{36}Ar$ or $CO_2/^4He$ ratios are not associated with I generations, although further data are required to confirm this.

The values of $^4He/^{40}Ar^*$ obtained for PI (≤1.74) cannot be reconciled with typical mantle U, Th and K compositions; it is likely that contamination by F with very low He/Ar ratios generated in the continental crust has occurred. The higher He/Ar ratios of PS and S F may indicate a different provenance for later F, although it should be noted that degassing of the magma (after formation of the PI) can account for the changes in composition. (From authors' abstract by E.R.)

BURRUS, Jean, BROSSE, E., de CHOPPIN, Janvry and GROSJEAN, Y., 1995, Interactions between tectonism, thermal history, and paleohydrology in the Mahakam Delta, Indonesia: Model results, petroleum consequences (abst): AAPG Abstracts, v. 4, p. 14.

Indexed under FI. (E.R.)

BUSHEV, A.G., SIDORENKO, G.A., CHERKASHINA, N.A. and ZHUYKOVA, T.L., 1995, Hydrocarbons as a prospecting guide and appraisal criterion for pegmatite deposits: Proc. Russian Mineral. Soc., v. 124, no. 3, p. 1-10 (in Russian, English abstract).

There are >90 species of saturated, unsaturated and aromatic hydrocarbons revealed within pegmatite deposits. They are concentrated in the form of G-L I in feldspars, micas and quartz. Their range of species and content may be used as regional and local prospecting guides for pegmatite mineral deposits with various ore specialization, as well as the appraisal criterion to estimate the commercial potential of these deposits. (Authors' abstract)

CAI, Jianming and LI, Baohua, 1995, Significance of inclusions in gem research: J. Chengdu Inst. Technology, v. 22, no. 4, p. 26-32 (in Chinese).

CAMERON, G.H., WALL, V.J., WALSHE, J.L. and HEINRICH, C.A., 1995, Gold mineralization at the Porgera gold mine, Papua New Guinea, in response to fluid mixing: PACRIM '95, p. 99-100. First author at Australian Nat'l Univ., Canberra ACT 0200, Australia.

The Porgera Gold Mine is spatially and temporally associated with the 6 Ma alkaline Porgera Intrusive Complex. (From authors' abstract by E.R.)

Our study has revealed evidence of CO_2-rich F indicated by the presence of clathrate and L CO_2 in both FI hosted in Stage II barren quartz. High salinity brine I have also been observed in quartz from vesicles hosted in fresh diorite. Similar brine I associated with low density V-rich I are observed in early quartz from Stage I quartz sulphide carbonate veins. (From authors' text by E.R.)

CAMPBELL, A.R., 1995, The evolution of a magmatic fluid: A case history from the Capitan Mountains, New Mexico: Mineral. Assoc. Canada Short Course, v. 23, p. 291-308.

See also next item. Includes 10 analyses of FI from quartz and calcite for 16 cations, all 14 REE (from Banks et al., FIR, v. 27, p. 8), B, F, Cl, Br, I and SO_4. (E.R.)

CAMPBELL, A.R., BANKS, D.A., PHILLIPS, R.S. and YARDLEY, B.W.D., 1995, Geochemistry of Th-U-REE mineralizing magmatic fluids, Capitan Mountains, New Mexico: Econ. Geol., v. 90, p. 1271-1287. First author at Dept. Geoscience, New Mexico Inst. Mining and Technology, Socorro, NM 87801.

The Capitan Mountains are formed by an alkali-feldspar granite pluton. Several widely distributed Th-U-REE veins which occur along the western end and flanks of the pluton are characterized by smoky and clear quartz, fluorite, adularia, hematite, calcite, thorite, titanite, allunite, chlorite, and clay minerals. Four main types of FI representing a large range in T and salinity occur in the quartz and fluorite. Type 1 I are the dominant type and represent high T-high salinity F with Th ≤600°C and bulk salinities ≤84 wt % NaCl + KCl eq. Inclusion types 2, 3, and 4 have decreasing Th and salinities. Type 1 and 2 I define a halite trend when plotted in the NaCl-KCl-H_2O system. The observed Th-salinity trends suggest a F evolution from the original parent F by cooling and crystallization of halite. The chemical composition of the I F was determined by a crush and leach extraction and analysis by ICP-MS, ICP-AES and ion chromatography. The cations are dominated by Na, K, Ca, Mn and Fe. Other cations analyzed include Mg, Al, Ba, Li, Sr, Rb, Cs, Pb, Zn and REE. Cu was below detection. The dominant anions are Cl and SO_4. Levels of I and Br were usually low. The main controls on F compositional variations are thought to be partitioning during V exsolution from the magma and mineral precipitation in the veins. The $\delta^{18}O$ (from quartz) and δD (from I F in quartz) values of the F are 7.1 to 8.0 and -54 to -80‰, respectively. Based on field relations, FI microthermometry, stable isotope data, petrographic data and I F chemistry, the F responsible for the Th-U-REE mineralized zones in the western half of the Capitan Mountains are most likely of magmatic origin. As a result of cooling-induced fracturing of the outer carapace of the Capitan pluton, the exsolved magmatic F were introduced into brecciated zones. Halogen ratios and sulfate concentrations are suggestive of evaporite assimilations into the magma before F exsolution. (From authors' abstract by E.R.)

See also previous item. (E.R.)

CAN, Xiaochun, 1995, A study of fluid inclusions on metamorphic rocks of Mayuan Group, Northern Fujian Province: Uplift P-T-t paths: Contrib. Geol. and Mineral. Resources Research, v. 10, no. 1, p. 38-41 (in Chinese, English abstract). Author at Tianjin Inst. Geology and Mineral Resources, Tianjin 300170, PR China.

FI were studied in quartz veins and migmatitic veins in Mayuan Group, Northern Fujian province. Three types of FI, CO_2, CO_2-H_2O and aqueous were identified, of different generations. Based on the isochores of FI according to the microthermometry and their time sequence of entrapment, the uplift P-T-t paths of Manshan Formation after peak metamorphism and Dajinshan Formation after migmatization have been inferred. They display a clockwise direction and convex toward the T axis [sic]. The P-T condition at which the shear deformation of quartz veins occurred is P = 85-100 MPa, T = 265-285°C. The F composition evolved from CO_2-rich F in the early period to aqueous F later. CO_2 is derived from host rocks. (Author's abstract)

CANALS, Martin and MEUNIER, J.D., 1995, A model for porosity reduction in quartzite reservoirs by quartz cementation: Geochim. Cosmochim. Acta, v. 59, p. 699-709. First author at CREGU and GS CNRS-CREGU, BP23, 54501 Vandoeuvre lès Nancy, France.

Quartz cementation is an important process of porosity reduction in sandstones. A mathematical model is presented for predicting the distribution and amount of quartz cement in a sandstone reservoir as a function of time and space. (From authors' abstract by E.R.)

CANDELA, P.A. and BLEVIN, P.L., 1995, Do some miarolitic granites preserve evidence of magmatic volatile phase permeability?: Econ. Geol., v. 90, p. 2310-2316.

CANNAT, Mathilde and 23 others, 1995, Site 922: Proc. Ocean Drilling Program, Part A: Initial Reports 153, p. 179-215.

Indexed under FI. (E.R.)

CAPACCIONI, B., MARTINI, M. and MANGANI, F., 1995, Light hydrocarbons in hydrothermal and magmatic fumaroles: Hints of catalytic and thermal reactions: Bull. Volcanol., v. 56, p. 593-600. First author at Inst. Volcanology and Geochemistry, Univ. Urbino, Via M. Oddi 14, Urbino, Italy.

Volcanic gaseous mixtures emitted from active volcanoes frequently show variable amounts of saturated (alkanes), unsaturated (alkenes) and aromatic volatile hydrocarbons. Three major patterns of distributions can be recognized, apparently related to the chemical-physical environment of formation of the gas exhalations: alkane-rich, low-T G emissions from recently active volcanic areas; aromatic-rich hydrothermal manifestations; and alkene-rich, "magmatic" fumaroles on active volcanoes. Thermodynamic data, together with theoretical and practical findings from the petroleum industry, point to two main types of reactions occurring in these volcanic environments: cracking and reforming. Cracking processes, mainly caused by thermal effects, occur when hydrocarbon-bearing hydrothermal F enter and mix with a hot and dry, rapidly rising magmatic G phase. The most probably products are light alkenes with carbon numbers decreasing with increasing reaction T. The presence of aromatic species in hydrothermal F can be linked to reforming processes, catalysed by several possible agents, such as smectites and zeolites, generally present in the hydrothermally altered volcanic terranes, and facilitated by long residence times in a hydrothermal envelope. (Authors' abstract)

CARROLL, M.R., DRAPER, D.S., BROOKER, R.A. and KELLEY, Simon, 1994, Noble gas solubilities in melts and crystals, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 325-341. First author at Dept. Geology, Bristol Univ., Bristol BS8 1RJ, UK.

The abundance and isotopic composition of trace amounts of noble G found in magmas can provide insight into a range of geological and planetary processes. These include; the large scale differentiation of the earth, the origin of the atmosphere, and potentially, the degassing and differentiation of mantle-derived magmas. Unlike most other trace elements whose behaviour can be understood from consideration of crystal-M equilibria, the noble G may also be partitioned into a magmatic V phase. This complicates the interpretation of observed variations in noble G abundances in magmas, but also means that noble G can yield information unobtainable from geochemical studies of non-volatile trace elements (e.g., regarding magma degassing history). The available experimental data and theoretical models allow a comprehensive description of how noble G solubilities vary with M composition, P, T, and the size of the noble G atom. However, partitioning of noble G between crystals and M or V is not so well understood, and the few data available are contradictory.

Of additional concern is the role of defects in allowing incorporation of electrically neutral noble G in crystals, especially since noble G contents of many natural crystals may be in the sub-parts per billion concentration range. Most data support incompatible behaviour for the noble G but complications arise from adsorption effects, especially for the heavy rare G, possible siting of noble G in defects, and concerns about "contamination" of samples by G-rich FI. Therefore, there is a need for additional investigation before we can quantitatively model the behaviour of noble G elements during partial melting or during crystal fractionation with any confidence. (From authors' abstract by E.R.)

CARTWRIGHT, I., BUICK, I.S., WEAVER, T.R., VRY, J.K. and OLIVER, N.H.S., 1995, Patterns of fluid flow in Proterozoic calc-silicates: Fluid channelling and variations in fluid fluxes and intrinsic permeabilities: Australian J. Earth Sci., v. 42, p. 259-265. First author at Victorian Inst. Earth and Planetary Sciences, Dept. Earth Sciences, Monash Univ., Clayton, Vic. 3168, Australia.

Calc-silicates in three Proterozoic terrains (Mt Isa, the Reynolds Range and the Grenville of Canada) record the influx of H_2O-rich F through the resetting of mineral assemblages, stable-isotope ratios and major elements. In all cases time-integrated F fluxes are inferred to have varied by over an order of magnitude on the millimetre to metre scale, and F were often channelled across strike. These results indicate that intrinsic permeabilities during metamorphism varied considerably over a small scale. It is suggested that F flow was within microfractures, and that the variations in intrinsic permeability reflect variable microfracture densities. (Authors' abstract)

CATHELINEAU, M., AYT OUGOUGDAL, M., BANKS, D., BOIRON, M.C., YARDLEY, B., LESPINASSE, M. and POTY, B., 1995a, Fluid inputs and mass transfer during alpine brittle deformation of the Mont-Blanc granite (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. ?

Along subhorizontal tension gash networks formed under ductile/brittle conditions at the end of the main compressional alpine event (Mt Blanc granite), strong water rock interactions occurred as shown by a complete quartz dissolution (episyenites) of the granite and redeposition of the transported silica, as euhedral quartz and silicates (albite, adularia, chlorite) in nearby fractures displaying or not quartz dissolution textures. F migrate not only in the sealed veins, but in healed cracks of the granite (fluid inclusion planes (FIP) attesting [to] the existence of a significant microfissural permeability in the whole granite mass.

F at the origin of the process are aqueous, with a salinity of 7-11 wt. % eq. NaCl (Th ~150°C in NW-SE FIP and 210°C in NS FIP). Presence of low density CO_2 component is frequent and show by FT-IR analysis, and in some instances by Raman spectroscopy, and indicate the input of volatiles from external sources. The halogen chemistry (Br/Cl and I/Cl ratios) data obtained after crushing of the quartz document the interactions between the F and the basement rocks, whilst the cation chemistry is used both for geothermometric purposes (K/Na ratios constraining the P-T conditions ~400 ± 30°C and 250 ± 50 MPa) and the identification of mass transfer during water-rock interactions. (From authors' abstract by E.R.)

CATHELINEAU, M., AYT OUGOUGDAL, M., BANKS, D., LESPINASSE, M., BOIRON, M.C. and POTY, B., 1995b, Fluid inputs and mass transfer during alpine brittle deformation of the Mont-Blanc granite (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 34-35. First author at CREGU, BP 23, 54501 Vandoeuvre-lès-Nancy, France.

The objective of this work was: (i) to describe the F migration outside major channels, using oriented blocks, and to determine if the microfissural permeability around the cleft networks has played a significant role in the F transfer, and then: (ii) to obtain additional constraints on the source of waters implicated in the strong water-rock interaction processes which affected the granites. It is clear that the transfer of silica which is extracted during the quartz dissolution process without any alteration of the other granite minerals is mainly linked to connected microcrack networks in the wall-rock of the main fractures. Originally the F were aqueous, with a salinity of 5.7-12.6 wt % eq. NaCl. Th range from 150 to 220°C in the euhedral quartz crystals. Tm-Th plot shows an evolution in the Tm-Th pairs. Values are nearly constant within specific FIP networks or cleft localities. The Th fluctuations cannot only be explained easily as markers of P fluctuation, but must also reflect some mixing and/ or cooling of the circulating F.

The main analyzed cations are Na, K, Ca, Mg, Sr, Fe, Mn. The ratio K/Na is rather constant for most of the early quartz generations, and equal to 0.15 ± 0.01. This ratio may indicate a T of ~400°C ± 50°C using the Na-feldspar/microcline geothermometer. Br/Cl and I/Cl ratios document the interactions between the F and the basement rocks and may indicate a mixing of two different F.

The data obtained at the scale of the studied alpine clefts indicate that F have similar sources (the surrounding metamorphic series) and produce the same effects. However, the data obtained argue in favour of more complex processes (mixing) than originally thought. (From authors' abstract by E.R.)

CAVARRETTA, Giuseppe and TECCE, Francesca, 1995, FLINCS and FLINCALC: PC programs for fluid inclusion calculations: Computers and Geosciences, v. 21, no. 5, p. 715-717.

CAWLEY, S.J., WILSON, N.P., PRIMMER, T., OXTOBY, Norman and KHATIR, B., 1995, Palaeozoic gas charging in the Ahnet-Timimoun Basin, Algeria (abst.): AAPG Bull., v. 79, no. 8, p. 1202.

Indexed under FI. (E.R.)

CESARE, Bernardo, 1995, Graphite precipitation in C-O-H fluid inclusions: Closed system compositional and density changes, and thermobarometric implications: Contrib. Mineral. Petrol., v. 122, p. 25-33. Author at Dipt. Mineralogia et Petrologia, Univ. Padova Corso Garibaldi, 37, 1-35137 Padova, Italy.

Equilibrium C-O-H F speciation calculations predict that graphite will precipitate from initially graphite-saturated FI during cooling and exhumation of metamorphic rocks. In the case that no mass is gained or lost by the I, the original X_o ratio [O/(O + H)] of the F phase must be maintained. Given this closed system constraint, the down-T progress of graphite precipitation can easily be monitored as a function of the variable X_o, and produces some effects that are of significance to FI studies: (1) Variation of the $H_2O:CO_2:CH_4$ relationship in the graphite-saturated COH F, namely increase of XH_2O and decrease of the carbonic fraction; (2) decrease of F density due to precipitation of graphite, which is denser than the residual F; (3) alteration of the $CO_2:CH_4$ ratio of the F, depending on the initial O:H ratio of the F: for $X_o > 1/3$, F increase their $CO_2:CH_4$ ratio with decreasing T, and vice-versa. This implies that the $CO_2:CH_4$ ratio measured at room T will not represent the trapping value, which is in any case closer to unit y. As a consequence of density reduction, isochores extrapolated from densities observed at room T do not pass through the P-T conditions at which the I was trapped, with P underestimated of ≤2 kb. Actual P-T trapping conditions are located along the equilibrium "bulk isochore" (curve of constant- X_o, constant-volume) of the F. Alteration of the $CO_2:CH_4$ ratio is a mechanism by which a CO_2-rich or CH_4-rich carbonic phase can be formed from aqueous F that are slightly off the neutral $X_o = 1/3$ value. Subsequent segregation of this phase from the aqueous counterpart may account for the formation of pure CO_2 and CH_4 F in the upper crust. (Author's abstract)

CESARE, B. and HOLLISTER, L.S., 1995, Andalusite-bearing veins at Vedrette di Ries (eastern Alps, Italy): Fluid phase composition based on fluid inclusions: J. Meta. Geol., v. 13, p. 687-700.

Full paper for abstract in FIR, v. 27, p. 21.

CHAREF, A. and SHEPPARD, S.M.F., 1995, The relationship between diapir and peridiapiric ore deposits, in Tunisia, as deduced from fluid inclusions studies (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 290-291. First author at I.N.R.S.T.B.P. 95-2050 Hammam-Lif-Tunisie.

In North Africa, the Triassic series are often in place and not associated to metallic deposits.

Nevertheless, in North Tunisia and East Algeria, the Trias outcrop as diapirs. These extrusion materials are gypsum with carbonate, clay, sandstones and automorphic minerals called Triassic neoformation minerals (TNM). These salt domes are associated with, economically, peridiapiric ore deposits.

The diapiric sediments are proposed as the main S and Zn-Pb reservoir of Fedj-El-Adoum (FH) and Bou Grine (BG) peridiapiric ore deposits.

To look for the possible relationship between the Tunisian diapirs and the peridiapiric mines, we tried to compare the composition, the physical and chemical parameters of trapped F both in Triassic neoformation minerals and in sphalerite and carbonate hosted minerals of peridiapiric FH and BG ore deposits.

The diagrams Th-Tm ice show that if the Th is relatively high there is little salinity variation. But when the Th decreases, we see wide salinity variations.

These distinctions and these likeness of F characteristics between the FNM and Fedj-El-Adoum and Bou Grine minerals suggest that all Triassic neoformation minerals have crystallised along the first evolution period of diapir rising. The late region fracturing (and TNM) have facilitated the mineralization F migration by the contact zone diapirs-wall rock. These F types were trapped at the same time in the sphalerite (of the ore deposits) and in the late fracture of TNM.

So, the diapirs play only an indirect role in the genesis of peridiapiric ore deposits. (From authors' abstract by E.R.)

CHAUVET, A., BARBANSON, L., PIANTONE, P. and NEHLIG, P., 1995, Mineralogical and structural constraints for P-T conditions and age formation of the Ouro Preto gold deposits (Minas Gerais, Brazil) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 292.

Au mineralizations of the Ouro Preto area (Quadrilatero Ferrifero) occur along a low-angle dipping thrust contact that separates Archean and Paleoproterozoic metasedimentary units. Preliminary FI study shows the existence of two types of SI (aqueous and CO_2-bearing I) that occur along distinct planes within quartz grains of the veins.

P-T conditions of the regional metamorphism and the following veins formation are estimated by the application of the garnet-biotite thermometer (within the matrix), the calibration of the arsenopyrite-pyrrhotite-pyrite equilibrium and the FI thermometry (within the vein).

The combination of these constraints demonstrates that Au concentration was realized by late deposition of Bi-Au paragenesis within microfractures of the veins-hosted arsenopyrite. Because vein emplacement did not create important hydrothermal changes in the matrix and quartz grains were not affected by intense plastic deformation, it is proposed that veins were formed later in the regional and metamorphic evolution of the area. Thus, a genetic model and a re-interpretation of the Paleoproterozoic age for Au concentration are suggested and discussed. (From authors' abstract by H.E.B.)

CHEN, Renyi, LIU, Yulin and RUI, Zongyao, 1995, Geological characteristics and genesis of the Xorkuduk skarn copper (molybdenum) deposit, Xinjiang: Geol. Rev. (Dizhi Lunping), v. 41, no. 2, p. 165-173 (Chinese, English summary).

Indexed under FI. (E.R.)

CHEN, Yanjing, ZHAO, Taiping, DENG, Jian, FU, Shigu and JIN, Chiyao, 1994, Genetic type and metallogenic mechanism of Bankuan gold deposit in special reference to the studies of fluid inclusions and isotopes in minerals: Chinese J. Geochem., v. 13, no. 1, p. 73-84 (in English). First author at Inst. Geochemistry, Chinese Acad. Sci., Guiyang 550002, PRC.

Auriferous quartz veins in the Bankuan Au deposit occur in the interlayer broken zone of the basal conglomerate of the Tietonggou Formation or at the unconformity between the Tietonggou Formation and the crystalline basement. The composition of FI in the minerals indicates that the nature and composition of ore-forming hydrothermal solutions show a drastic change soon after the solutions reached the Tietonggou Formation from the crystalline basement, resulting in Au precipitation. So the Bankuan Au deposit can be assigned to the conglomerate stratabound-type deposits. 137 thermometric data are concentrated in the three ranges 400-340°C, 330-220°C and 180-160°C, representing three episodes of metallogenesis. O isotope studies demonstrate the evolution of ore-forming hydrothermal solutions from early metamorphic to late meteoric. Diversity of ore-forming materials dominated by deep-source material is supported by S and Pb isotope data. From the above discussions it may be concluded that the deposit formed by metamorphism induced as a result of Mesozoic northward intracontinental subduction along the Machaoying fault. (Authors' abstract)

CHENG, L.Z., CHU, Q.X., DUBE, B. and SCHRIJVER, K., 1995, Metallogeny of gold indicators in the Gaspe Peninsula, Canada (abst.): GAC/MAC, Program with Abstracts, v. 20, p. 16.

Indexed under FI. (E.R.)

CHENJERAI, K.G., SCHMIDT MUMM, A., BLENKINSOP, T.G. and CHATORA, D.R., 1995, Tectonic setting and regional exploration significance of the Mutare greenstone belt, Zimbabwe: Redwing gold deposit (abst.), *in* T.G. Blenkinsop and P.L. Tromp, eds., Sub-Saharan Economic Geology: Geol. Soc. Zimbabwe Spec. Pub. 3, p. 213-224.

CHEPIZHKO, A.V. and DUBLYANSKY, Y.V., 1995, Hydrothermal accessory zircon in tuffs, mosaic breccias, and micritic calcite/opal veins at Yucca Mountain, Nevada (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 418.

Indexed under FI. (E.R.)

CHI, Guoxiang and SAVARD, M.M., 1995a, A preliminary microthermometric study of the Sugar Camp, Yankee Line, and MacPhails Brook Pb-Zn showings, Cape Breton Island, Nova Scotia: Current Research 1995-D, Geol. Surv. Canada, p. 53-58.

A number of small Pb-Zn occurrences are hosted by Carboniferous basal Windsor carbonates in addition to the Jubilee deposit on Cape Breton Island in Nova Scotia. This paper reports some preliminary microthermometric data on the Sugar Camp, Yankee Line, and MacPhails Brook showings, and compares them with data from the Jubilee and Gays River deposits.

FI from all the showings have first-melting T <-55°C, indicating that the F composition may be modeled by the system H_2O-NaCl-$CaCl_2$. Bulk salinities are generally between 20 and 30 wt % NaCl eq., comparable to the Gays River deposit but statistically higher than the Jubilee deposit. Th vary between 123-220°C, 79-110°C, and 66-118°C for the Sugar Camp, Yankee Line, and MacPhails Brook showings, respectively. The microthermometric attributes of the Sugar Camp showing have more affinities with those of the Gays River deposit than those of the Jubilee deposit. (Authors' abstract)

CHI, G.-X. and SAVARD, M.M., 1995b, Fluid evolution and mixing in the Gays River carbonate-hosted Zn-Pb deposit and its surrounding barren areas, Nova Scotia: Atlantic Geology, v. 31, p. 141-152. Authors at Quebec Geoscience Centre, Geol. Surv. Canada, 2700 Einstein, Sainte-Foy, Quebec G1V 4C7, Canada.

This paper presents the results of a microthermometric study of FI in authigenic dolomite (preore), sphalerite (syn-ore), calcite and quartz (syn- to post-ore) from the Gays River Zn-Pb deposit and its surrounding barren carbonates. Th and salinity data from the deposit indicate that during precipitation of most sphalerite and minor calcite and quartz, a high-T (>200°C), high-salinity (>27 wt % NaCl eq.) F mixed with a F having lower T (Th = 107-147°C) and salinity (24 wt % NaCl eq.), i.e., the F that dolomitized the carbonates and saturated their pores before mineralization. During precipitation of most calcite and minor sphalerite, a third F with lower salinity (<20 wt % NaCl eq.) and T (Th <90°C) affected the hydrothermal system and mixed with the two pre-existing F. A similar mixing trend has been observed for the barren areas. A group of FI in calcite (both from the deposit and barren areas) have very low salinities (0.4-14 wt % NaCl eq.) and variable Th (60-246°C); these results are interpreted as artifacts due to leaking and refill by late, low-salinity F. (Authors' abstract)

CHI, Guoxiang, SAVARD, M.M., and HÉROUX, Yvon, 1995, Constraints from fluid-inclusion data on the origin of the Jubilee carbonate-hosted Zn-Pb deposit, Cape Breton, Nova Scotia: Canadian Mineral., v. 33, p. 709-721. First author at Geol. Surv. Canada, Quebec Geoscience Centre, PO Box 7500, Sainte-Foy, Quebec G1V 4C7, Canada.

Aqueous (Aq) and hydrocarbon (HC) FI were studied in fibrous calcite (pre-ore), sphalerite, and coarse, anhedral calcite (syn- to post-ore) of the Jubilee Zn-Pb deposit, Cape Breton, Nova Scotia. The deposit is hosted by a limestone breccia at the top of the Macumber Formation (limestones) and under the Carrolls Corner Formation (evaporites). Aq I from different minerals have similar T of first melting (62.1 to -46.7°C), indicating a H_2O-NaCl-$CaCl_2$ compositional system. Salinities (wt %), NaCl/(NaCl + $CaCl_2$) weight ratios, and Th of Aq I range from 21 to 27%, 0.16 to 0.73, and 53 to 79°C for fibrous calcite, 15 to 24%, 0.26 to 0.64, and 59 to 228°C for sphalerite, and 12 to 24%, 0.17 to 0.72, and 66 to 224°C for anhedral calcite. The Th-salinity correlation suggests that a high-T, high-salinity F first mixed with a low-T, high-salinity F, then mixed with a F of low T and salinity. HC I coexist with Aq I. The Th of HC I ranges from 34 to 89°C for fibrous calcite, 46 to 87°C for sphalerite, and 31 to 238°C for anhedral calcite. F P estimated from the intersection of isochores of coexisting Aq and HC I range from 175 to 363 bars for the fibrous calcite, and from 160 to 398 bars for the anhedral calcite. The microthermometric data suggest that the Jubilee deposit formed from a hot, metal-carrying brine in a shallow environment (probably <1500 m) characterized by a low background T. Hydrocarbons migrated into the limestone breccia before the mineralizing event, reacted with oxidized S derived from the evaporites, and produced a reservoir of reduced S available for mineralization when the metal-carrying brine migrated through. (Authors' abstract)

CHI, Guoxiang, SAVARD, M.M., ST-ANTOINE, Pierre and HÉROUX, Yvon, 1995, Basinal fluid flow mechanism related to carbonate-hosted Zn-Pb mineralization in the Maritimes Basin, Nova Scotia, Canada- an overview (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-378.

FI studies in the Grays [Gays?] River and Jubilee deposits indicate two stages of F mixing. In the first stage, hot brines (Th = 200-230°C, salinity = 24-27 wt %) mixed with cooler burial background brines (Th = 53-161°C, sal. = 21-27 wt %). In the second stage, mainly post-ore, F of relatively low salinities (<14 wt %) and low T (<90°C) invaded the hydrothermal systems and mixed with the previous F. The succession of F types and their mixing likely reflect changes in the F regime. In the first stage, geopressured F flow of hot brines, probably provoked by faulting, may have dominated under the evaporite seal, while gravity-driven flow may have been operating above. With the fading of the geopressured system, the low-salinity low-T F in the upper system may have entered the lower system and mixed with F there.

Vitrinite reflectance from a deep drill core of the Subenacadie sub-basin indicates a geothermal gradient of at least 80°C/km. This result supports a previous suggestion that the Maritimes Basin was underplated by basaltic magmas ~300 Ma, and implies that the central (deepest) part of the Maritimes Basin is not the only source region that could have provided the hot mineralizing F. High geothermal gradients, if not evenly distributed in the region, may have provided yet another possible driving force for basinal brine circulation. (From authors' abstract by H.E.B.)

CHINN, I.L. et al., 1995, Cathodoluminescence properties of CO_2-bearing and CO_2-free diamonds from the George Creek K1 kimberlite dike: Int'l Geol. Rev., v. 37, no. 3, p. 254-xxx.

CHIODINI, G., FRONDINI, F. and MARINI, L., 1995, Theoretical geothermometers and PCO_2 indicators for aqueous solutions coming from hydrothermal systems of medium-low temperature hosted in carbonate-evaporite rocks. Applications to the thermal springs of the Etruscan Swell, Italy: Appl. Geochem., v. 10, p. 337-346. First author at Dipt. Scienze della Terra, Univ. Perugia, Piazza dell'Univ., 06100 Perugia, Italy.

In order to derive T-PCO_2 geoindicators suitable for thermal waters coming from the hydrothermal systems of medium-low T which are hosted in carbonate-evaporite rocks, the theoretical concentration of Ca, Mg, HCO_3, SO_4, F and their complexes in aqueous solutions in equilibrium with a mineral assemblage made up of calcite, dolomite, anhydrite and fluorite has been calculated between 0 and 150°C, at PCO_2 in the 0.1-100 bar interval and for total molality of mobile species Na and Cl ranging between 0.0001 and 0.3. A first geothermometric and geobarometric evaluation of the thermal springs of the Etruscan Swell is consistent with the general knowledge of the hydrothermal systems of medium-low T present in the region. (From authors' abstract by E.R.)

CHIPLEY, D.B.L., 1995, Fluid history of the Saskatchewan subbasin of the Western Canada sedimentary basin: Evidence from geochemistry of evaporites: Unpub. PhD thesis, Univ. Saskatchewan, Saskatoon, SK, Canada, 317 p.

Indexed under FI. (E.R.)

CHOMIAK, B. and LINDBLOM; S., 1995, Progressive deformation as evidenced by fluid inclusions in quartz from the Zinkgruvan basin, south-central Sweden (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1. Note: Late(?) two-page abstract, unpaginated and not bound in Abstracts volume. Authors at Dept. Geology and Geochemistry, Stockholm Univ., S-106 91 Stockholm, Sweden.

The footwall rock of the Zinkgruvan massive sulfide deposit, south-central Sweden, is a quartz porphyry metamorphosed to amphibolite grade. Relict quartz phenocrysts are unusually rich in FI. Interpretation of the microstructures in the quartz allows us to relate FI generations to phases of deformation already established for the Zinkgruvan Basin.

Phenocrysts of lower grade porphyry contain the earliest FI discovered. Where best preserved they are stretched out and necked down, forming linear arrays inside the FI trails. We interpret the trails to be transposed structures of the first deformation (F_1). These inclusions (type I) have relatively low density and P correction of >2.5 kb is inappropriate.

Later FI occur in a bewildering pattern of microfractures that we interpret to be the result of shearing related to folding and refolding of the porphyry. Most later FI are hosted by healed F_2 and F_3 microfractures.

Features that unify the FI types III through VI include: (1) nahcolite(?) dm in larger (>5 µm) I; (2) similar proportions of V, solid and L—typically 5:10:85 and 2:0:98 for larger and smaller I; (3) homogenization to the L phase without complete dissolution of a solid phase; and (4) linear correlation of salinity and density for I of all sizes and types. A P correction of 6 kb representing peak metamorphism is appropriate for FI types III and V; a lesser P should be used for type VI inclusions.

FI with unusual heating cycle behavior were encountered. Unique characteristics include: (1) a bubble remains attached to the solid phase(s); (2) growth of calcite at the expense of nahcolite(?) when V is present; and (3) homogenization (the bubble fades) after nahcolite(?) dissolution. These inclusions (type IV) commonly display a stable or metastable eutectic for the NaCl-$CaCl_2$-H_2O system at ~-54°C and -70°C, respectively.

We conclude that there was one basic type of Na-Ca-rich, mixed H_2O-CO_2 F, trapped in the microfractures of quartz phenocrysts at various P-T conditions during different phases of deformation. This is not surprising in that the massive porphyries are likely to have acted as aquacludes relative to adjacent metasedimentary rocks. Early metamorphic conditions may be recorded by the stretched FI preserved in lower amphibolite grade phenocrysts. If so, an anticlockwise PT-time path may be indicated. (From authors' abstract by E.R.)

CHOVAN, M., HURAI, V., SACHAN, H.K. and KANTOR, J., 1995a, Origin of the fluids associated with granodiorite-hosted, Sb-As-Au-W mineralisation at Dúbrava (Nízke Tatry Mts, Western Carpathians): Mineral. Deposita, v. 30, p. 48-54.

Full paper for abstract in FIR, v. 27, p. 24. See also next item. (E.R.)

CHOVAN, M., HURAI, V., SACHAN, H.K. and KANTOR, J., 1995b, Origin of the fluids associated with granodiorite-hosted, Sb-As-Au-W mineralisation at Dubrava (Nizke Tatry Mts., Western Carpathians): Mineral. Deposita, v. 30, p. 48-54. First author at

Dept. Mineralogy and Petrology, Comenius Univ., 842 15 Bratislava, Slovakia.

Mineral parageneses of the polymetallic, Sb-rich deposit at Dubrava have been formed during five stages. A FI study demonstrates that the earliest stages with scheelite, molybdenite and arsenopyrite have been associated with immiscible CO_2 ($\pm CH_4$)-rich, low salinity aqueous F at T between 300 and 400°C and P as much as 2 kb. Deposition of the main, superimposed ores, stibnite and zinckenite, has been intimately connected with circulation of aqueous, moderately saline F (15.5-23.5 wt % NaCl eq.) under epithermal conditions. Salinity of the aqueous F associated with tetrahedrite is clustered ~10 wt % NaCl eq. Quartz from the latest, barite stage has precipitated from aqueous F enriched in divalent cations. These F are believed to be genetically linked with Triassic evaporite formations preserved in the region. T-salinity diagrams constructed from microthermometry data indicate influx of diluted meteoric water in the stibnite, tetrahedrite and barite stages. Isotopic data are in accordance with the model. The $\delta^{18}O$ values between -9.3 and +1.5‰ SMOW have been derived for water in equilibrium with quartz, coexisting with sphalerite, tetrahedrite and barite, thus confirming the participation of isotopically lighter meteoric water in mineral-forming solutions. The $\delta^{18}O$ values between +3.3 and +8.5‰ estimated for the water associated with the scheelite and arsenopyrite stages are suggestive of the majority of metamorphic and/or magmatic water in the mineral-forming, CO_2-rich solutions. (Authors' abstract)

See also previous item. (E.R.)

CHRISTENSEN, J.N. and HALLIDAY, A.N., 1995, Multiple age components in the Bishop Tuff: evidence from Rb-Sr and Nd isotopic compositions of melt inclusions (abst.): Eos, v. 76, no. 46, p. F713.

MI in quartz provide direct samples of magma during the evolution of a magmatic system. We have determined the Rb-Sr isotopic compositions of MI in individual quartz crystals and bulk quartz separates from the 0.76 Ma Bishop Tuff (BT). In order to calculate apparent Rb-Sr ages for the MI we use an initial $^{87}Sr/^{86}Sr$ of 0.7060±1, based on Sr isotopic data for the BT and the precaldera Glass Mt. (GM) rhyolites. Two I bearing quartz crystals from BT airfall have apparent ages of 2.1 ± 0.1 Ma and 2.19±0.15 Ma similar to the Rb-Sr isochron ages of late GM rhyolites (2.047 ± 0.013 and 1.894 ± 0.013 Ma, Davies et al. 1994). Two other quartz crystals have apparent ages of 2.5 ± 0.2 Ma and 1.45±0.08 Ma. A bulk quartz crystal separate from the same pumice sample has an apparent age of 1.9±0.3 Ma, but a much lower $^{87}Rb/^{86}Sr$ than the individual crystals (33 vs. 107 to 150), indicating a mixed population. A second multiple airfall-pumice sample yielded a bulk quartz separate with an apparent age of 2.7±0.4 Ma. Except for the 1.45 Ma MI, the other samples above yield an array indicating an age of 2.2 Ma and an initial ratio of 0.706.

MI from the upper BT have a different apparent age, 1.04 ± 0.14 Ma, similar to the isochron age for the late GM rhyolites, 1.14 ± 0.08 Ma (Halliday et al., 1989) and consistent with the 500 ka timescale of differentiation of the Bishop Tuff (Christensen and DePaolo, 1993). A bulk quartz separate from a single airfall-pumice lump also has an apparent age of 1.18 ± 0.09 Ma. All bulk quartz separates have MI with $\varepsilon_{Nd} = -1$, identical to the BT and the late GM rhyolites but distinct from the early GM rhyolites $\varepsilon_{Nd} = -3$). This indicates the existence at ~2 Ma of two separate cupolas of magma, one that erupted to form the early GM rhyolites the other reserved until the eruption at 0.76 Ma of the Plinian Phase of the Bishop Tuff.

Although the Rb-Sr data support the presence of a 1.89 to 2.3 Ma component in the BT airfall as determined by $^{40}Ar/^{39}Ar$ on MI (Bogaard and Schirnick, 1995), they also indicate the presence of ~1.1 Ma MI in later erupted portions of the Bishop Tuff. (Authors' abstract)

CHRISTENSEN, J.N., HALLIDAY, A.N., LEIGH, K.E., RANDELL, R.N. and KESLER, S.E., 1995a, Direct dating of sulfides by Rb-Sr: A critical test using the Polaris Mississippi Valley-type Zn-Pb deposit: Geochim. Cosmochim. Acta, v. 59, p. 5191-5197. First author at Dept. Geological Sciences, Univ. Michigan, Ann Arbor, MI 48109.

The Rb-Sr dating of sphalerites is a powerful method for directly determining the age of base metal deposits and testing models for large-scale F flow. However, the uncertainty over the exact host phases for the trace amounts of Rb and Sr and the causes of variability in Rb/Sr have caused concern over the reliability of the method. Here we show that the Polaris MVT deposit, with a geologically well-constrained age of formation, confirmed by paleomagnetic measurements, and hosted in significantly older sedimentary rocks, yields a consistent Rb-Sr age of 366 ± 15 Ma, providing the first unequivocal vindication of the reliability of the method. (Authors' abstract)

CHRISTENSEN, J.N., HALLIDAY, A.N., LEIGH, K.E., RANDELL, R.N. and KESLER, S.E., 1995b, Testing models of large-scale crustal fluid flow using direct dating of sulfides: Rb-Sr evidence for early dewatering and formation of Mississippi Valley-type deposits, Canning Basin, Australia: Econ. Geol., v. 90, p. 877-884. First author at Dept. Geological Sciences, Univ. Michigan, Ann Arbor, MI 48109.

The Rb-Sr dating of sphalerite is a powerful method for evaluating the timing of large-scale crustal F flow events and testing hydrological models. Rb-Sr isotope analysis of six sphalerites and their FI leachates form an isochron indicating an age of 357 ± 3 Ma ($(^{87}Sr/^{86}Sr)_0 = 0.7129 \pm 2$), in good agreement with the average age, 355 ± 14 Ma, of the leachate-sphalerite pairs and an isochron consisting of a sphalerite sample, its leachate, and associated host carbonate (362 ± 12 Ma). (From authors' abstract by E.R.)

CHU, Xuelei, HUO, Weiguo, FAN, Qicheng and LIU, Ruoxin, 1995, Stable isotopic investigation on CO_2 fluid inclusions in ultramafic xenoliths of the Cenozoic basalts in eastern China, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 179-181. First author at Inst. Geology, Acad. Sinica, Beijing, PRC.

For CO_2 trapped in the ultramafic xenoliths in the Cenozoic alkaline basalts of eastern China, C and 0 isotopic ratios vary respectively in ranges of -9.9 to -35.7‰, and +25.5 to +0.7‰. It is notable that there seems to be a good positive correlation between the $\delta^{13}C$ and $\delta^{18}O$ values of CO_2 extracted at the same T for Minqing and Wangqing samples. (Authors' abstract)

CHUPIN, V.P. and CHUPIN, S.V., 1995, Melt inclusions in zircon from Archean rocks: Petrological significance and results of study (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 36-37.

Study of P glassy MI in Archean zircon from various localities yields compositions suggesting the nature of the host magmas. The analyses were of the chemical composition [electron microprobe?] and Raman spectra. See also Chupin et al., FIR, v. 26, p. 30. (E.R.)

CHUPIN, V.P., SMIRNOV, S.Z., KUZMIN, D.V. and TITOV, A.V., 1995, Evolution of fluorine and other volatiles during the crystallization of rare-metal granitoid and ongonite melts: The study of melt and fluid inclusions (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 38-39. Authors at Inst. Mineralogy and Petrography, Univ. Pr. 3, 630090 Novosibirsk, Russia.

Crystallized M and syngenetic FI in quartz, zircon and topaz of Li-fluorine granitoids of the Bazardarin polyphase massif (SE Pamir) and glassy and partially crystallized MI from ongonites of the Ary-Bulak stock (eastern Transbaikalia) have been studied, by electron microprobe, Raman spectroscopy and freezing and heating stage. H_2O content in MI has been determined by calculation method. The major elements, F and Cl contents in glasses of heated MI have been analyzed by electron microprobe.

Enrichment in H_2O, F and Na is characteristic of the differentiates of Bazardarin polyphase massif. The sequence of phases is: granites of the first phase (820°C, <4 wt % H_2O) → leucogranites of the main phase (750°C, ~0.5 wt % F and 4-5 wt % H_2O) → leucogranites of additional intrusion phase (730°C, ~0.5 wt % F and ~5-6 wt % H_2O) → topaz-bearing aplites (650°C, 1.1 wt % F and 9-10 wt % H_2O) → topaz-protolitionite granites (660°C, 1.2 wt % F and 8-11 wt % H_2O) → ongonites (700°C, 1.9 wt % F and 6-7 wt % H_2O). M and syngenetic FI in quartz of granites, aplites and pegmatites contain CO_2 and fewer amounts of N_2 and CH_4 along with H_2O. Inclusions in quartz of ongonites contain N_2 and CH_4 in addition to H_2O. It is shown that initial M of Ary-Bulak stock ongonites were richer in F (~3 wt %) and higher in T (≤1000°C) than L of the Bazardarin massif ongonites (700-670°C) and topaz-bearing granites (~660°C). High-T (≤1000°C) H_2O-poor (<2 wt % H_2O) MI in quartz of Ary-Bulak ongonites contain N_2 and trace amounts of CO_2. The later MI (Th=) contain only low-density CO_2. FI syngenetic to the later M ones contain $CO_2 + H_2O$ solution of low density.

The specific residual M depleted in SiO_2 (≤60-62 wt %) and enriched in F and other volatiles were formed during crystallization of rare-metal ultrafluorine magmas of both massifs. The high F-contents in initial ongonitic M is suggested to be responsible for considerable T interval of magmatic crystallization of the Ary-Bulak massif ongonites (from ~1000° to 500°C for quartz and ≤450°C for topaz). (From authors' abstract by E.R.)

CHUPIN, V.P. and TOMILENKO, A.A., 1995, Melt and fluid inclusions in high-pressure minerals (kyanite, garnet, quartz): Features of study and interpretation (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 39-40. Authors at Inst. Mineralogy and Petrography, Univ. Pr. 3, 630090 Novosibirsk, Russia.

High-P minerals expand at reduced P. Thus, the sizes of I increases (especially in quartz) and their density decreases. These phenomena influence Th. On heating in standard stages (at 1 atm.) Th of MI may be higher than Tt (for volatile-saturated melts). The negative T correction for MI in quartz of migmatites of granulite facies (P 5-7 kb) reaches 30-50°C (Tomilenko and Chupin, 1983).

For MI trapped at higher P (~15 kb) this correction may be 200°C and more. These data were obtained when studying MI in kyanite, garnet, quartz and sanidine from low-crust (P ~15 kb) granulites from xenoliths in alkali-basaltoid explosion pipe, Eastern Pamir (Chupin, et al., 1993). Inclusions in quartz contain: glass + heterogeneous F bubble + crystalline phases. The F bubble consists of CO_2 with a density 0.3 g/cm^3 (data of cryometric and Raman-spectroscopy analyses). On heating to 800°C in a standard stage (at 1 atm), separation of additional CO_2 bubbles occurs and their density increases ≤0.8 g/cm^3. The concentration of CO_2 reached 1.5 wt % (calculated data). At 1 atm I do not homogenize even at 1300°C. However, they homogenize at 1050°C when the external P is 12 kb (the experiments were carried out by A.D. Babansky in the IGEM of the RAS, Moscow on the device of cylinder-piston type).

Results of these studies showed that: (a) Th of MI in high-P minerals might be considerably higher than their Tt. To estimate their true Th, it was necessary to perform the experiments at P similar to natural ones; (b) the appearance of additional bubbles of CO_2 in I and the decrease in its density is of great importance in calculation of CO_2 concentration in the M and estimation of P. If the density of CO_2 is taken as 0.3 g/cm^3, then the calculation will yield a content of CO_2 in MI that is reduced 2.5-3 times.

The volumetric effect of compression of minerals is needed to be taken into account when determining the density of FI in high-P minerals. Phase transformations in FI in quartz were observed when the P was increased from 1 atm to 50 kb. The experiments were performed at room T at high-P [in a] diamond anvil cell for optic, X-ray and Raman-spectroscopic studies (Belitsky et al., 1992). An increase in the density of CO_2 I from 0.60 to 0.75 g/cm^3 was found when P increased ≤18 kb. A solid phase (ice or crystal hydrate) appears in water-salt I (G + L) at P of ~20 kb, and the bubble disappears at P ~30 kb. (From authors' abstract by E.R.)

References:

Belitsky, I.A. et al. (1992) Phys. Chem. Minerals, v. 18, p. 497-505.

Chupin, V.P. Tomilenko, A.A. and Chupin S.V. (1993) Geology and Geophysics (in Russian), v. 34, no. 12, 116-131.

Tomilenko, A.A. and Chupin, V.P. (1983) Thermobarogeochemistry of metamorphic complexes. Nauka, Novosibirsk (in Russian), 200 p.

CHURCH, A.A. and JONES, A.P., 1995, Silicate-carbonate immiscibility at Oldoinyo Lengai: J. Petrol., v. 36, no. 4, p. 809-889. First author at Dept. Mineralogy, The Natural History Museum, Cromwell Rd., London S27 5BD, UK.

For approximately the last 50 years eruptions at Oldoinyo Lengai have produced passive natrocarbonatite lavas interspersed with mixed silicate-natrocarbonatite. Petrographic textures are characteristic of L immiscibility between coexisting natrocarbonatite and silicate melts. Our detailed model for the petrogenesis of the natrocarbonatites at Oldoinyo Lengai involves extensive fractionation of a carbonate-rich alkaline silicate magma followed by immiscible separation of natrocarbonatite at low P. (From authors' abstract by E.R.)

CLAGUE, A.J., KEPEZHINSKAS, P., DEFANT, M., NESBITT, R.W. and MILTON, J.A., 1995, Laser ablation ICP-MS study of fluid inclusions in mantle xenoliths from Kamchatka, Russia: preliminary results (abst.): Eos, v. 76, no. 46, p. F538.

Mantle xenoliths were collected from the Avachinsky volcano located within the eastern volcanic front of the Kamchatka arc. The xenoliths are mostly harzburgites and dunites, with a small number of pyroxenites. A number of the dunite xenoliths also contain small pyroxenite veins.

Three of the harzbugites xenoliths (AVA-33, AVA-46 and AVA-50) were studied. They contained FI in both olivine and orthopyroxene crystals. The I consist of two phase (L + V) CO_2. The I ranged in size from <10 microns to ≤60 microns and are primary in origin. The studied I are found exclusively in the crystal rims and are probably related to cryptic metasomatic events in the Kamchatka sub arc mantle.

Double polished FI wafers of the xenoliths were analyzed for both rare earth and trace elements using time resolved laser ablation ICP-MS at the University of Southampton. FI near the surface of the wafers and least 30 microns in size returned the best results. Laser ablation analyses of a pyroxenite vein in the AVA-33 xenolith was also attempted without result.

The time resolved analyses showed peaks of light rare earths and a number of trace elements when an I was ruptured. The strongest and most consistent peaks were for Ce, La, Nb and Sr. Peaks for the elements Nd, Pr, Rb, and Y were also observed, but are weaker and occasionally absent. No rare earths heavier than Nd were detected.

These preliminary results are consistent with pervasive cryptic mantle metasomatism by slab derived F resulting in the introduction of a distinct slab signature (LREE and Sr) into the sub-arc mantle wedge below Kamchatka. (Authors' abstract)

CLAYTON, R.E., 1995, Geochemistry of Variscan antimony deposits, SW England, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 39-40. Author at Dept. Earth Sciences, Univ. Manchester, UK.

Although this region of the Variscan foldbelt was characterised by the loss of large volumes of F derived from the emplacement of the Cornubian Granite and associated polymetallic mineralization, this was not responsible for the genesis of the Variscan antimony deposits. (From author's abstract by E.R.)

FI reveal that the mineralizing F evolved from a dominantly high T, CO_2-(CH_4)-H_2O-NaCl composition to a lower T, dominantly aqueous F. A disparity in salinity between different deposits suggests that individual vein systems evolved independently. A minimum T of ca. 380°C at P between 1250-1650b reflects earliest quartz (Q1) deposition. Q2 formed from a CO_2-H_2O F of <10 wt % NaCl eq. Salinity at a minimum T of ca. 280°C and P between 750-950b. Q3 deposition immediately preceding Pb-Sb sulphosalt-carbonate mineralization provides a maximum T and P of ca. 270°C and 750b for the Pb-Sb-carbonate event. F immiscibility under falling P may have controlled antimony and Au mineralization. (From author's text by E.R.)

CLAYTON, R. and BURNARD, P., 1995, Pressure constraints using CO_2 inclusions in olivine from an ultramafic xenolith [from] Australia (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 165.

Preliminary measurements undertaken on predominantly CO_2-MI in olivines from an ultramafic xenolith from Mt Noorat, Victoria, S. Australia reveal estimates for trapping P in two I populations. The xenolith is an olivine-orthopyroxene cumulate sampled from Holocene basalts, for which noble G data has recently been presented (Burnard et al., vol. 7, 1995). The I show CO_2-M ratios between 0.10 and 0.50. By using the strong P dependency shown by the density of supercritical CO_2 and typical basaltic eruption T (~1200°C) the trapping P is obtained by calculating the density from the behavior of the CO_2 phase using thermometric studies.

Homogenization of the CO_2 phase reveals a narrow density range for primary ('P' type) I between 0.73 and 0.80g cm^{-3}

CLINE, J.S., HOFSTRA, A.H. and LANDIS, G.P. 1995
Data as range of values in mole percent

Sample	H_2O	CO_2	N_2	H_2S	CH_4	C_nH_m	± trace
Mz-Q-not near ore	15-82	15-77	1-7		tr	tr	H_2
MzQ-near ore	10-30	37-80	5-7	2-4	2-22	tr	
MzQ-near ore*	90-93	7-10					
Q-mineralized	18-97	3-73	<1-8	0.1-1.6	tr	tr	
Fl-ore stage	3-91	10-89	<1-8	0.1-0.7	tr	tr	H_2-HF
Orp-ore stage?	44-61	30-45	2-4	0.2-0.4	1.3-2.4	3-6	SO_2
Rlg-late ore stage	95-98	1-3	tr	0.03-0.5	tr	tr	H_2
Cc-late ore stage*	20-96	3-74	tr	tr			
Bar-late ore stage	No I bursts						
Cc-post ore*	99	1					

*Few data points

while a wider range for density between 0.52 - 0.77g cm^{-3} is recorded for PS and SI. The lower densities represent CO_2 of near critical density close to the top of the solvus above the two-phase CO_2 L-V field. Evidence for higher density F (0.96 g cm^{-3}) in PS I is also contained in our data. The density of CO_2 in PI translate to P of between 4.2 kb and 5.3 kb which is inferred to indicate the trapping P during crystallisation of the olivine cumulate. Trapping P between 2.3 kb and 4.9 kb for PS/SI are interpreted in terms of grain fracturing permitting admission of a later CO_2 F, post-crystallisation and at higher crustal levels. The measured CO_2 triple point for all I (-57.7 to -59.6°C) are below that for a pure CO_2 F and suggest the presence of additional, as yet uncharacterized, components in the F. Further analysis of the F composition is planned. (Authors' abstract.)

CLIFF, D.C. and MORÁVEK, P., 1995, The Mokrsko gold deposit, Central Bohemia, Czech Republic, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 105-108. First author at RTZ Mining and Exploration Ltd, Bristol, UK.

The Mokrsko gold deposit, hosted by Variscan granodiorite and Upper Proterozoic volcano-sedimentary units of the Bohemian Massif, represents a prospective type of low grade/bulk tonnage resource within greenstone-granitic terrains. (Authors' abstract)

FI research carried out on P and SI in quartz from Mokrsko shows CO_2-CH_4 ± N_2-H_2O-NaCl composition of F and minimum Tt ~330 ± 20°C. It is highly probable that the F entering the open system of dilation fractures were of metamorphic origin mobilised by the thermal effect of granodiorite on Upper Proterozoic rocks. The youngest mineral assemblages crystallised from the low salinity aqueous F (1-9 wt % NaCl eq.), under minimal Tt in the range 140-300°C. This assemblage has no genetic relationship with Au and has not influenced its distribution within the deposit. (From authors' text by E.R.)

CLINE, J.S., 1995, Genesis of porphyry copper deposits: The behavior of water, chloride, and copper in crystallizing melts, *in* F.W. Pierce and J.G. Bolm, eds., Porphyry Copper Deposits of the American Cordillera: Arizona Geol. Soc. Digest, v. 20, p. 69-82. Author at Univ. New Mexico, Las Vegas, NV.

A revised numerical model evaluates the partitioning of chloride and Cu among M, aqueous V, and brine in a crystallizing porphyry system. This model differs from previous models which evaluated partitioning between M and bulk aqueous F. The model is designed to determine the amount of M necessary to provide sufficient Cu to form an economic deposit and to test the capability of typical calc-alkaline M to produce economic porphyry systems.

M containing ~4 wt % H_2O and intruded at P of ~1 kb may approximate typical porphyry systems. Such M are H_2O-saturated at emplacement. The earliest aqueous F to exsolve are capable of transporting as much as 8000 ppm Cu from the M, and M volumes as low as 13 to 14 cubic km can provide the required mass of Cu. (From author's abstract by E.R.)

CLINE, J.S., HOFSTRA, A.H. and LANDIS, G.P., 1995, Quantitative analyses of volatile components in fluid inclusions from the Getchell, Carlin-type gold deposit, Nevada, USA (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-18. First author at Department of Geoscience, Univ. New Mexico, Las Vegas, NV 89154.

The volatile compositions of FI in minerals from the Getchell Au deposit were analyzed quantitatively using a quadrupole mass spectrometer (QMS). Analyzed samples include Mesozoic quartz veins (MzQ) in and outside of the deposit; ore-stage quartz (Q), fluorite (F) and possible ore-stage realgar (Rlg), calcite (Cc), and barite (Bar); and post-ore calcite. Bar and Rlg samples were incrementally heated and gases from individual I planes were released by thermal decrepitation and were analyzed. Orpiment was crushed and a bulk F was analyzed.

Mesozoic F (MzQ) are variable and may contain dominant H_2O, CO_2, or CH_4 and significant N_2 and H_2S. Ore-stage F (Q, FL, Orp) are distinguished by dominant, but highly variable H_2O/CO_2, ubiquitous minor H_2S, and possible minor N_2 and trace hydrocarbons. Late ore-stage F (Rlg) contain minor CO_2 and minor, but consistent H_2S. Inclusions in paragenetically younger Cc have highly variable H_2O/CO_2. Post-ore calcite is nearly pure H_2O.

The low T, moderate pH (4-6) and consistent H_2S (10^{-1} to 10^{-2} molal) in ore F suggest that Au was transported as a bisulfide complex. The assemblage Q-Fl-Orp-Rlg indicated that cooling played a role in Au deposition, however, variable H_2O/CO_2 ratios suggest that effervescence may have been important also. (Authors' abstract)

CLINE, J.S., HOFSTRA, A.H., LANDIS, G.P. and ALLERTON, S., 1995, Volatile compositions of fluid inclusions from a Carlin-type gold deposit: Getchell, Nevada, USA (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 41-42. First author at Dept. Geoscience, Univ. Nevada, Las Vegas, NV 89154.

The volatile compositions of FI in quartz, fluorite, orpiment, realgar, barite, and calcite were analyzed quantitatively using a quadrupole mass spectrometer. Most samples were incrementally heated and gases from individual I or I planes were released by decrepitation and analyzed. Orpiment and realgar were crushed and a bulk F was analyzed.

Calibration studies have shown that the amount of H_2O measured from small I is low owing to adsorption of H_2O onto surfaces inside the mass spectrometer during analysis. H_2O measurements from larger I, with signal to noise (SN) ratios >5, are accurate because the amount of H_2O lost by adsorption is negligible relative to the amount of H_2O in the I. Losses by adsorption for most other G analyzed are negligible for G concentrations large enough to be detected.

Inclusions in pre-ore Mesozoic quartz veins (MzQ) have a wide variety of compositions and variable H_2O-gas ratios. Most I in ore-stage minerals are H_2O-dominant. CO_2 is the major gas and minor H_2S is ubiquitous. Minor to trace CH_4, short chain hydrocarbons (SCHC), and N_2 may be present. The presence of both H_2O- and CO_2-dominant I in fluorite (Fl) may indicate F immiscibility or I necking. Immiscibility is substantiated by petrographic observation of two-phase L-rich and two- and three-phase V-rich I. Inclusion F released from orpiment (Orp) by crushing contain sub equal H_2O and CO_2 with minor N_2, CH_4, SCHC, and H_2S. The near equivalence of H_2O and CO_2 in bulk analyses may indicate the presence of H_2O-dominant and CO_2-dominant I. Inclusion F in late ore-stage realgar (Rlg) and calcite (Cc) are H_2O-dominant and contain minor CO_2 and small amounts of N_2, HC, and ubiquitous H_2S. Late ore-stage minerals generally have lower CO_2 concentrations than ore-stage minerals, although one calcite sample had relatively high CO_2. No I were detected in barite (Bar). Post-ore I in calcite are H_2O-dominant.

The ore F is H_2O-dominant with major CO_2 and ubiquitous, minor H_2S, and was capable of producing observed mineral and alteration assemblages. The low Th (<260°C), moderate pH (4-6) and consistent H_2S concentrations (10^{-1} to 10^{-2} molal) in ore stage F suggest that Au was transported as a bisulfide complex. The high CO_2 concentrations promoted decarbonatization of the host rocks, increased rock permeability, and exposed Fe. Sulfidation of Fe in host rocks may account for much of the Au in the replacement ores. The open-space-filling assemblage quartz-fluorite-orpiment-realgar indicates that cooling played a role in Au deposition; however, the presence of G-dominant I suggests that effervescence may have been important also. (From authors' abstract by E.R.)

CLINE, J.S., HOFSTRA, A.H., LANDIS, G.P., ALLERTON, S.B., GENT, C.A. and EASTOE, C.J., 1995, Stable isotope and gas compositions of ore fluids from the Getchell mine, Nevada: Evidence for contrasting ore fluids (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-66 - A-67

The Getchell, Carlin-type, Au deposit lies within a series of anastomosing faults. Au occurs in fault-zone-hosted replacement and coarse-grained, open-space-filling ore. Euhedral, open-space minerals exhibit three stages: main ore quartz (q), fluorite (fl), orpiment (orp), pyrite (py), marcasite, and Au; late ore realgar (rlg), calcite (cc), and Au; and post-ore calcite. Volatiles in FI were released for analysis by thermal decrepitation (q, fl, rlg, cc) and crushing (rlg, orp) and quantified using a quadrupole mass spectrometer (QMS). QMS (26 samples, mole %) and stable isotope (20 samples, ‰) data are tabulated.

The δD_{H2O} from orp and $\delta^{18}O$ of q and cc provide evidence for both an evolved meteoric water and a magmatic or metamorphic F. The $\delta^{34}S$ of orp, rlg, and py and $\delta^{13}C$ of cc are consistent with derivation of H_2S and CO_2 from sedimentary sources, although a magmatic component is permissive. The δD_{H2O} value from rlg is much less than Cretaceous meteoric water (-107‰, Taylor, 1976) suggesting that mineralization took place during the mid-Tertiary, when the climate was cooler.

Most FI are H_2O-dominant; however, gas-dominant FI are present in fl and orp. CO_2 is the major gas present; trace H_2S is ubiquitous. Analyses show that gaseous components declined and H_2O increased in the F as the system evolved.

High CO_2 ore F decarbonatized host rocks, increased permeability, and exposed Fe. Sulfidation of host rock Fe caused Au to precipitate forming replacement ores. The open space assemblage q-fl-ort-rlg-Au likely formed by cooling or dilution with meteoric F. (Authors' abstract)

CLINE, J.S. and VANKO, D.A., 1995, Magmatically generated saline brines related to molybdenum at Questa, New Mexico, USA: Mineral. Assoc. Canada Short Course, v. 23, p. 153-174.

A thorough review of the conditions of formation of the ore F responsible for forming this ore deposit, based on detailed petrography, thermometry, chemical analyses, and PVTX data and phase diagrams for the system NaCl-H_2O. SXRF data are given for 33 I for Cl, K, Ca, Mn, Fe, Cu, Zn, Pb, Br and Mo.

See also Cline and Bodnar, 1994b, FIR, v. 27, p. 25. (E.R.)

COELHO, C.E.S., RAMBOZ, C. and BENY, C., 1995, Contrasted polyphase history of gold mobilization at Fazenda Brasileiro and Fazenda Maria Preta, Rio Itapicuru greenstone belt: The role of early hydrothermalism, organic matter, ductile-brittle deformation and temperature (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 43-45. First author at Dept. Nacional da Produçao Mineral, Brazil.

Fazenda Brasileiro (FB) and Fazenda Maria Preta (FMP) Au mining districts are located in the Early Proterozoic Rio Itapicuru greenstone belt (RIGB), which lies in the NE part of the Precambrian Sao Francisco Craton (Bahia State, Brazil). Structural studies in the field and at the micrometer scale show that both mineralized districts were emplaced during the greenschist facies ductile/brittle deformation.

Polyphased hydrothermal history of the Au mineralizations

•*Early hydrothermal metamorphism H1*. Petrography, FI, and Raman spectrometric studies show that in FB mine area the M1 early hydrothermal metamorphism is marked by the "semi-graphite"; oxidation of the wall-rock related to long-duration boiling of the CO_2-CH_4 saline F, with transient halite saturation; and Au preconcentration on semi-graphite. At FMP, the widespread occurrence of hematite and "anthracite-like" particles in the carbonaceous schists from the wall-rock of the vein system confirms a pervasive oxidation.

•*Mechanism of vein opening during prograde metamorphism*. Mineralized quartz at FMP and FB characteristically contain primary water-deficient (≤1 mol %) CO_2-CH_4-bearing FI with trapped anthracite-like C compounds. Their composition in the C-O-H system consistently shows that, rather than being leaked aqueous FI, they record the primary mechanism of quartz vein opening and filling: the combustion of early-formed "semi-graphite" or "anthracite," which favoured the disappearance of the metastable hematite-C association inherited from stage H1. At FB, T was high enough to allow a near complete disappearance of earlier-formed hematite. At FB, the P-T conditions of vein opening fixed by FI data are ≈400°C-500°C, 2 to 3.5 kb, with fO_2 overpassing the upper stability limit of C ≈2 10^{-25} bar. At FMP, the widespread persistence of the metastable C-hematite association in the wall-rock, the coexistence in vein quartz of primary H_2O-dominant CO_2-CH_4-bearing FI with H_2O-free C-bearing FI suggests that T only transiently reached the blocking T of the "graphite-fluid" equilibrium ≈400°C. This is confirmed by the fact that the isochores representative of cogenetic H_2O-rich and H_2O-poor FI intersect at ≈350°C, 2 kb. Au was probably introduced in the vein system at FB and FMP attached on C compounds and freed as C volatilized. This is confirmed by the reported presence of Au particles in H_2O-poor FI at FMP.

•*Ductile, ductile-brittle evolution*. At FMP, quartz vein fabric study points out limited recrystallization textures and widespread microfracturing processes. Cogenetic secondary H_2O-rich and H_2O-poor FI underlining µm- to cm-long cracks in quartz show that P-T-fO_2 conditions did not significantly change during later brittle-ductile, brittle evolution of the vein system. (From authors' abstract by E.R.)

COETZEE, D.S. and KALBSKOPF, S., 1995, Thrust associated gold mineralization in an Archaean auriferous quartz-carbonate vein system at the Eersteling gold mine, South Africa (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 46-47. First author at Dept. Materials Technology, Technikon Pretoria, Private Bag X680, Pretoria 0001, South Africa.

The Au mineralization in the vicinity of Eersteling typically occurs in quartz-carbonate vein systems within coupled shear zones in 3000 m.y. greenstones. FI observed in undeformed, moderately deformed and highly deformed vein-quartz have clearly different typologies and modes of occurrence. These differences have been carefully studied in order to characterize the mineralizing F phase (Coetzee and van den Kerkhof, this volume). (From authors' abstract by E.R.)

See also next item. (E.R.)

COETZEE, D.S. and KERKHOF, A.M. van den, 1995, Fluid inclusions and cathodoluminescence of Maltz Reef quartz veins: Eersteling gold mine, Pietersburg greenstone belt, South Africa (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 48-49. First author at Dept. Materials Technology, Technikon Pretoria, Private Bag X680, Pretoria 0001, South Africa.

The Eersteling Au mine is situated in greenschist-amphibolites of the Eersteling Formation (Pietersburg Greenstone Belt), South Africa. The Maltz Reef represents a typical mesothermal shear zone in which Au is hosted in quartz-carbonate vein systems. The Maltz Reef is dominated by vein quartz which varies from massive unmineralized to highly brecciated mineralized varieties. Shearing, accompanied by different stages of carbonate crystallization, was responsible for the different vein-quartz varieties within the Maltz Reef. *Optical cathodoluminesence* (CL) distinguishes at least six visible geological activities: (1) an early stage F inflow related to quartz deformation; (2) recrystallization and F infiltration; (3) F migration in micro-crack systems; (4) F flow and carbonate introduction; (5) a late-stage shearing and/or brecciation; and (6) hydrothermal quartz vein filling showing primary growth zonation (no FI). SEM CL textures also indicate widespread decrepitation of FI and a late, superimposed pattern of healed microfractures characterized by very small (<3 µm) FI.

FI in least deformed vein quartz (massive to slightly recrystallized) which usually shows blue CL are of three types: (1) Oversaturated L-rich aqueous FI containing 1, 2 or 3 (most frequently 2) dxls (LVSS), which occur in irregular clusters, SEM analyses of decrepitates show Na-Ca-K-Cl compositions; dxls are halite and carbonate, L-V-Th of LVSS-type FI are between 110 and 150°C. The halite dxls show dissolution T in the range of 170-300°C, always above LV-homogenization. In many I showing one solid phase, due to metastability halite does not nucleate at room T and appears after freezing. The carbonate crystals are rounded and partly dissolved during cooling as a result of retrograde solubility and clearly grow larger on warming. Carbonate dissolution must be higher than the Td at 480-520°C and cannot be measured. The strongest transposed I which have higher Th show evidence of partial water leakage. Te melting during freezing experiments has been observed at T well below the Te of Na and K in a number of I. This significantly depressed Te can be ascribed to the presence of $CaCl_2$ in the system, and confirms the SEM-observation. (2) Undersaturated L-rich aqueous FI (LV) along healed cracks exhibit strong variation in salinity from the saturation point to almost pure water. These I homogenize between ~110°C (high salinity) and 170°C (low salinity). P LV-aqueous I in carbonate veinlets have salt content of ±10 eq. wt % NaCl and homogenize at 110-180°C (typically at ±110-120°C). (3) Few mixed H_2O (brines)-CO_2 I (LLV) occur mainly in quartz showing little or no secondary changes. Assuming a geothermal gradient of 29°C and d = 2.65 $g.cm^{-3}$, F trapping must have been from 300°C at ±2.5 kb to 180°C at ±1.5 kb.

FI in moderately deformed quartz (visibly recrystallized) contain undersaturated aqueous I (mostly 8-18 eq. wt % NaCl), which occur as either small clusters with Th ~140°C, or very tiny I (1-2 µm) for which no microthermometric data is available.

Highly deformed quartz (sheared, greenish-grey, translucent quartz) is the only quartz variety in which visible Au is sometimes present. It is therefore thought that Au came in during brecciation. Vast numbers of very small FI (<1 µm) in highly deformed quartz are responsible for its translucent appearance. The extremely small size of these FI made it impossible to collect any quantitative microthermometric data for these I. Qualitatively, however, no phase changes could be observed during freezing runs to T as low as -170°C. Single-phase I observed here are therefore interpreted as empty cavities of I destroyed by shearing.

Carbonic FI (LLV) were only observed in a single sample (20/5W-FW), showing little deformation. This contradicts the observation in Au-bearing vein-quartz which in general contains abundant CO_2. Calcite, however, is present in almost all the studied vein-quartz samples from Eersteling, which may imply that all the CO_2 which was present could have been consumed during the process of carbonization to form calcite. Carbonate I are mainly associated with the oversaturated FI. Seen the widespread occurrence of SSLV I in the least deformed quartz and the consistency of phase volumes (notably of the solids), the carbonate I are supposed to be trapped during an early stage of F evolution and at least in part be real dxls. During secondary processes like partial water leakage out of FI salinity may have increased (≤±38 eq. wt % NaCl). It can therefore be *concluded* that the final equilibration of the FI must postdate an early carbonitization event. The gradual lower salinities of FI in the higher (moderately) deformed quartz are supposed to present a mixing trend with meteoric water. The latest recognizable hydrothermal stage resulted in (non-deformed) carbonate veins which are associated with low-salinity FI (10 eq. wt % NaCl) homogenizing at 150°C and probably trapped at 250°C and 2 kb. Lower salinities of F in higher deformed quartz (sometimes containing free Au) are favourable for Au transport. (Authors' abstract)

COETZE, D.S., VAN REENEN, D.D. and ROERING, C., 1995, Quartz vein formation, metamorphism, and fluid inclusions associated with thrusting and bedding-parallel shear in Witwatersrand quartzites, South Africa: S. African J. Geol., v. 98, p. 371-381. First author at Dept. Materials Technology, Pretoria Technikon, PB X680, Pretoria 0001, South Africa.

A second thrust event, associated with bedding-parallel shear along the northern margin of the Witwatersrand Basin, has been identified and characterized by means of an integrated metamorphic and FI study of data obtained from syntectonic vein quartz. SiO_2-oversaturated aluminous schists and vein quartz with pyrophyllite and pyrophyllite-kyanite selvages clearly demonstrate varying P-T conditions along the northern margin of the Witwatersrand Basin. The regional metamorphic and accompanying hydrothermal event that affected the Witwatersrand rocks clearly predates this shear-zone metamorphism, which suggests that the redistribution of Au due to hydrothermal activity, as suggested by other authors, must also be pre-Transvaal in age. Peak P-T conditions of ±390°C at ± 3 kb inferred for the shear zone event (the second thrust event) along the northern margin of the Witwatersrand Basin are indicative of an abnormally high geothermal gradient. (From authors' abstract by H.E.B.)

COLLINS, C.J., HATTORI, Keiko and STIX, John, 1995, Incursion of hot mafic magma into an evolved magma chamber beneath Galeras volcano (Colombia): Eruption mechanism implied from mineral and melt inclusion geochemistry (abst.): Eos, v. 76, no. 17, p. S269. First author at Ottawa-Carleton Geoscience Centre and Univ. Ottawa, Ottawa, Ontario K1N 6N5, Canada.

Olivine compositions indicate that it crystallized from a M with a Mg# of ~45 which is consistent with the composition of MI in olivine and crystallization under relatively high fO_2 ($\Delta FMQ \geq +1$). MI from various phenocryst phases show a fractional crystallization trend from andesite to dacite and rhyolite. Light coloured groundmass glass has a composition near the high silica end of this trend. However, the trend defined by MI is not consistent with the bulk composition. The higher CaO, MgO and FeO of the bulk rocks require the addition of a mafic component that was more primitive than the melt from which the olivine crystallized.

The addition of a hotter mafic melt into a more evolved magma chamber is further supported by the textures of plagioclase phenocrysts. Some phenocrysts are rounded, with truncated growth zoning, due to resorption. They commonly display "sieve" textures and dusty zones within their cores, and some have narrow calcic rims, suggesting destablization (due to an influx of heat) followed by renewed crystal growth. The absence or narrow width of such overgrowths attest to the short time span between the destablization event and eruption. (From authors' abstract by E.R.)

CONG, Y.X., TOURET, J.L.R. and STEL, H., 1995, Fluids in Caledonian shear zones, Kwangping group, Qinling Mountains, China: A reconnaissance study: Petrologiya, v. 3, no. 3, p. 325-336 (in Russian; translated in Petrology, v. 3, no. 3, 1995, p. 291-300). First author at Inst. Geology, Chinese Acad. Geological Sciences, Beijing, China.

In the Qinling mobile belt, Central China, Proterozoic metamorphic rocks were deformed and partly reequilibrated during the Caledonian orogeny along prominent shear zones. Three types of FI were observed during a detailed study of seven samples with comparable lithology (quartz-rich sediments) and well-defined microstructural characteristics. The Proterozoic samples (S1) showed an evolution from purely aqueous F in the lowest metamorphic grade to dominant gaseous I (pure CO_2) in the highest grade (lower amphibolite). In the Caledonian shear zones, the earliest F (S2a) were low-salinity, purely aqueous F introduced during large-scale thrusting. Later F (S2b) were hotter, complex mixtures of gases (CO_2 with variable amounts of CH_4 and N_2) and aqueous F of variable salinities emplaced in discrete, less ductile zones of deformation, which were formed at the end of the thrusting. (From authors' abstract by E.R.)

CONNOLLY, J.A.D., 1995, Phase diagram methods for graphitic rocks and application to the system C-O-H-FeO-TiO_2-SiO_2: Contrib. Mineral. Petrol., v. 119, p. 94-116. Author at Inst. Mineralogy and Petrography, Swiss Federal Inst. Technology, CH-8092 Zürich, Switzerland.

Carbon-saturated C-O-H (GCOH) F have only one compositional degree of freedom. This degree of freedom is specified by the variable X_o that expresses the atomic fraction of oxygen relative to O and H. The only valid constraint on the maximum in the activity of GCOH F species is related to the bulk composition of the F, as can be expressed by X_o. In F-saturated graphitic rocks, mineral devolatilization reactions are the dominant factor in determining the redox state of the metamorphic environment. X_o is directly proportional to the fO_2 of GCOH F, and because its value can only be affected by F-rock interaction, it is an ideal measure of the redox character and composition of GCOH F. Phase diagrams as a function of X_o are analogous to the P-T-XCO_2 diagrams used for binary H_2O-CO_2 F; this analogy can be made rigorously if the C-O-H F composition is projected through C into the O-H subcomposition. After projection, the F is described as a binary F with the components O and H, and the compositional variable X_o. Description of GCOH F in this manner facilitates construction of phase diagram projections that define the P-T stability of mineral assemblages for all possible F compositions as well as F-absent conditions. In comparison to phase diagrams with variables based on the properties of F species, P-T-X_o diagrams more clearly constrain accessible F compositions and F evolution paths. Calculated P-T-X_o projections are presented for the C-O-H-FeO-TiO_2-SiO_2 system, a limiting model for the stability of Fe-Ti oxides in graphitic metapelites and phase relations in metamorphosed Fe-formations. With regard to the latter, the stability of the assemblage qtz + mag + gph has been a source of controversy. Both the calculated C-O-H-FeO-TiO_2-SiO_2 system petrogenetic grid and natural examples suggest that this assemblage has a large P-T stability field. Discrepancies between earlier C-O-H-FeO-TiO_2-SiO_2 system phase diagram topologies are reconciled by the qtz + mag + gph = sid + fa phase field, a barometric indicator for metamorphosed-Fe formations. A more general implication of calculated P-T-X_o phase relation is that few inorganic mineral-F equilibria appear to be capable of generating H-rich $X_o < 1/3$, GCOH F at crustal metamorphic conditions. The utility of P-T-X_o diagrams derives from the use of a true compositional variable to describe F composition; this approach can be extended to the treatment of C-undersaturated systems, and provides a simple means of understanding metasomatic processes of graphite precipitation. (Author's abstract)

CONRAD, M.E., O'NEIL, J.R. and PETERSEN, Ulrich, 1995, The relation between widespread ^{18}O depletion patterns and precious metal mineralization in the Tayoltita mine, Durango, Mexico: Econ. Geol., v. 90, p. 322-342. First author at Lawrence Berkeley Laboratory, MS 3363, 1 Cyclotron Rd, Berkeley, CA 94720.

The $\delta^{18}O$ values of the wall rocks in the vicinity of the Tayoltita mine were shifted to significantly lower values as a result of interaction with geothermal F of predominantly meteoric origin. By estimating the $\delta^{18}O$ values of the evolving F from analyses of the other minerals, we have calculated that the degree of O isotope shift of the feldspars is consistent with a period of F circulation lasting 10,000 to 100,000 years at a Darcy flow velocity of 10^{-9} to 10^{-11} m/s. This indicates that although pervasive F flow through the rocks may have occurred during the formation of the veins, it was extremely limited and had little effect on the regional $\delta^{18}O$ rock patterns. The coincidence of the veins with the areas of strong ^{18}O depletion of the rocks must, therefore, be an indication that there was a single, long-lived episode of hydrothermal activity that remained focused in the same vicinity throughout the life of the system. (From authors' abstract by E.R.)

Uses FI data from the literature. (E.R.)

CORDON, S. and GUILHAUMOU, N., 1995a, Physicochemical conditions of silicification in Brent Group sandstones, Dunbar Field (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 200.

Brent Group sandstones (middle Jurassic), in the North Sea, are the largest hydrocarbon reservoirs of north-western Europe. In Dunbar Field (Great Alwyn area), important illitization and silicification have drastically reduced their permeability and porosity. These diagenetic processes are controlled by the physicochemical conditions in the reservoir. These conditions can be derived from FI formed during overgrowth crystallization episodes. Four wells in the Dunbar field showing intense diagenetic levels in Tarbert and Ness formation were studied. Petrographic observations by SEM-CL and microscopy in UV lighting allow recognition of cogenetic aqueous and hydrocarbon bearing FI at the [edge] of the detrital grains and quartz overgrowth. Methane is systematically detected in aqueous type by Raman microspectrometric analyses, and Infrared microspectrometry allows to characterise light aliphatic oil with dissolved CO_2 in hydrocarbon type. Microthermometric measurements of these I display Th ~105-110°C for aqueous ones and ~85°C for hydrocarbon bearing ones. The presence of methane in aqueous FI allows to interpret their Th as Tt in the hypothesis of methane saturation at the time of F entrapment. If we consider the T increase caused only by burial, and a thermal equilibrium between the F and the host rocks, this would correspond to depths of 2.5-2.9 km for the beginning of silicification in these wells. An evaluation of the associated P from the position of the Raman spectra of methane in a saturated system gives a minimal value of 150 bars. Observations of hydrocarbon FI in all samples indicate that the beginning of silicification occurred during the circulation of brine and oil. (From authors' abstract by E.R.)

CORDON, S. and GUILHAUMOU, N., 1995b, Silicification temperature of the Brent Group, Middle Jurassic sandstones of Dubar Field, UK North Sea: Comptes Rendus de l'Academie des Sciences, Serie II. Sciences de la Terre des Planetes, v. 320, no. 7, p. 563-567.

See previous item. (E.R.)

COVENEY, R.M., Jr. and SANGSTER, D.F., 1995a, Distinguishing hydrothermal sources of metals for black shales, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 939-941.

See also next item. (E.R.)

COVENEY, R.M., Jr. and SANGSTER, D.F., 1995b, Hydrothermal origins for metals in black shales (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 463.

Indexed under FI. See also previous item. (E.R.)

COX, S.F., SUN, S.-S., ETHERIDGE, M.A., WALL, V.J. and POTTER, T.F., 1995, Structural and geochemical controls on the development of turbidite-hosted gold quartz vein deposits, Wattle Gully mine, central Victoria, Australia: Econ. Geol., v. 90, p. 1722-1746. First author at Geology Dept., Univ. Newcastle, Callaghan, NSW 2308, Australia.

Au quartz vein deposits developed in a low-grade metamorphosed quartz-rich flysch sequence. FI in vein quartz contain C-O-H F of variable compositions, but three main types are recognized. Type I FI are two-phase aqueous I with low salinities, low CO_2 and CH_4 contents, and quite variable CO_2/CH_4 ratios. Th between 160° and 240°C are consistent with trapping ~300°C and F P ~130 MPa. Type II inclusions contain ≤20 mol % CO_2 and have final Th in the range of 280° to 310°C, high but variable CO_2/CH_4 ratios, and variable CO_2 densities. Rare, high-density carbonic I (type III) contain <40 mol % H_2O and could have formed by phase separation from type II F.

The isotopic and bulk chemistry of F is consistent with derivation by metamorphic devolatilization or via exchange with metamorphic rocks at mid- to lower crustal levels late during crustal thickening and prior to widespread lower crustal anatexis in the Late Devonian.

The evolution of F chemistry in the Wattle Gully fault is interpreted to have been controlled by redox reactions, F mixing and phase separation in response to F P cycling, and F-rock interaction during fault-valve behavior. A major influence on Au deposition has been mixing between deeply sourced type II F and more reduced CH_4-bearing F that evolved during F reaction with carbonaceous pelites in the alteration envelope. Repeated episodes of mixing of these F, especially at the dilatant jog, have been governed by the cyclic changes in hydraulic head associated with fault-valve behavior. (From authors' abstract by E.R.)

COX, W., RANKIN, A. and ALDERTON, D., 1995, Late-stage fluid evolution model for extensive kaolinization and related ferruginous lode formation in south-west England (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 50-51. First author at School of Geological Sciences, Kingston University, Kingston-upon-Thames, Surrey, UK.

A combination of petrographic, microstructural and FI techniques have been employed on variably altered granites and Fe vein samples.

Detailed studies of *secondary* FI in granite quartz reveal that the intensity of kaolinization correlates with the abundance of dilute, low to moderate T F (Th 70-200°C, <1-10 wt % NaCl eq.). This evidence indicates that kaolinization was achieved by the late-stage influx of meteoric waters through a consolidated and essentially cooled granite. Pervasive alteration was achieved by focusing F flow along microfractures in the granite, and it will be argued that this micropermeability was primarily developed during the earlier episode of main-stage hydrothermal activity.

Analysis of *primary* I in vein quartz from Goonbarrow and elsewhere, indicate that the veins were precipitated by basinal brines (Th 100-150°C, 24 wt % NaCl eq., Te <45°C). These brines were probably tapped from compacting offshore sedimentary basins via major NW-SE wrench faults that transect the Cornubian peninsula and have already been proposed as base metal (Pb-Zn) mineralizing agents in SW England. "Primary" I of a dilute F are believed to represent subsequent recrystallization and/or flushing through of the original I contents by a later low salinity, "kaolinizing" F.

The observed disposition of ferruginous lodes around the heavily kaolinized St. Austell granite has been promoted as evidence in favour of a common genetic association between kaolinization and Fe-vein formation. It is speculated that Fe released from the deferruginization of granitic biotite during argillic alteration was precipitated in dilatant N-S structures, within and adjacent to the kaolinized granite pluton.

Although Fe may have been directly sourced from the granites, FI evidence from this study suggests that the lodes were not precipitated from dilute, kaolinizing F charged with Fe, Si, and U, but basinal brines. This evidence, therefore, is at variance with the previously accepted model invoking a common F source for both kaolinization and Fe vein formation. (From authors' abstract by E.R.)

CRAIG, J.R., GUO, D.J. and SHE, H.Q., 1995, Ore mineralogy and geochemistry of the Ji Long Shan copper-gold skarn deposit, Hubei Province, China (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-378-A-379.

The Ji Long Shan Cu-Au skarn deposit is located on the central portion of the Yangtze River in eastern Hubei Province of the Peoples' Republic of China. It is a typical Cu-Au skarn deposit containing ~30 million metric tons of ore at ~1 % Cu, 1.1 gram/ton Au, and 12.8 gram/ton Ag. The deposit consists of a large number of individual skarn bodies which have developed where the Triassic Daye limestone unit has been cut and replaced by the granodiorite porphyry of the Ji Long Shan stock.

FI studies indicate that the ore forming F contained 2-4 wt % NaCl equivalent and precipitated ores in the T range 430 to 150°C. (From authors' abstract by H.E.B.; note that the two parts of the abstract are actually on p. A-379 and then A-378, as printed.)

CRAIG, J.R. and VAUGHAN, D.J., 1994, Ore Microscopy and Ore Petrography: New York, John Wiley & Sons, Inc., 434 p.

Provides a 13-page discussion (p. 193-205) of FI related to ore deposit petrography and petrogenesis. (H.E.B.)

CRAW, D. and COOK. Y.A., 1995, Retrogressive fluids and vein formation during uplift of the Priestley metamorphic complex, north Victoria Land, Antarctica: Antarctic Sci., v. 7, p. 283-291. Authors at Geology Dept., Univ. Otago, PO Box 56, Dunedin, New Zealand.

The polydeformed Priestley schist (Wilson Terrane) of north Victoria Land, Antarctica, ranges in metamorphic grade from lower greenschist facies to upper amphibolite facies. All grades of schist have been affected by structurally controlled retrogressive H_2O-CO_2 F with 45-70 mol % CO_2. The F have deposited quartz-carbonate veins with pyrite and chlorite or biotite in late stage structures. Veins typically constitute <1% of the rock mass, but in one greenschist facies area >10% of the rock is vein. Veins in higher grade schists have been boudinaged after formation, and many have been annealed. P FI are preserved in veins in biotite zone schists in two localities. At one locality, entrapment of immiscible F (water with c. 8 and 45 mol % CO_2) occurred during vein formation, at ~280-300°C and 700 ± 200 bars F P. The aqueous F is slightly saline (4 wt % NaCl eq.). At the other P FI locality, veins were formed from a single phase F (c. 70 mol % CO_2) at 200-350°C and 1600 ± 500 bars F P. Both these vein systems are inferred to have formed between 2 and 8 km depth, near the brittle-ductile transition. Retrogressive F mobility and vein formation occurred throughout schist in the Priestly metamorphic complex during uplift in the latter part of the Ross Orogeny (c. 490 Ma), following near-isobaric cooling at metamorphic depths. (Authors' abstract)

CRAW, D. and McKEAG, S.A., 1995, Structural control of Tertiary Au-Ag-bearing breccias in an extensional environment, Nelson area, Southern Nevada, USA: Mineral. Deposita, v. 30, p. 1-10. Authors at Geology Dept., Univ. Otago, PO Box 56, Dunedin, New Zealand.

The mineralizing F was H_2O which was boiling at or near 100°C. The calcite deposited by this water has $\delta^{13}C$ = -5.4 to -7.1 and $\delta^{18}O$ = +5.8 to +11.3, and the water was probably meteoric in origin. Mineralization had an epithermal style, with strong local structural control, rather than deep-sourced regional detachment-related hydrothermal origin. (From authors' abstract by E.R.)

FI are typically <5 μm and S. Th 90-160°C; Tm ice -1.3 to 0°C. (E.R.)

CRISPINI, L., FREZZOTTI, M.L. and CATHELINEAU, M., 1995, Syntectonic CO_2-H_2O fluids in extensional veins in metasediments of the Voltri Groups (NW Alps) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 52-53. First author at Dip. Scienze Terra, Corso Europa 26, I-16132 Genova.

The Voltri Group is a metaophiolitic complex. FI studies have been performed in syntectonic extensional quartz-veins in the metasediments to characterize the synmetamorphic F composition. Study veins pertain to three distinct generations of folds, that formed during the retrograde evolution.

Euhedral quartz grains (5-10 mm), growing perpendicular to the vein walls, characterize vein set 1 and 2; grains usually show heterogeneous intracrystalline plastic deformation and dynamic recrystallization, occurring at the transition between the field of grain boundary migration and of subgrain rotation. Veins of set 3 are always recrystallized; they consist of minute quartz grains (30-40 μm) with granoblastic textures and repeated microfractures.

Different types of aqueo-carbonic FI are observed in each vein set. The relative chronology between F trapping, quartz growth or deformation has been studied with respect to the geometric features of the host micro- to macrostructures, using optical and scanning electron microscopy (back scattered electron mode, cathodoluminescence imaging). In addition, systematic 3D measurements of microfracture network geometry are carried out in each sample using an image analyser to depict palaeofluid pathways during the brittle deformation of the extensional veins. Quartz microstructures and FI distribution permit distinguishing different generations of FI, in order of decreasing ages: (A) I present isolated or in small clusters within single quartz grains; (B) I occurring along quartz grain boundaries; (C) I along healed fractures. As FI in vein set 1 and 2 have the same distribution, composition, and densities, these two vein sets will be discussed together.

Vein set 1 and 2: The oldest aqueo-carbonic I (type A1 and A2) are water dominated at room T ($CO_2 \approx$ 20-40 % tot. vol). Tm for the carbonic part of the F are recorded at -56.9°C. ThL are recorded between 7.5 and 20.9°C. Clathrate melting occurs at ≈7°C. The F composition results 8 CO_2, 90 H_2O, 2 NaCl in mol %, with densities between O.75 and 0.87 g/cm^3. Inclusions delineating subgrain boundaries (type B1 and B2) are CO_2 dominated (CO_2 ≈70-80 % tot. vol). Tm CO_2 are ~-56.6°C, with ThL between 22.3 and 26.1 °C. Clathrate melting occurs at ≈8°C. F composition is 37 CO_2, 62 H_2O, 1 NaCl in mol %, with densities between 0.30 and 0.60 g/cm^3. Late trail-bound aqueo-carbonic I (type C1 and C2) with extremely variable H_2O/CO_2 ratios are also observed in early vein sets.

Vein set 3: Isolated aqueo-carbonic I are CO_2 dominated at room T (type A3). Tm CO_2 are ~-56.6°C, with ThL between 23.2 and 27°C. Clathrate melting occurs at ≈7°C. F composition is 23 CO_2, 76 H_2O, 1 NaCl in mol %. The F density is ≈0.25 g/cm^3.

Isochores distribution in the P-T space gives a better definition of the retrograde P-T path followed by the Voltri Group metasediments, and of the relationships between the late stages of deformation. Type A1 and A2 aqueo-carbonic F in vein sets 1 and 2, have compositions and densities consistent with Greenschist facies conditions (P = 5-6 kb; T = °C). For these F we propose a pseudo-isochoric retrograde evolution, that is in agreement with a development of the F1-F2 folds under very similar P-T conditions, during progressive and continuous deformational events. The oldest aqueo-carbonic F in late set 3 veins (type A3), can be related to the late stages of circulation of type B1 and B2 F in the early veins. (From authors' abstract by E.R.)

CRISS, R.E. and DAVISSON, M.L., 1995, New explanation of Na-Ca-Cl relations in basinal fluids (abst.): Geol. Soc. Am., Absts. with

Programs, v. 27, no. 6, p. A-291.

A new mathematical transformation of Na, Ca and Cl concentrations in numerous basinal F around the world produces a linear slope of unity between the milliequivalencies of Na and Ca cations. The transformation entails a simple milliequivalent comparison between the excess Ca and Na deficit relative to seawater reference ratios. The relevant parameters are:

$$Ca_{excess} = \{Ca_{meas} - (Ca/Cl)_{sw}Cl_{meas}\}2/40.08$$

$$Na_{deficit} = \{(Na/Cl)_{sw}Cl_{meas} - Na_{meas}\}/22.99$$

where the concentrations (in mg/L) of the ions measured (meas) in a sample are referred to those in seawater (sw), and the numerical constants convert the results to meq/L. For >800 samples from numerous F reservoirs, with Cl concentrations that range ~1-300 g/L and host lithologies from carbonates to granites, a highly correlated regression is found:

$$Ca_{excess} = 0.967(Na_{deficit}) + 140.3$$

$$R = 0.981.$$

The unit slope indicates an equilibrium cation exchange of 2Na for 1Ca, and suggests the predominance of albitization and local conservation of Al. The regression offers no support for a 1:1 exchange of Na for Ca that has also been proposed for albitization reactions, because this would create a slope of 2x greater than observed. The small y-intercept of 140.3 is generally consistent with an origination of the brines from seawater, which would plot at the origin of the graph. However, for individual basins, the y-intercepts increase with increasing salinity of the F, consistent with model predictions for dissolution of halite into either a seawater or freshwater parent, followed by 2Na for 1Ca exchange.

On the same diagram, different relationships are exhibited by different water types. For instance, the Na deficit of halite FI is significantly greater than the Ca excess. Hydrothermal waters are scattered with small Ca excesses accompanied by small positive or negative Na deficits. Potable groundwaters typically have negative Na deficits that may follow a halite dissolution line accompanied by minor Ca excesses. The uniform distribution of basinal F on an excess-deficit plot contrasts with these behaviors and provides a framework in which we postulate that basinal F undergo large-scale circulation through the crystalline basement. (Authors' abstract)

CUCURELLA, Jimena and FLORES, Ivonne, 1994, Condoriaco silver deposit: A geological, mineralogical and genetic reconstitution from I. Domeyko collection of the University la Serena, Chile: Mineral. Polonica, v. 25, p. 59-68. Authors at Univ. Serena, Casilla 554, La Serena, Chile.

The Condoriaco Ag district had a high economic significance at the end of XIXth century. As these deposits were intensely mined, the testimony of the I. Domeyko collection at the Mineralogical Museum of La Serena University has been much helpful to understand the district formation environment.

The Condoriaco deposit is located in early Tertiary andesitic and rhyolitic rocks that crop out in an almost circular structure, 29 km in diameter, interpreted as a subsidence caldera. Sulphides paragenesis is represented by argentite, pyrargyrite, polybasite, chalcopyrite, pyrite, galena, arsenopyrite, bornite, sphalerite and tetrahedrite-tennantite in a quartz, calcite and barite gangues. The F phase is characterized by a salinity of 5-21 wt % NaCl eq. T obtained from FI for the hydrothermal event range from 340 to 160°C, with a sulphides paragenesis developed between 290 and 220°C.

Considering the thermal and salinity conditions the deposit generation model can be considered as an epithermal system with an intermediate salinity. (Authors' abstract)

D'ALESSANDRO, Walter, DONGARRÀ, Gaetano, GURRIERI, Sergio, PARELLO, Franco and VALENZA, Mariano, 1994, Geochemical characterization of naturally occurring fluids on the Island of Pantelleria (Italy): Miner. Petrogr. Acta, v. 37, p. 91-102 (in English). First author at Inst. Geochimica dei Fluidi, CNR, via Torina 27d, 90133 Palermo, Italy.

Between 1987 and 1990, samplings of both thermal and cold waters (total 70 samples) and free and dissolved gases (73 samples) were carried out on the island of Pantelleria, located between Sicily and Tunisia. The analytical data point to the substantial geochemical constancy in time of the main thermal springs, which are characterized by the following geochemical processes: (1) mixing between local meteoric water and seawater; (2) water-rock interaction at high T with enrichment of Na^+ and K^+ and depletion of Mg^{++} in the F; (3) addition of CO_2 of deep origin. Geothermometric calculations indicate a F source with a T in the range 180-230°C. The C isotope ratios ($^{13}C/^{12}C$) of CO_2 and isotope ratios of He ($^3He/^4He$) indicate the deep origin of these two gases. (From authors' abstract by E.R.)

da SILVEIRA BELLO, R.M., GANDINI, A.L., FUZIKAWA, Kazuo and SVISERO, D.P., 1995, Estudo microtermométrico de inclusões fluidas do topázio imperial da jazida de Boa Vista, Ouro Preto, MG: Rev. Esc. de Minas, Ouro Preto, v. 49, no. 2, p. 111-116 (in Portuguese, English abstract). First author at Geólogia, Msc., Dr.-IGC/USP.

P FI microthermometry of five imperial topaz crystals from the Boa Vista deposit, near Ouro Preto, MG, led to the separation of three different groups according to their Th(CO_2) and V(CO_2)/V_{tot}. The obtained corresponding densities (g/cm^3) are: Group 1 - dCO_2 = 0.951-0.954 and d_{tot} = 0.961-0.977; Group 2 - dCO_2 = 0.936-0.942 and d_{tot} = 0.956-0.988; Group 3 - dCO_2 = 0.668 and d_{tot} = 1.005. The estimated salinities from $Tm_{clathrate}$ varied from 3.8 to 7.6 wt % NaCl eq. in groups 1 and 2. In group 3 the Tm(ice) indicated a much higher salinity of 11.6 to 14.0 wt % NaCl eq. The trapping of FI took place under hydrothermal H_2O and CO_2 unmiscible conditions at the following determined P-T values: Group 1 - T = 230/260°C and P = 1.8/2.25 kb; Group 2 - T = 240/280°C and P = 1.75/2.75 kb; Group 3 - T = 300/320°C and P = 2.2/2.6 kb. These data suggest an initial crystallization of topazes from groups 1 and 2 and at a later stage, after losing most of CO_2 and increasing the salinity of the F, of gemstones from group 3. (Authors' abstract)

da SILVEIRA BELLO, R.M., ORDÓÑEZ, FUZIKAWA, Kazuo, PIMENTA, M.A., SVISERO, D.P. and SCHULTZ-GÜTTLER, R.A., 1995, Caracterização das inclusões fluidas de esmeraldas de Muzo, Pacho, Pacho, Coscuez e Yacopí, Colômbia: Rev. Esc. de Minas, Ouro Preto, v. 49, no. 2, p. 127-130 (in Portuguese, English abstract).

Emeralds have been exploited in the central part of the Eastern Andean Range in Colombia. In this paper we present some recent data on the FI of emeralds from the localities of Muzo, Pacho, Coscuez and Yacopi. The emerald-greenish beryls are found associated with calcite in vugs, lenses and breccia faults in weakly metamorphosed sedimentary rocks of the Late Cretaceous.

Our studies revealed the presence of abundant FI displaying complex compositions. The I contain brines (Na^+, K^+, Ca^{2+} and probably Mg^{2+} and Al^{3+}) as well as variable contents of CO_2 and small amounts of N_2. The solutions have relatively high densities and salinities (37-44 wt % NaCl eq.) and were trapped at T of 29-300°C and P of 1.2-1.8 kb.

The source of NaCl and KCl could be related to the Late Cretaceous evaporites widespread throughout the area around the deposits. In addition, solutions containing these and other salts probably percolated faults of Cretaceous or Tertiary age. Further interactions between country rocks and sulphate-rich and carbonate-rich solutions at shallow depths could have led to the compositions presently observed. (Authors' abstract)

DALPÉ, Claude, BAKER, D.R. and SUTTON, S.R., 1995, Synchrotron X-ray-fluorescence and laser-ablation ICP-MS microprobes: Useful instruments for analysis of experimental run-products: Canadian Mineral., v. 33, p. 481-498. First author at Dept. Earth and Planetary Sciences, McGill Univ., Montreal, Quebec H3A 2A7, Canada.

The synchrotron X-ray-fluorescence microprobe (SXRFM) and laser-ablation microprobe with inductively coupled plasma-mass spectrometer (LAM-ICP-MS) have been found to be efficient instruments for the accurate measurement of a large suite of trace elements in natural and synthetic minerals and glasses. The small beam-sizes of both instruments (10 and 34 µm in diameter for SXRFM and LAM-ICP-MS, respectively) permit *in situ* analysis of samples whose cross-section is at least 7500 µm^2 (i.e., corresponding to a sampling area of 50 × 150 µm analyzed by LAM-ICP-MS in rastered grid). This sampling technique applied to LAM-ICP-MS avoids sample damage and minimizes the depth of penetration by the laser using a single hole. Optimization of both instruments was carried out using two in-house basaltic glass standards. The lower limits of detection of the SXRFM for Rb, Sr, Y, Zr and Nb are ~5.5 ppm or less, based upon our in-house standards, and the analyses have an associated precision of ±20% relative. The lower limits of detection of the LAM-ICP-MS are ~2‰ or less; these analyses have a precision of ±10 to 15% relative. (From authors' abstract by E.R.)

Particularly pertinent to analysis of MI. (E.R.)

DAMIAN, G., NEDELCU, L. and ISTVAN, D., 1995, Excursion A: Two representative vein deposits (Au-Ag and Pb-Zn) related to Neogene volcanic structures: Romanian J. Mineral., v. 77, p. 45-63.

DANGIC, Adam, 1993, Tertiary lead-zinc ore deposits and calco-alkaline magmatism of the Serbo-Macedonian Province: Metallogenic and geochemical characteristics, hydrothermal systems and their evolution: Ann. Géol. Penins. Balk., v. 57, p. 257-285 (in Russian; extended English summary). Author at Univ. Belgrade, Faculty of Mining and Geology, Djusina 7, Belgrade, Yugoslavia.

The Serbo-Macedonian metallogenic and magmatic province extending over central parts of the Balkan Peninsula is characterized by numerous Pb-Zn ore deposits belonging to the Alpidic metallogenic epoch, which associate with the calco-alkaline volcano-intrusive magmatic complexes of Tertiary age. Both magmatism and metallogeny are nearly similar in all the six magmatic-metallogenic districts of the province. The ore assemblages and wall rock alteration phenomena indicate the same mechanism of ore deposition over the province, and geochemical evolution trends of magmatism and isotopic composition of Pb and S indicate a genetic relation of magmatism and ore deposits. Based on geochemistry of ore assemblages, wall rock alteration, FI studies and geochemical thermometry, hydrothermal F composition and evolution as well as ore deposition processes are considered. (Author's abstract)

DANYUSHEVSKY, L.V., 1995, Mineralogical constraints on primary melt compositions (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-22. Author at Geol. Dept., Univ. of Tasmania, Hobart, Tasmania, 7001, Australia.

Our study [of Tongan high-Ca boninites?] has shown that melts in equilibrium with Fo_{94} had very high MgO (18-24 wt %). These estimations are significantly higher than is generally accepted for arc primitive melts, and indicate higher degrees of melting in the mantle wedge.

Given that the compositions of "primary" melts are known, their crystallization T (i.e., T of equilibrium with olivine) are a function of melt H_2O content. Our study, based on H_2O contents of MI in olivine phenocrysts, has show that H_2O contents of "primary" arc melts do not exceed 3-3.5 wt %. This suggests that crystallization T of these melts are in the range 1300-1380°C and estimated T of equilibrium with the mantle sources are >1400°C. Our experimental study of MI yielded the same results. Such T are significantly higher than generally proposed for the mantle wedge, and require modification to the geodynamic models of low-Ti arc magmatism. Our preferred explanation is the involvement of deep mantle sources (i.e., deep mantle plumes) in arc low-Ti magma genesis.

A geodynamic model for the origin of the north Tongan high-Ca boninites has been developed. It includes penetration of the hot Samoan plume mantle, previously depleted by separation of Samoan OIB, into the mantle wedge and subsequent melting caused by the reaction with subduction-derived F. (From authors' abstract by E.R.)

DANYUSHEVSKY, L.V. and FALLOON, T.J., 1995, Origin of high-An (An >90) plagioclases in high-Ca boninites (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-22. Authors at Geol. Dept., Univ. of Tasmania, Hobart, Tasmania, 7001, Australia.

A considerable effort has been made in recent years to understand plag-melt equilibria, and a number of models describing hydrous and anhydrous system has been developed. However, our study of Tongan high-Ca boninites revealed that plag phenocrysts in these rock are much more calcic than can be predicted by existing models.

An experimental study of MI in plag phenocrysts An_{87-91} from primitive plag+pyx+ol-phyric boninite 3-24 (MgO = 10.8 wt %) was performed using a 1 atm heating stage which allows visual control of experiments and rapid quenching. The study demonstrated that these plagioclases crystallized at 1040-1080°C. These T correspond to the moment of complete homogenization of I, i.e., disappearance of the F bubble inside I. The melt composition, established by analyzing quenched MI after experiments (average of five I, wt %, $SiO_2 = 66.4 \pm 3.0$, $TiO_2 = 0.42 \pm 0.03$, $Al_2O_3 = 13.9 \pm 0.4$, $FeO^* = 7.0 \pm 1.0$, $MgO = 1.7 \pm 0.4$, $CaO = 6.5 \pm 0.7$, $Na_2O = 2.20 \pm 0.08$; $K_2O = 0.94 \pm 0.10$; $P_2O_5 = 0.10 \pm 0.02$), is characterized by a very low CaO/Na_2O value of 2.9. This composition is identical to the average in 15 unheated naturally-quenched glassy MI in plagioclases An_{88-94}, and to the composition of the natural glass from this same sample, and of evolved rocks from this suite. A good correlation exists between host An and I compositions (SiO_2, Al_2O_3, FeO, MgO, CaO, CaO/Na_2O). This correlation holds for both homogenized and unheated I, and is consistent with a L line of descent along the plag+pyx cotectic. The lack of post-trapping modification of I compositions, and the similarity between the compositions of I and natural glasses indicated that these plag phenocrysts formed during the final ascent to eruption. Thus the Tt (i.e., crystallization T) is close to the eruption T of the evolved melts from the suite. Samples from this suite which have more primitive natural glass compositions (i.e., higher MgO and CaO/Na_2O) do not contain plagioclase phenocrysts, which is a independent indication that these plagioclases crystallized from very evolved melts.

Available models on plag-melt equilibria predict plag compositions $<An_{75}$ in equilibrium with such melts ($CaO/Na_2O <3$; H_2O contents <2 wt %). Our results indicate that some additional factor(s) must exist which control plag-melt equilibria and which have not been yet accounted for. Also, our results demonstrate that the presence of high-An plag phenocrysts does not necessarily indicate the involvement of highly refractory ($CaO/Na_2O >10$) melts in the petrogenesis of magmatic suites where they are present. (Authors' abstract)

DANYUSHEVSKY, L.V., McNEILL, A.W. and BLUNDY, J., 1995, Melt inclusions in high-AN plagioclases (AN > 88-95) from MORB and high-Ca boninites (abst.): Eos, v. 76, no. 17, p. S267. First author at Dept. Geology, Univ. Tasmania, GPO Box 252C, Hobart, TAS 7001, Australia.

Experimental study of MI was performed under optical control using a heating stage (Sobolev et al., Proc. 11th LPSC, 1980). MORB plagioclases from ODP hole 896A crystallized at 1195-1215°C, those from Gorda Ridge at 1210-1225°C. Homogenized I from Gorda plagioclases have similar MgO (9.5-10 wt % vs. 9-9.5 wt % of 896A) but lower FeO* content (7.5-8 vs. 8.5-9.5 wt %). AN correlates with CaO/Na_2O of I for each suite; however, the 896A I have higher CaO/Na_2O and lower Al_2O_3 than Gorda I in equilibrium with similar AN; also, a significant range of AN is in equilibrium with m of similar MgO. Homogenized and unheated I from both suites have variable TiO_2, which are lower or equal to those of pillow-rim glasses at similar MgO. Vairations in TiO_2 are not correlated with other elements. Incompatible trace element concentrations in the 896A I resemble those of pillow-rim glasses. Some 896A I have higher LILE than pillow-rim glasses but "unmodified" REE and HFSE. The 896A plagioclases cocrystallized with olivine Fo_{86-87}, Gorda plagioclases with $Fo_{90-90.5}$. The former crystallized from M which underwent 15% of olivine crystallization, the latter from nearly primary M. Plagioclases from Tongan high-Ca boninites crystallized at 1040°C from evlved (2 wt % mgO) H_2O-saturated M with low CaO/Na_2O of 3, which resemble evolved rocks and pillow-rim glasses of this suite. Thus, the presence of high-AN plagioclases in arc magmas does not imply the existence of refractory primary M. (Authors' abstract)

DARCE, Mauricio, DOWN, Miriam, LEVI, Beatriz, MARTÍNEZ, Ernesto, PÉREZ, Magdalena and SABATINO, Giuseppina, 1995, Similarities and differences between the Momotombo geothermal field and the La Libertad gold deposit, Nicaragua: Rev. Geol. Amér. Central, v. 18, p. 95. First author at Empresa Minera de Occidente, PO Box RP-01, Managua, Nicaragua.

Measurements of FI in vein quartz from La Libertad give lower T than those inferred from the alteration assemblages in the host

DE JONG, G. and WILLIAMS, P.J. 1995
A summary of observed melting behaviours of halite-bearing aqueous solution in the system $NaCl-CaCl_2-H_2O$ is included:

Observed melting behavior	Observed temperatures (°C)	Interpretation
Dark blackish browning, glassy and occasionally decrease or sudden collapse of vapour bubble	-75 to -54	Melting of metastable $CaCl_2$-hydrate
Coarser granular appearance than above, more brown than black	-65 to -44	Eutectic melting and recrystallizing ice
Inclusions become lighter, rim of melt visible, still granular, fewer grains but coarser, still brown	-45 to -20	Melting of $CaCl_2$-hydrate grains and occasionally hydrohalite and H_2O-ice
Brown colour disappears, still coarse, granular.	-45 to -30	All hydrohalite melted
Colourless inclusions, with fewer larger subrounded cubes starting to melt, more liquid, bubble movement	-50 to -10	Final melting of ice (low melting T due to metastability of ice)
Occasionally sudden movement of bubble, due to melting of clear lath-like crystals with similar refractive index to liquid	-10 to +10	Possibly final melting of $CaCl_2$-hydrate; only observed occasionally

(From authors' text by E.R.)

rock, showing that the epithermal veins formed after the alteration, during the cooling of the geothermal system. We suggest that the Momotombo geothermal field is a modern analogue of the partly eroded fossil field at La Libertad, but that cooling, hydraulic fracturing and infilling of fractures with (auriferous) quartz has not started yet at Momotombo. (From authors' abstract by H.E.B.)

DARLING, W.G., GRIESSHABER, E., ANDREWS, J.N., ARMANNSSON, H. and O'NIONS, R.K., 1995, The origin of hydrothermal and other gases in the Kenya Rift Valley: Geochim. Cosmochim. Acta, v. 59, p. 2501-2512.

DE GOUTIÉRE, A., 1995, Photogenic inclusions in moldavite: J. Gemm., v. 24, no. 6, p. 415-419.

Natural glasses in the form of tektites are found in many regions around the world. This article with accompanying photographs is intended to acquaint the reader with the unusual and very photogenic I and occasional occlusions that occur in the moldavite tektites from two southern areas of former Czechoslovakia. This article also looks briefly at tektite specimens from Thailand. (Author's abstract)

DE JONG, G. and WILLIAMS, P.J., 1995, Giant metasomatic system formed during exhumation of mid-crustal Proterozoic rocks in the vicinity of the Cloncurry Fault, northwest Queensland: Australian J. Earth Sci., v. 42, p. 281-290. Authors at Nat'l Key Centre in Economic Geology, Dept. Geology, James Cook Univ. North Queensland, Townsville Qld 4811, Australia.

Metasomatism and vein emplacement occurred under a range of retrograde conditions during the transition from a compressional regime in a ductile regional metamorphic environment, through late- to post-orogenic granitoid emplacement, and ultimately high-level brittle faulting. The dominant sodic-calcic alteration occurred in multiple overprinting F buffered systems at 400-500°C with P initially <200 MPa. Complex hypersaline $H_2O-NaCl-CaCl_2-KCl-(?FeCl_2)$ F with high Ca:Na ratios were present at all stages. The main controls on the nature of metasomatic products were probably T, P and the direction of F flow with respect to the geothermal gradient. The large volumes, high salinities and oxidized nature of the F responsible for alteration close to the Cloncurry Fault indicate that these could have played a significant role in the regional metallogeny through the mobilization of metals. (From authors' abstract by H.E.B.)

DE LAS CUEVAS, C. and PUEYO, J.J., 1995, The influence of mineralogy and texture in the water content of rock salt formations. Its implication in radioactive waste disposal: Appl. Geochem., v. 10, p. 317-327. Authors at LIFS, Dept. Geoquimica, Univ. Barcelona, 08028 Barcelona, Spain.

The consideration of the use of salt formations as possible radioactive waste disposal sites led us to attempt to determine the extent to which their brine content could influence the performance of the disposal system. Bedded rock salt from the Cardona, Zaragoza and Guendulain Fms., as well as diapiric rock salt from northern and SE Spain, have been selected and their water contents characterized by thermogravimetry. Free water content (intergranular water and water in FI) in the studied formations ranges from 0.01 to 1.24% wt. In addition, the presence of hydrated minerals increases the amount of total water in the rock (≤3.5%). Clear differences between the studied formations are observed in the total amount of water and in the form of water entrapment in rock salt. The results obtained have allowed the classification of the studied rock salt formations with respect to their free-brine content as water-poor (~0.1% in average), intermediate water-rich (~0.2%) and water-rich (>0.3%). The petrographical features of the rock salt, such as mineralogical content and halitic textures, play an important role in its water content. Whilst brine in FI is related to the halite texture, intergranular brine depends mainly on the content of clay and sulphate minerals. (Authors' abstract)

de OLIVEIRA FORTES, P.T.F., GIULIANI, Gaston and COELHO, R.F., 1995, Estudo de inclusões fluidas em corpos de minério dos depósitos auríferos Mina III e Mina Inglesa, *greenstone belt* de Crixás, GO: Rev. Esc. de Minas, Ouro Preto, v. 49, no. 2, p. 111-116 (in Portuguese, English abstract).

FI studies on the ore bodies from Mina III (massive sulphide from the Upper Ore Zone and quartz vein from the Lower Ore Zone) and Mina Inglesa (quartz vein) Au deposits, Crixás greenstone belt, Goiás, have revealed the presence of different associations of early F associated to the mineralizations. At Mina III, petrographic, microthermometric and Raman data suggest a process of heterogeneous trapping (immiscibility) involving carbonic, aqueous-carbonic and aqueous F ($H_2O-NaCl-CO_2-CH_4-N_2$ system) and lithological control to the generation of saturated aqueous-carbonic F ($H_2O-NaCl-KCl-CO_2-CH_4-N_2$ system) and CH_4-N_2 rich F ($(H_2O)-CH_4-N_2-(H_2S-C_2H_6)$ system). These three F were trapped penecontemporaneously, with no or little partial mixing and under similar T conditions (~350°C). At Mina Inglesa, petrographic and microthermometric data indicate the occurrence of aqueous F which have percolated under lower T conditions (~230°C). In both Au deposits FI T data are compatible with the mineral paragenesis of retrometamophic hydrothermal alteration (greenschist facies) related with the mineralization. (Authors' abstract)

DE PAOLI, G.R. and PATTISON, D.R.M., 1995, Constraints on temperature-pressure conditions and fluid composition during metamorphism of the Sullivan orebody, Kimberley, British Columbia, from silicate-carbonate equilibria: Can. J. Earth Sci., v. 32, p. 1937-1949. Authors at Dept. Geology and Geophysics, Univ. Calgary, Calgary, Alberta T2N 1N4, Canada.

The Sullivan mine, one of the world's largest sediment-hosted massive sulphide deposits, has undergone at least one period of metamorphism since it was deposited in mid-Proterozoic times. Estimates of metamorphic conditions were estimated using multiequilibrium thermobarometric techniques involving silicate-carbonate-F equilibria. Peak metamorphic T constrained by calibration of the garnet-biotite Fe-Mg exchange equilibrium is 450 ± 50°C. Peak metamorphic P as determined from equilibria applicable to the assemblage garnet-biotite-muscovite-chlorite-calcite-quartz-F is 380 ± 100 MPa. The F composition accompanying this P estimate is $XH_2O = 0.38$, $XCO_2 = 0.62 \pm 0.07$. This estimate is particular to one sample and may not be representative for the deposit as a whole. Metamorphic F at the estimated P-T conditions would not have contained significant concentrations of C-O-H-S species other than H_2O and CO_2. (From authors' abstract by E.R.)

DE RONDE, C.E.J., 1995, Fluid chemistry and isotopic characteristics of seafloor hydrothermal systems and associated VMS deposits: Potential for magmatic contributions: Mineral. Assoc. Canada Short Course, v. 23, p. 479-509.

An extensive review, including tables summarizing the FI data from the literature on 20 VMS deposits and 11 hydrothermal systems hosted by oceanic crust. Evidence of phase separation, salinity, Th, isotopic data, etc. (E.R.)

DE VIVO, B. and FREZZOTTI, M.L., editors, 1994, Fluid Inclusions in Minerals: Methods and Applications: Short Course of the Working Group, "Inclusions in Minerals," Pontignano (Siena), 1-4 Sept. 1994, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, 376 p.

Individual papers abstracted in FIR, v. 27. (E.R.)

DE VIVO, B., TOROK, K., AYUSO, R.A., LIMA, A. and LIRER, L., 1995, Fluid inclusion evidence for magmatic silicate/saline/CO_2 immiscibility and geochemistry of alkaline xenoliths from Ventotene Island, Italy: Geochim. Cosmochim. Acta, v. 59, p. 2941-2953.

Full paper for next item. (E.R.)

DE VIVO, B., TOROK, K. and LIMA, A., 1995, Magmatic silicate/saline/CO_2 immiscibility: Other evidence from Ponza Island, Pontine Archipelago, Italy (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 54-55. First author at Dip. Geofisica e Vulcanologia, Largo S. Marcelino 10, 80138 Napoli, Italy.

Ponza, one of the islands of the Pontine Archipelago is located in the Gulf of Gaeta. This area is part of the Tyrrhenian volcanism of the Roman alkaline province.

FI, mainly in potash feldspar, were measured from a foid-bearing syenite xenolith entrained in trachite. The foid-bearing syenite consists of potash feldspar, clinopyroxene, amphibole, biotite, nosean and accessory sphene, opaques and apatite. They can be divided into three categories:

(1) Large, one-phase V, or silicate MI. (2) Two-phase I: (a) V-dominated, V + L aqueous I with a small amount of CO_2 in most cases. The presence of the CO_2 was proved by the formation of the CO_2 clathrate on cooling. Homogenization of the I always occurred to the V phase between 359 and 424°C. Salinities vary from 2.9 to 8.5 wt % NaCl eq. (b) Silicate M + V I. The silicate M was mostly colourless, transparent, but in some cases it has been observed pale brown and devitrified. The V/silicate M ratio is highly variable, indicating nonhomogeneous trapping of these two phases.

(3) Three phase and multiphase I. Hypersaline aqueous I, sometimes with ≤8 or more solid phases. Isotropic, cubic dms (≤5 in one I), [dissolve] on heating; they are thought to be NaCl, and possibly KCl. The birefringent phases may or may not dissolve on heating. Some I contain acicular minerals (≤3), which seem to be isotropic, or slightly birefringent. The acicular phase is soluble on heating, and this is the last to dissolve and the first to reappear on cooling. The opaque phase is rather an accidentally trapped mineral, because it is absent from most of the I. Some hypersaline I may contain a small amount of silicate M as well.

SEM analyses revealed the existence of Na, K, Ca chlorides; Ca, K sulphates; Fe-Mn oxides (or hydroxides), pyrite and potash feldspar as daughter and accidentally trapped minerals in the multiphase hypersaline I.

Hypersaline I occur in clusters together with V/silicate MI, but with no significant difference in Th or in salinity. Melting of the NaCl dxls occur between 459 and 536°C which means a salinity range from 54 to 65 wt % NaCl eq. The last phase transition [on heating] is the homogenization of the V bubble between 640 and 755°C.

Though the evidence for immiscibility between the silicate M and the hydrosaline M is not as spectacular as in the similar alkali syenite xenolith of the Ventotene island (De Vivo et al., Geochim. Cosmochim. Acta, in press), it is quite clear that the associated aqueous hypersaline/V/silicate MI unmixed at magma conditions at subvolcanic level. The V-rich aqueous $\pm CO_2$ I are the trace of a later high T hydrothermal F. (From authors' abstract by E.R.)

See also previous item. (E.R.)

DEINES, Peter and HARRIS, J.W., 1995, Sulfide inclusion chemistry and carbon isotopes of African diamonds: Geochim. Cosmochim. Acta, v. 59, p. 3173-3188. First author at Dept. Geosciences, Pennsylvania State Univ., University Park, PA 16802.

Significant differences in the composition of sulfide mineral I among various diamond suites have been found. The current observations, in conjunction with other chemical properties of diamonds suggest that F reactions rather than silica M equilibria may be important in diamond formation. A dominance of F processes would have significant implications for the interpretation of the chemical and geochronological record of diamond I. (From authors' abstract by E.R.)

DELITSYN, L.M., 1995, Partition of strontium and the REE between phosphate and silicate liquid phases during liquation of an urtite magma: : Dokl. Ross. Akad. Nauk, v. 341, no. 4, p. 527-531 (in Russian).

The "system" apatite-urtite-NaF was examined at 1200, 1300 and 1400°C. L immiscibility was widespread; the REE were strongly enriched in the phosphatic melt. (E.R.)

DELLA-PASQUA, F.N. and VARNE, R., 1995, Primitive ankaramitic magmas in volcanic arcs (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-24. Authors at Geol. Dept., Univ. Tasmania, GPO Box 252C, Hobart, Tasmania, 7001, Australia.

We report the compositions of MI in olivine phenocrysts from four different suites of ancaramites from island arcs (Ulukan Formation, Bali, and Rinjani volcano, Lombok, in the Sunda arc; Merelava and Epi, in the Vanuatu arc). The compositions of homogenised MI in primitive olivines (Fo>90) contain >13 wt % CaO and CaO/Al_2O_3 values >1, consistent with ankaramitic parent melts similar in composition to the most primitive samples in each suite. (From authors' abstract by E.R.)

DELOULE, Étienne, PAILLAT, Olivier, PICHAVANT, Michel and SCAILLET, Bruno, 1995, Ion microprobe determination of water in silicate glasses: Methods and applications: Chem. Geol., v. 125, p. 19-28. First author at CRPG-CNRS, BP 20, F-54501 Vandoeuvre-lès-Nancy Cedex, France.

Ion probe measurements offer the advantage of *in situ* determination of water content with a few micrometers spatial resolution. After a brief review of ion microprobe procedures used for the determination of water concentration in silicates, we examine three important effects on analytical precision: (1) the effect of energy filtering on the background; (2) the variation of the H/Si ratio with time; and (3) the dependence of the H/Si ratio on the composition of the matrix, which requires the use of standards close in chemical composition to the unknowns.

Finally, applications of this method to the determination of water in glasses quenched from water-saturated melts, to experimental products consisting of a mixture of glass and crystals, and to natural MI illustrate the advantages and the limitations of the ion microprobe. (Authors' abstract)

DEMÉNY, A., 1995, H isotope fractionation due to hydrogen-zinc reactions and its implications on D/H analysis of water samples: Chem. Geol., v. 121, p. 19-25. Author at Laboratory for Geochemical Research, Hungarian Acad. Sci., Budaörsi út 45, H-1112, Budapest, Hungary.

After conversion of water to H_2 gas with zinc for D/H ratio determination, H_2 gas can be absorbed by the Zn during cooling, resulting in H isotope fractionation. For measurement of hydrogen isotope composition of geological samples with varying and sometimes unpredictable water content (e.g., FI of minerals) recording a calibration curve of varying water/zinc ratios and JD-values is proposed. (From author's abstract by E.R.)

DEMICCO, R.V. and YAO, Qingjun, 1995, Numerical simulations of dolomitization in the Cambrian Cathedral Formation (Southern Canadian Rocky Mountains) based on dolomite front geometry and fluid inclusion geochemistry (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-275.

Two distinct generations of massive, replacement dolomite occur in the Middle Cambrian Cathedral Formation in the Southern Canadian Rocky Mountains in Alberta and adjacent British Columbia. A widespread, early, fine-grained dolomite preserves sedimentary structures. We mapped the "dolomite front geometry" of a second generation of white dolomite. Second generation dolomites are confined to a belt 10 km wide adjacent to the platform-basin transition. At the platform margin, the second generation dolomite comprises a swarm of vertically-oriented, discordant pipes and dikes with a characteristic brecciated fabric and cement-crystals of dolomite ≤0.2 m in diameter. Associated minor MVT mineralization is common. The white dolomite becomes sheets that thin and branch eastward onto the platform. FI in the dolomite cements yield salinities of 13-25% and Tt of 100-200°C with the highest T at the platform margin.

The dolomite front geometry, T, and salinity data obtained from field mapping served as "targets" for numerical simulations of possible dolomitizing flow systems. Simulations used the JHU2D finite element code of Dr. Grant Garven. Two flow systems were modeled, a topography-driven flow system and a freely convecting system driven by T variations. Both flow systems could account for the geometry, T, and salinity structures observed in the field. However, mass balance considerations show that the topography-driven flow system modeled accomplished the dolomitization in ~2.5-3 m.y. whereas the freely convecting model took 40-60 m.y. (Authors' abstract)

DEMIKHOV, Y., FOMIN, Y., VITYK, M. and SHIBETSKY, Y., 1995, Isotope composition of the water oxygen in fluid inclusions of oxygen-containing minerals: Dopovidi Nat'l Acad. Sci. Ukraine, no. 2, p. 90-93 (in Russian, English abstract).

Isotope O and H compositions of H_2O I in various minerals from different age deposits have been measured. The I were opened by means of mechanical crushing of analyzed samples in vacuum. The coincidence between $\delta^{18}O$ values of F H_2O in coexisting quartz and sulphides, Th and those calculated from the difference in mineral-F H_2O $\delta^{18}O$ values, H_2O $\delta^{18}O$ independence of mineral $\delta^{18}O$ and of age testify to preservation of the O isotope composition of H_2O FI in O minerals and to a possibility of getting the true $\delta^{18}O$ mineral-forming F. (Authors' abstract)

DEMING, David, 1994, Fluid flow and heat transport in the upper continental crust, *in* J. Parnell, ed., Geofluids: Origin, Migration and Evolution of Fluids in Sedimentary Basins: Geol. Soc. (London) Spec. Publ. No. 78, p. 27-42. Author at School of Geology and Geophysics, Univ. Oklahoma, Norman, OK 73019.

The upper 10-15 km of the continental crust is saturated with aqueous brines and is sufficiently permeable to allow the circulation of these F. The most important driving forces for F flow in the continental crust are topography gradients, sediment compaction and diagenesis, and buoyancy forces. Topographically-driven flow is generally the most efficient mechanism for mass and heat transport, and therefore has recently been favoured in theories of the origin of MVT Pb-Zn deposits. The magnitude of heat transport by F movement in the crust has an exponential dependence upon the depth of circulation. In areas of the continental crust with appreciable topography gradients (c. 0.01) and permeabilities >c.10^{-17} m^2, the background thermal state will likely be appreciably perturbed by groundwater movement. F circulation in the upper crust is both continuous and pervasive due to topography and F-density gradients. The old conception of the continental crust as an unchanging body of solid rock should be replaced by a paradigm that recognizes the continental crust as a two-component system; a solid framework which continuously evolves through thermal, chemical, and mechanical interaction with crustal F. (Author's abstract)

DENWER, K.P., LEACH, T.M. and MOWAT, B.A., 1995, Mineralisation of the Morobe goldfield, Morobe Province, Papua New Guinea: PACRIM '95, p. 181-185. First author at RGC (PNG) Exploration, PO Box 84, Wua, Papua New Guinea.

It is proposed that magmatic F which evolved from parent melts to the high level Edie porphyry stocks mixed with convecting meteoric F and were channeled along major structure and diatreme contacts. Proximal to the intrusives, Au mineralisation is associated with deposition of pyrite-hematite-quartz ± magnetite-Au (Hamata) and pyrite-basemetals-quartz-Au (Wau). The mineralising F were hot, and periodically saline due to pulses of magmatic F.

CO_2 and H_2S gases which evolved off the upwelling hydrothermal F as a result of boiling and P reductions condensed within superficial groundwater and formed cool oxygenated bicarbonate F. These F percolated back down the structures, depositing manganocarbonate in the upper parts of the hydrothermal system. At deeper levels in the system mixing of the descending bicarbonate F with upwelling mineralised F deposited manganocarbonate-quartz-sulfide-nonrefractory Au (Hidden Valley, Wau and Edie Creek).

At Kerimenge the cool bicarbonate F have also quenched a late stage magmatic F rising along high permeability structures. The quenching has resulted in deposition of non-refractory Au mineralisation associated with hessite (Ag_2Te)-tennantite-chalcopyrite deposition.

Within the Morobe Goldfield, a transition from deeper level pyrite-quartz ± hematite-magnetite to intermediate level quartz sulfide and quartz-carbonate-sulfide deposition to upper level, massive manganocarbonate deposition is recognized. Au mineralisation can occur within all levels up the system.

Summary of Fluid Inclusion Data*

Location	Th Range	wt % NaCl eq.
Wau	210-295°C	<1 wt %
Edie CK	190-290°C	0.8 to 2.4%
Hidden Valley	No data	
Kerimenge	145-296°C	0 to 2.1%
Hamata	292-344°C	3.2 to 7.7%

*All FI simple L-rich, no V-rich I, no dp FI host minerals (S-quartz and carbonate(?)). (From authors' text by S. Simmons)

DEVINE, J.D., GARDNER, J.E., BRACK, H.P., LAYNE, G.D. and RUTHERFORD, M.J., 1995, Comparison of microanalytical methods for estimating H_2O contents of silicic volcanic glasses: Am. Mineral., v. 80, p. 319-328. First author at Dept. Geological Sciences, Brown Univ.., Providence, RI 02912.

Three methods of estimating H_2O contents of geologic glasses are compared: (1) ion microprobe analysis (secondary ion mass spectrometry), (2) Fourier-transform infrared spectroscopy (FTIR), and (3) electron microprobe analysis using the Na decay-curve method. Each analytical method has its own advantages under certain conditions, depending on the relative importance of analytical accuracy, precision, sensitivity, spatial resolution, and convenience, and each is capable of providing reasonably accurate estimates of the H_2O, or total volatile, content of geologic glasses. The accuracy of ion microprobe analyses depends critically on the availability of well-characterized hydrous standard glasses. Precision is often >0.2 wt % (1σ). The method provides good spatial resolution (~15 μm) and the capability to determine simultaneously the abundance of other volatile species of interest (e.g., F, B). FTIR spectroscopy provides excellent analytical sensitivity (~10‰), accuracy and precision (<0.1 wt %), and the capability to determine the abundance of H_2O and CO_2 species (H_2O, OH^-, CO_2, CO_3^{2-}) in analyzed glasses, although the spatial resolution (>25-35 μm) is not as good as that of the ion microprobe. The main advantages of the estimation of H_2O contents of hydrous glasses using the electron microprobe are excellent spatial resolution (~10 μm) and analytical convenience. The disadvantages are that accuracy and precision (>0.5 wt %) are not as good as those associated with the other methods, but, for certain applications, these uncertainties may be acceptable for the estimation of H_2O contents of H_2O-rich (>1 wt %) samples. (Authors' abstract)

DEWERS, Thomas and HAJASH, Andrew, 1995, Rate laws for water-assisted compaction and stress-induced water-rock interaction in sandstones: J. Geophys. Res., v. 100, no. B7, p. 13,093-13,112.

DHANA RAJU, R., ROY, M., PANDA, A. and RAO, M.V., 1995, Fluid flow during contact metamorphism: Petrographic evidence from the uranium prospect at Tummalapalle in the southwestern part of Cuddapah basin, India: J. Geol. Soc. India, v. 45, p. 439-444.

Indexed under FI. (E.R.)

DIAMOND, L.W., 1995a, Fluid inclusions as samples of fluids in the lithosphere: Advances in methodology: Habilitation thesis, Univ. Bern, 117 p.

This thesis contains an introductory chapter, followed by six chapters, each a previously published paper, as follows:

Chapter 2	Diamond, 1994a, FIR, v. 27, p. 31;
Chapter 3	Diamond, 1995a (this volume);
Chapter 4	Diamond, 1992c, FIR, v. 225, p. 56;
Chapter 5	Diamond, 1994b, FIR, v. 27, p. 32;
Chapter 6	Diamond et al., 1990, FIR, v. 23, p. 41;
Chapter 7	Diamond et al., 1991, FIR, v. 24, p. 47. (E.R.)

DIAMOND, L.W., 1995b, Isochoric paths in multicomponent fluids and the interpretation of fluid inclusions (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 56-57. Author at Mineralogisch-Petrographisches Inst., Univ. Bern, Baltzerstr. 1, CH-3012 Bern, Switzerland.

FI in minerals are usually considered in the context of a simple thermodynamic model which states that their bulk compositions and total volumes are fixed as constants during initial F entrapment. Hence in the ideal case, FI are constrained to follow isochoric-isoplethic paths through P-T space, both in nature and during microthermometry. In an influential paper on the systematics arising from the ideal isochoric-isoplethic model, Pichavant et al. (1982, p. 7-8) claimed to prove by phase-rule analysis that isochoric paths may transect a given phase boundary only once. Thus, they discredited reports in the literature (summarised by Roedder, 1984, p. 51-52) of reversible bubble reappearances in natural FI. Their work also implies that the experimental work on CO_2-H_2O-NaCl F by Frantz et al. (1992) could not be correct.

In the present communication it will be shown that the generalisation of Pichavant et al. (1982) is false. The implications for FI interpretation are therefore reconsidered, both with respect to reconstructing geological environments of paleofluid activity, and with respect to microthermometric analysis.

The deduction of Pichavant et al. (1982) regarding the general nature of isochoric paths is based on an erroneous application of the phase rule. In fact, there is no general thermodynamic reason why an ideal FI trajectory cannot intersect the same equilibrium phase boundary many times.

A growing body of evidence from FI and from synthetic isochoric systems suggests that multiple intersections indeed occur and are important for the understanding of natural, multicomponent F ($C \geq 2$), particularly with regard to the extent of immiscibility at elevated P-T conditions. For example, Figure 1 shows a P-T projection of a hypothetical isopleth in a volatile-bearing, saline aqueous system (based in part on data in Frantz et al., 1992). The fine line passing through points 1-3 represents an isochoric path. FI trapped on the isochore above point 3 would show homogenisation by V expansion at point 1, followed by reappearance of the L at point 2, followed by disappearance of the L again at point 3. Such a phase diagram could explain some of the unusual observations reported in the literature (Roedder, 1984, p. 51-52).

Cases such as Figure 1 cannot be interpreted in the same way as FI with only one intersection of an immiscibility boundary. If an assemblage of FI with the depicted V-X properties shows petrographic evidence for homogeneous trapping, there is no way to deduce from the I data alone, whether the F was trapped on the isochore between points 1 and 2, or above point 3. Conversely, if petrography indicates heterogeneous trapping, microthermometry does not yield a unique Tf. There are three possible P-T points of entrapment (1, 2 and 3) and these could be distinguished only by examining the P-V-T-X properties of cogenetic I which trapped the conjugate immiscible F.

The consequence for microthermometry is that reproducibility and reversibility are the only criteria available to substantiate unusual phase transitions. Artifacts of non-ideal behaviour are still possible, however, and the feasibility of suspected phase equilibria must checked against experimental P-V-T-X data. (From authors' abstract by E.R.)

References:
Pichavant, M., Ramboz, C. and Weisbrod, A. (1982) Chemical Geology, 37, 1-27.
Roedder, E. (1984) Fluid inclusions. Vol. 12. Reviews in Mineralogy, Mineralogical Society of America.
Frantz, J.D., Popp, R.K. and Hoering, T.C. (1992) Chemical Geology, 98, 237-255.

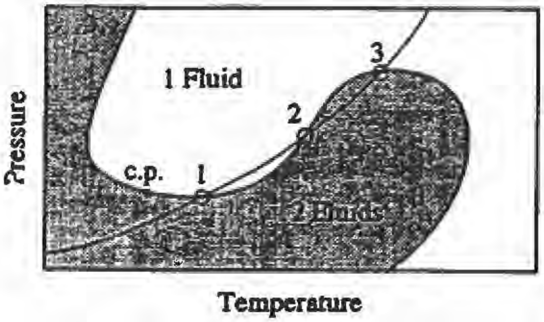


Figure 1

DIEHL, S.F., CLENDENIN, C.W. and LOWELL, G.R., 1995, The Ironton Fault: Additional observations and interpretations of the significance of a Precambrian mylonitic shear zone (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 222.

Indexed under FI. (E.R.)

DILL, H.G., WEISER, T., BERNHARDT, I.R. and KILIBARDA, C.R., 1995, The composite gold-antimony vein deposit at Kharma (Bolivia): Econ. Geol., v. 90, p. 51-66. First author at Bundesanstalt für Geowissenschaften und Rohstoffe, PO Box 51 01 53, D-30631 Hannover, Germany.

The Kharma antimony deposit in the Cordillera Oriental, Bolivia, is representative of vein-type antimony deposits that have stibnite as the only mineral of economic interest and a low Au content. Neither stibnite nor antimony sulfosalts, both of which are major stage II minerals in addition to quartz, is host to appreciable Au concentrations (max 0.8 ppm). FI studies on stage II quartz indicate a Tf of 130° to 234°C. Stage III is characterized by an influx of Ag-bearing solutions at <360°C, which led to the conversion of primary Au (gold I) into argentiferous Au (gold II) and reaction of Au and stibnite to form antimony and aurostibite. (From authors' abstract by E.R.)

DILLES, J.H., FARMER, G.L. and FIELD, C.W., 1995, Sodium-calcium alteration by non-magmatic saline fluids in porphyry copper deposits: Results from Yerington, Nevada: Mineral. Assoc. Canada Short Course, v. 23, p. 309-333(?). First author at Dept. Geosciences, Oregon State Univ., Corvallis, OR 97331.

F responsible for sodic-calcic alteration at Yerington were hypersaline formation waters derived from the Mesozoic volcanic-sedimentary section intruded by the Yerington batholith. (From authors' conclusions by E.R.)

DING, K. and SEYFRIED, W.E., Jr., 1995, In-situ measurement of dissolved H_2 in aqueous fluid at elevated temperatures and pressures: Geochim. Cosmochim. Acta, v. 59, p. 4679-4773.

DINGWELL, D.B., ROMANO, C., MUNGALL, J. and STERNER, S.M., 1995, Properties of fluid-saturated felsic magma derived from synthetic fluid inclusions (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-25. First author at Bayerisches Geoinst., Univ. Bayreuth, 95440 Bayreuth, Germany.

The degassing of magmatic systems occurs by the generation and escape of vesicles containing the saturating phase. Several aspects of the degassing of natural systems and the properties of the F and melt phases present during the process can be studied by the investigation of quenched vesicles in silicate melts using methods developed for the study of FI in crystal hosts. In our investigations, FI are generated by the isobaric rapid quenching of hydrothermal experiments in which a F phase has been equilibrated at elevated P and T with a vesicular melt. To date, H_2O, CO_2 and a noble gas (Xe) have been used as the saturating phase.

The FI in the quenched glasses are investigation by optical methods using heating/freezing stage techniques to determine salinity and Th (homogenization to L). The Th correspond to Tt that represent the freezing in of the L state to a glass at the glass transition. From the consideration of the kinetics of quenching and the properties of the quenched materials, the Tt can be used to define the viscosity, density and thermal expansion coefficient of the L host at the trapping T and P. The long-term and/or high T instability of these FI can also be used to obtain information on the effective tensile strength of the vesicular magma below the glass transition. Water-saturated vesicular glasses have an unusually low tensile strength which almost certainly results from the presence of microcracks in the vesicle walls generated by gradient stresses. Preserved, low-salinity FI may also be suitable for the study of geochemical melt-F partitioning in felsic system using either microanalysis or crushing methods. Currently, such methods are being investigated. (Authors' abstract).

DINI, Andrea, BENVENUTI, Marco, LATTANZI, Pierfranco and TANELLI, Giuseppe, 1995, Mineral assemblages in the Hg-Zn-(Fe)-S system at Levigliani, Tuscany, Italy: Eur. J. Mineral., v. 7, p. 417-427. First author at Dip. Scienze della Terra, Univ. Pisa, via S. Maria 53, I-56100 Pisa, Italy.

A number of minerals of the Hg-Zn-(Fe)-S system occur in the Hg deposit at Levigliani (Apuane Alps, northern Tuscany). The deposit is hosted within phyllitic and metavolcanic rocks of Paleozoic age, which were intensely deformed and metamorphosed to the greenschist facies (~3-4 kb and 350°-370°C) during the Tertiary Apenninic orogeny.

Mineralization is mostly synchronous to the first deformation stage (D_1). Specifically, an earlier, quantitatively more abundant cinnabar I + pyrite + zincian metacinnabar assemblage was deposited at conditions not far from the metamorphic peak. The zincian metacinnabar shows fairly constant chemical composition, with average 7.3 ± 1.2 (1σ) mol % ZnS and 1.4 ± 0.5 mol % FeS. Extrapolation to 3.5 kb of available experimental and thermodynamic data in the system Hg-Zn-(Fe)-S indicates that a zincian metacinnabar with the above composition can coexist at equilibrium with cinnabar at a T of 375°-385°C. Such a range is in good accordance with the above reported estimates of peak metamorphic T, and with calculate Tt for FI in vein quartz (~370°C at P ≈ 3.5 kb).

The earlier assemblage was later overprinted and partially replaced by cinnabar II + mercurian sphalerite ± pyrite. Except for a few optically zoned crystals, mercurian sphalerite has fairly constant HgS and FeS contents (on average 25.3 ± 0.6 mol % and 6.4 ± 0.2 mol %, respectively). P-T conditions for this late assemblage are less constrained; however, by combining phase equilibria with recently proposed post-metamorphic P-T paths of Apuane Alps, indicative upper T and P limits of, respectively, ≈200°C and 1.5 kb can be suggested.

The reasonable agreement between extrapolated conditions and independent P-T estimates suggests that the available experimental and thermodynamic data, although limited, may be cautiously used to model phase equilibria in the HgS-ZnS-(FeS) system in geological environments. The persistence of zincian metacinnabar as a metastable phase through the post-peak metamorphic path down to room T further confirms that Zn (and Fe) severely inhibit the transition from metacinnabar to cinnabar. (Authors' abstract)

DIXON, J.E., STOLPER, E.M. and HOLLOWAY, J.R., 1995, An experimental study of water and carbon dioxide solubilities in mid-ocean ridge basaltic liquids. Part I: Calibration and solubility models: J. Petrol., v. 36, no. 6, p. 1607-1631. First author at Div. Geological and Planetary Sciences, California Inst. Technology, Pasadena, CA 91125.

Experiments were conducted to determine the solubilities of H_2O and CO_2 and the nature of their mixing behavior in basaltic L at P and T relevant to seafloor eruption. (From authors' abstract by E.R.)

DIXON, J.E. and STOLPER, E.M., 1995, An experimental study of water and carbon dioxide solubilities in mid-ocean ridge basaltic liquids. Part II: Applications to degassing: J. Petrol., v. 36, no. 6, p. 1607-1631. First author at Div. Geological and Planetary Sciences, California Inst. Technology, Pasadena, CA 91125.

Degassing processes in basaltic magmas rich in both H_2O and CO_2 can be modeled using the solubilities of the end-member systems and the assumption of Henry's law. (From authors' abstract by E.R.)

DO, H.D., 1990, Fluid inclusions from the gold mines and deposits in Vietnam: Geology of Cambodia, Lao and Vietnam, v. 2, no. 12, p. 71-76. Author at Mineral Development Co., (MIDECO) Vietnam.

Three types of FI have been distinguished through a detailed examination of the characteristics of 13 documented hydrothermal Au mines and deposits in Vietnam. These characteristics include I petrology and Th. The relative value of each of these features for distinguishing Au deposits is estimated.

Three major types are designated: L-rich inclusions (type I), V-rich inclusions (type II) and two-L inclusions (type III). FI studies reveal that the first inclusion type in quartz veins of Paclang mine and Langmo, Camtam, Langneo, Tasoi deposits is characterised by forming T between 198°C and 278°C. In NgamSon and KimBoi areas the second FI type was observed and appeared to form under similar T values [at] a maximum of 294°C and P of 70 atm. The two-L inclusions (type III) have formed in quartz veins of Bocu, Bongmieu and Tranang deposits. Some samples have a maximum Th of 302°C to 311°C, and L solutions often have two or more portions of apparent salinities (29-30% eq. wt % NaCl) and inferred CO_2 content. The FI data show that the most probable depositional T of gold mineralization in Vietnam is therefore in the range 252°C-294°C and clearly post-magmatic. (From author's abstract by E.R.)

DO, H.-D., 1995, Characteristics of hydrothermal and epithermal gold mineralization in Viet Nam: J. Geol. [Vietnam], Series B, no. 5-6, p. 354-363 (in English).

Indexed under FI. (E.R.)

DOBES, P. and DUBESSY, J., 1995, Fluid evolution in bitumen-rich formations of the volcano-sedimentary complex of the Barrandian Upper Proterozoic (Czech Republic) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 58-59. First author at Czech Geol. Surv., Klarov 3, 118 21 Prague 1, Czech Republic

The rocks underwent submarine basalt-sediment-water interaction producing solid bitumen resembling poorly ordered graphite under T of 350-400°C. To aid in the interpretation of F evolution in C-rich formations of low-grade metamorphic terrains FI in bitumen-rich inter-pillow fillings of pillow lavas of the spilitized basaltic andesites and in younger oblique quartz-calcite-axinite veins were studied by optical microthermometry and micro-Raman spectrometry.

The inter-pillow matter consists of quartz, calcite, solid bitumens, chlorite ± pyrite. Calcite of concentric texture growing on lava pillows represents the initial stage of formation of the inter-pillow matter. PI in calcite contain water solution with low salinity (c < 10 wt. % NaCl eq.) and Th between 225 and 315°C with most values in the range of ~250°C.

The majority of the inter-pillow matter is dark-coloured quartz and coarse-grained calcite with an admixture of organic matter with H_2O-rich or CH_4-rich I or I with their mixture. Either H_2O or CH_4 predominates (≤94 mol %) in I. CH_4 (the density of CH_4 = 0.162-0.363 g/cm^3) contains of ~3 mol % of CO_2 and 1 mol % of N_2 +

H_2S. H_2O-rich I have low salinity between 1 and 7 wt. % NaCl eq. and Th in the interval of 135-207°C. The I are believed to be trapped under the conditions of immiscibility of H_2O solution and CH_4. The Th of H_2O-rich I are in this case considered to be the Tt of I and thus the P of trapping (derived from the crossing of the isochores of CH_4-rich and H_2O-rich I) corresponds to 50 to 100 MPa.

Quartz, calcite and axinite of the oblique veins contain H_2O-rich I with Th from 190 to 270°C and variable salinity from 1 to 23 wt. % NaCl eq. Only rarely do secondary H_2O-CO_2 I with variable content of both phases (the density of gaseous phase = 0.615-0.741 g/cm^3, admixture of CH_4 ≤20 mol %) and low salinity occur in vein quartz.

The FI study suggests that the relics of F of various stages of the basalt-sediment-water interaction were trapped in the inter-pillow matter. Formation of the concentric calcite (Th to 315°C) probably corresponds to the initial stage of basalt-H_2O interaction, whereas dark-coloured quartz and calcite formed during successive circulation of H_2O solution rich in SiO_2 and CH_4 (together with organic matter) under lower T ~200°C and P ~100 MPa. (From authors' abstract by E.R.)

DOBES, P., DUBESSY, J. and KOTKOVA J., 1995, Fluid inclusion record in high-pressure granulites of northern Bohemia (Czech Republic) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 60-61. First author at Czech Geol. Surv., Klarov 3, 118 21 Prague 1, Czech Republic.

FI in quartz were studied from various types of granulites. Regardless of the type of granulite, FI were found mostly in quartz porphyroblasts and were distributed virtually only on planes or trails along healed fractures. Several types of I showing large differences in composition and density were distinguished:

(1) $CO_2 >> N_2 > CH_4$, H_2O-free I composed of CO_2 = 84-89 mol %, N_2 = 8-15 mol % and CH_4 = 1-3 mol %. $TmCO_2$ was measured between -59.5 and -60.9°C, $ThCO_2$ = -9.1 to 2.0°C, the density of I corresponds to 0.82 to 0.95 g/cm^3.

(2) $CO_2 > N_2 >> CH_4$, H_2O-free I consisted of CO_2 = 51-65 mol %, N_2 = 33-47 mol % and CH_4 = 1-2 mol %. $TmCO_2$ was observed in the range from -60.0 to -60.7°C, $ThCO_2$ = -5.5 to -6.6°C, only in a few I Th (V) of $N_2 + CH_4$ phase occurred between -145.8 and -146.3°C. The density of I is in the interval 0.30-0.68 g/cm^3.

(3) CO_2-rich I without detectable H_2O, with $TmCO_2$ = -57.1 to -57.8°C, $ThCO_2$ = 13.6 to 30.9°C, density was established to be between 0.48 and 0.84 g/cm^3.

(4) Low density CO_2 I, V-rich only or with ≤30 vol. % of H_2O, $TmCO_2$ = -58.0 to -60.3°C, $ThCO_2$ (V) = 2.6 to 30.8°C. The density of CO_2 was estimated as 0.11-0.41 g/cm^3. $TmCO_2$ clathrate = 8.7 to 9.2°C, corresponding to low salinity from 1.6 to 2.6 wt. % NaCl eq.

(5) Low density N_2-CH_4 I, V-rich only or with ≤20 vol. % of H_2O. Th(V) was observed between -108.0 and -143.5°C, corresponding to density from 0.039 to 0.104 g/cm^3. The V-rich I are composed of 40.3-73.7 mol % of N_2 and 26.3-60.0 mol % of CH_4.

(6) H_2O-rich I. At least three generations of H_2O-rich I were found in the samples. The I with low Th (138 to 192°C and 187 to 274°C) have higher salinity from 4.03 to 6.30 wt. % NaCl eq. and, conversely, the I with high Th (346 to 389°C) have very low salinity between 0.18 and 2.57 wt. % NaCl eq.

Types 1-3 and type 6 form the separate trails or planes, whereas the common occurrence types 4 or 5 and type 6 is obvious. These I were probably trapped under conditions of immiscibility but stretching or leakage cannot be excluded.

Based on the distribution and the P-T path of FI isochores, it is apparent that the trapping conditions of I do not correspond to the peak of granulite-facies metamorphism. FI are thought to be trapped during the late stage of granulite evolution under the conditions of brittle deformation, probably under the conditions of greenschist facies metamorphism. The data suggest that the P-T-t path of granulite rocks is a result of crustal thickening and subsequent tectonic uplift during orogenic collapse following plate collision (Kotkova, 1993). P-T trajectory, reconstructed from the FI data, is convex towards the T axis, i.e. the trapping of I was probably connected with the decompression regime of the late stage of the tectonic uplift of granulite bodies. Since FI correspond to the peak of metamorphism neither in granulite xenoliths nor in undeformed relics of granulite rocks, it is suggested that granulites formed under high-P low-CO_2 virtually F-free environment. (From authors' abstract by E.R.)

See also Dobes and Dubessy, FIR, v. 26, p. 40. (E.R.)

DOBES, P., ZAK, K., VIETS, J. and LEACH, D., 1995, Epithermal Pb-Zn vein mineralization of the Stríbro ore district, Bohemian Massif, Czech Republic: Fluid inclusion and stable isotope study: *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 345-348. First author at Czech Geol. Surv., Prague, Czech Republic.

Pb-Zn hydrothermal vein mineralization of the Stríbro ore region in the Western part of the Bohemian massif has been studied using FI and stable isotope techniques. Obtained data indicate low-T character of the mineralization and participation of more F types. (Authors' abstract)

A complex multistage paragenesis shows four stages of quartz, with dolomite and fluorite between stages 1 and 2, and barite and calcite late (see Fig. 2). (E.R:)

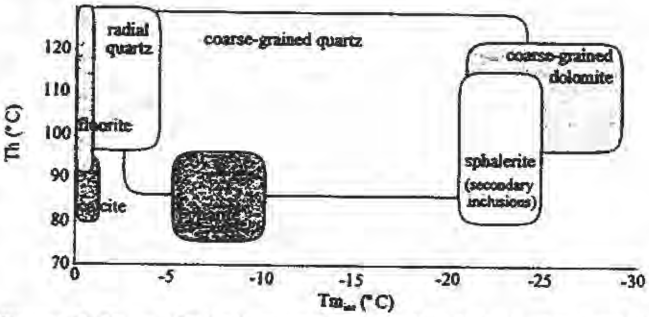


Figure 2. Th vs. Tm(ice) diagram for studied FI in hydrothermal minerals of the Stríbro ore district.

DOBRZHINETSKAYA, L.F., EIDE, E.A., LARSEN, R.B., STURT, B.A., TRØNNES, R.G., SMITH, D.C., TAYLOR, W.R. and POSUKHOVA, T.V., 1995, Microdiamond in high-grade metamorphic rocks of the Western Gneiss region, Norway: Geology, v. 23, no. 7, p. 597-600. First author at Lithosphere Inst., Russian Acad. Sci., Staromonetny per. 22, 109180 Moscow, Russia.

Three grains of microdiamond were recovered from high-grade gneiss exposed in the Western Gneiss region, Norway. Identification and characterization of the diamond grains by Raman and infrared spectroscopy indicate the presence of substitutional impurities of H and N. P FI in garnet and quartz in the diamond-bearing rock demonstrate the evolution of metamorphic volatile F from reduced N_2-CO_2 compositions during the peak phase of metamorphism. Compatible geologic, petrologic, and F composition data imply a metamorphic origin for the microdiamonds; if so, the metamorphic and F conditions recorded by the microdiamonds and gneissic host may be applicable to microdiamond investigations in other high-P, regionally metamorphosed orogens. (Authors' abstract)

DOBSON, P.F., SKOGBY, Henrik and ROSSMAN, G.R., 1995, Water in boninite glass and coexisting orthopyroxene: Concentration and partitioning: Contrib. Mineral. Petrol., v. 128, p. 414-419. First author at Unocal Energy Resources Div., Fred L. Hartley Res. Center, 376 S Valencia Ave, Brea, CA 92621.

Spectroscopic measurements of water in glass I in pyroxene from boninite samples from the Bonin Islands conclusively document the high (2.8-3.2 wt %) primary water contents of boninite magmas. Associated quenched glass from pillow lava rims have slightly lower (2.2-2.4 wt %) H_2O contents, suggesting that minor amounts of degassing occurred between the time of melt entrapment in the orthopyroxenes and subsequent eruption on the sea floor. Some zonation of molecular water in pillow rim glasses was observed. OH contents of the host orthopyroxene phenocrysts were also measured, allowing for the calculation of partition coefficients for water between boninite melt and orthopyroxene. These values (0.003-0.004) for water partitioning between orthopyroxene and mafic melts may help constrain petrogenetic models of mantle-derived magmas. (Authors' abstract)

DONG, G. and MORRISON, G.W., 1995, Adularia in epithermal veins, Queensland: Morphology, structural state and origin: Mineral. Deposita, v. 30, p. 11-19.

Includes a table on the 10 studied epithermal vein deposits, with Th and sal. data on five, from the literature. (E.R.)

DONG, Guoyi, MORRISON, Gregg and JAIRETH, Subhash, 1995, Quartz textures in epithermal veins, Queensland—Classification, origin, and implication: Econ. Geol., v. 90, p. 1841-1856. First author at Dept. Earth Sciences, James Cook Univ. North Queensland, Townsville 4811, Australia.

The main themes of this paper are to develop a unified classification of common quartz textures in epithermal veins, to understand their possible origins in terms of the processes of formation and F conditions, and to explore the relationship between quartz textures and Au mineralization on a broad scale. A systematic evaluation of three-dimensional distribution of quartz textures and textural assemblages in selected epithermal systems and thereby the textural zoning model will be presented. (From authors' abstract by E.R.)

DORIA, A., NOGUEIRA, P., CATHELINEAU, M. and NORONHA, F., 1995, Fluid/deformation relationships in contrasted lithologies: An integrated fluid inclusion study of northern Portugal Au-quartz veins (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 62-63. First author at Centro de Geologia, Fac. Ciàncias U.P., Pr. Gomes Teixeira. 4050 Porto, Portugal.

Microthermometric studies, Raman analyses and bulk composition calculations of FI have been carried out in order to establish a P-T-V-X reconstruction of the F migration. The study of FI has been carried out as a function of the sequence of deformation, and related quartz crystallization or healing.

Five main types of host macro- to micro structures for FI are distinguished:

(i) inherited quartz filling structures ante-D4 phase, observed in metamorphic series, and partially recrystallized;

(ii) earlier milky quartz, the main infilling of the D4 structures;

(iii) clear quartz resulting from the recrystallization of former milky and associated with arsenopyrite;

(iv) an hyaline quartz, sometimes euhedral, associated with late sulphides;

(v) healed microstructures which may be related to stages (iii), (iv) or later stages.

Several types of F have been recognized as a function of the host rocks and host structures: H_2O-CO_2 I (Lc-w) displaying dense volatile phase (ThCO_2 (L/V → L)) is one of the main FI types and is characteristic of the early milky quartz; (ii) Vc-w two- or three-phase I with lower density volatile phase (ThCO_2 (L/V → V)); (iii) Vm-w two-phase I with a dominating CH_4 V phase, mostly observed in metamorphic environments; (iv) Lw-© aqueous two-phase H_2O-rich I with a very low density CO_2 (CH_4); (v) Lw H_2O-NaCl two-phase I (mostly in FIP).

The F composition from both systems evolved from C-H-O-(N) dense F trapped under P >1 kb and T of 350° to 450°C to progressive diluted F which are enriched in CH_4 and N_2 mainly when metamorphic series are present (VPA). The later F, associated with main Au mineralization, are dominantly aqueous with low salinities, and trapped under low T (180° to 250°C) and low P (hydrostatic P). (From authors' abstract by E.R.)

See also Doria et al., FIR, v. 26, p. 41-42. (E.R.)

DORIA, A., NORONHA, F., BOIRON, M.C. and CATHELINEAU, M., 1995, Fluid rock interactions in C-rich units during ductile to brittle deformation related to regional metamorphism (Vila Pouca de Aguiar, Northern Portugal) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 312.

Nature of the F produced during the late Hercynian regional metamorphism affecting Paleozoic C-rich metasediments has been studied as a function of the deformational stages (ductile to brittle) on the example of the Vila Pouca area (Northern Portugal). Paleofluids as I in quartz have been systematically studied by microthermometry, Raman spectroscopy, on the basis of a typology of quartz types and textures by optical and SEM-CL examination, and structural features of the host structure.

Three kind of paleofluids may be distinguished: (i) CO_2 = H_2O F associated with the recrystallization of quartz in ante-D3 quartz structures during ductile/brittle deformational stage D3, and trapped in P-T conditions compatible with the metamorphic assemblages (biotite/phengite, proximity of the andalusite isograde) e.g., ~350/400 MPa and 500°C; (ii) CO_2-H_2O F mixing locally with CH_4-N_2 rich F produced at the same stages within the C-rich units, and trapped under slightly lower P-T conditions; (iii) aqueous F with a low density volatile phase dominated by CH_4, and trapped during the decompression related to the basement uplift and/or lithostatic/hydrostatic P fluctuation (250 to 80 MPa) linked to the late D3 brittle deformation; and (iv) aqueous F associated with the general micro to macro fracturation of the series during the latest brittle stages (D4).

F compositions, modeled in the C-H-O9N) system, are clearly controlled by the general P-T path during the cooling and especially the presence of solid phases such as C, sulphides, or ammonium rich minerals which have controlled the volatile phase equilibria and oxydo-reduction conditions. (From authors' abstract by E.R.)

DOSTAL, J. and CHATTERJEE, A.K., 1995, Origin of topaz-bearing and related peraluminous granites of the Late Devonian Davis Lake pluton, Nova Scotia, Canada: Crystal versus fluid fractionation: Chem. Geol., v. 123, p. 67-88. First author at Dept. Geology, Saint Mary's Univ., Halifax, Nova Scotia B3H 3C3, Canada.

The Davis Lake pluton, in the Late Devonian South Mountain Batholith in SW Nova Scotia (Canada), is composed of peraluminous leucomonzogranites and subordinate topaz-bearing leucogranites that host greisens and a primary Sn deposit. Fractional crystallization of the evolving F-rich peraluminous granitic magma was accompanied, particularly in later stages, by F fractionation involving fluorine complexing. Fluorine-rich F modified the Rb/Sr and U/Pb ratios which produced the distinct variations of $^{87}Sr/^{86}Sr$ and $^{206}Pb/^{204}Pb$ isotopic ratios. (From authors' abstract by E.R.)

DOUGLASS, S.E. and CAMPBELL, A.R., 1994, Characterization of alkaline rock-related mineralization in the Nogal mining district, Lincoln County, New Mexico: Econ. Geol., v. 89, p. 1306-1321. Authors at Dept. Geosciences, New Mexico Inst. Mining and Technology, Socorro, NM 87801.

FI from most Au deposits in the district have Th from 230° to 540°C with an average salinity of ~6 wt % NaCl eq. Two Au deposits, the Waterdog and the Helen Rae, also contain I with salinities of 18 to 50 wt % NaCl eq. The Ag-Pb-Zn deposits have FI Th from 180° to 350°C with an average salinity of 4 wt % NaCl eq.

The combined mineralogical and geochemical characteristics of the Au and the Ag-Pb-Zu deposits suggest that the Ag-Pb-Zn mineralization may have been associated with the regional propylitic alteration and that the Au deposits were later. Two of the Au deposits have many features in common with other alkaline rock-associated Au deposits, with the Helen Rae deposit exhibiting intermediate characteristics between the magmatic and epithermal end members. (From authors' abstract by E.R.)

DOUGLASS, S.E. and CAMPBELL, A.R., 1995, Characterization of alkaline rock-related mineralization in the Nogal mining district, Lincoln County, New Mexico—A reply: Econ. Geol., v. 90, p. 985-987.

An answer to a discussion by Thompson of the interpretation of FI and other data in Douglass and Campbell (1994) (previous item). (E.R.)

DOUMBIA, S., GAGNY, C. and MARIGNAC, CH., 1995, Late magmatic overpressuring in leucogranite magmas: The layered pegmatite of Ribeira (NE Portugal) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 64-65. Author at Dept. Sciences de la Terre, Univ. Orléans, France.

The studied quartz came from a sample of a layered pegmatite, enclosed in a leucogranite (endogranite) cupola with Sn-W mineralization at Ribeira (NE Portugal). The sample (Fig. 1) comprises two sets: a layered set, with quartz and aplite 1, overprinted by another set with quartz and aplite 2. The layered part displays an alternation of milky quartz layers and aplite 1 layers; quartz crystals show a palissadic structure, with growth zones and automorphic terminations covered by aplite material and delineated by quartz

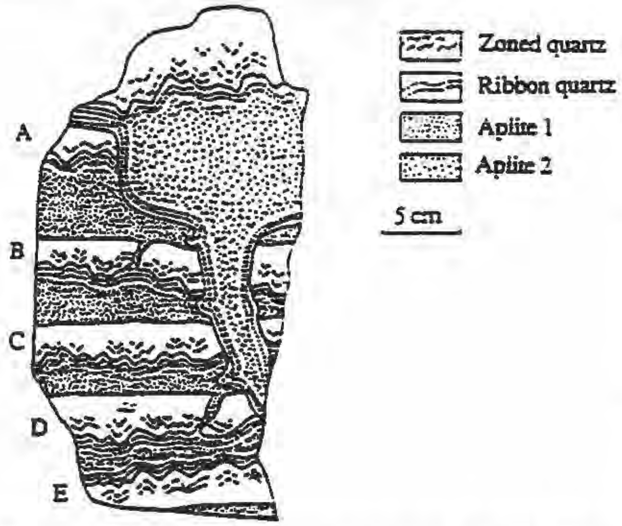


Figure 1. The sample of layered pegmatite from the Ribeira leucogranite cupola. Although the layering is known to be close to the horizontal, "up" and "down" could not be determined for that sample.

strips ("ribbon quartz").

FI were studied in a quartz from the C layer displaying a complex internal structure: a core (QI), with plastic deformation texture; and growth zones (QII), delineated by rims of aplitic material. In both QI and QII are included minute crystals of K-feldspar, either isolated or in rows. Both QI and QII are recrystallized: the whole quartz consists of 2-3 individuals, with denticulate boundaries, reminiscent of a "Dauphiné twin."

In QI, most FI are large decrepitated (exploded) two-phase (aqueous) I (DPI FI),together with small two-phase (aqueous) I containing a minute K-feldspar prism (Sk FI), which are therefore considered primaries. DPI and Sk FI have similar Tmi (-3.6 to -4.4 for DPI; -4° to -6.2 for Sk), but Sk have more dispersed Th (280°-400°C) than DPI (290°-330°C). Other FI are small two-phase secondaries, with low salinity (Tmi between -1° and -2°C) and variable Th (280°-400°C).

In QII are mainly found hypersaline halite-containing FI (Sh) and numerous secondaries organized into densely spaced planes of I. Sh FI display no change at T ≤500°C. Secondaries are low salinity (Tmi in the -1° to -2°C range) low Th (150°-250°C) FI.

There are also quite rare one-phase (carbonic) I, with a few non-CO_2 component (Tm CO_2 between -58.3° and -57.9°C), and similar Th CO_2, either in the L (Cl FI 19.2°C) or in the V (Cv FI; 19.7°C) phase. These Cl and Cv FI are either disseminated or located at the boundary between large K-feldspar inclusions and the host quartz; they thus appear to be primaries in the QII.

The Sh and C(V,L) FI are considered to result of the unmixing of a L1 magmatic F during the growth of QII, whereas the DPI and Sk are considered to be representatives of the unmixed L1 magmatic F. As a consequence, the trapping P during the QI growth is estimated at ca. 3 to 3.5 kb, whereas QII growth would have taken place under quickly decreasing P, ≥0.75 kb, thus explaining: (i) the unmixing of L1 F; (2) the coexistence in a very restricted space of both high (Cl) and low (Cv) carbonic I; and (iii) the decrepitation of former L1 I trapped in QI, due to internal overpressure, the Sk being the only to escape, due to their small size.

The layered pegmatite record the repetitive occurrence of a cycle of quartz growth from a magma, in the presence of exsolved magmatic F, under successively high (≤3 to 3.5 kb) and low (down to lithostatic, at 0.75 kb) P, due to the successive building up of that P by the exsolved magmatic F and releasing by the escape of the F out of the magmatic system. (Authors' abstract)

DRENNAN, G.R., 1995, The association between fluids and mineralization in the Witwatersrand Basin, South Africa (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 211.

Migrated kerogen nodules in fault related quartz veins are characterized by enriched Au, U, Fe, Cu, As, Pb and Ni concentrations. These elements occur pervasively distributed throughout the nodules and in particulate form as localized high concentrations. This suggests that U, Au, kerogen and other metals were transported in the same solution probably as organo-urano-Au complexes as well as thio-Au complexes or as organo-urano-Au-sulphide complexes.

FI microthermometry from quartz in these veins suggest entrapment T of between 300°C and 400°C. These T are related to localized high P-T conditions experienced during faulting. Under such conditions the organo-urano-Au-, thio-Au- and/or organo-urano-Au-sulphide complexes underwent reduction and dehydrogenation, resulting in the co-precipitation of sulphides, Au and REE enriched uraniferous kerogen nodules, together with the entrapment of hydrocarbon-rich FI. (From authors' abstract by H.E.B.)

DRENNAN, G.R., CATHELINEAU, M., BOIRON, M-C., LANDAIS, P. and ROBB, L.J., 1995, Characteristics of post-depositional fluids in the Witwatersrand Basin, with emphasis on hydrocarbon-bearing fluids: Proc. Symp. Economic Significance of Metamorphism and Fluid Movement within the Witwatersrand Basin, Econ. Geol. Research Unit Info. Circ. 296, p. 9-15. First author at Geology Dept., Univ. Witwatersrand, Johannesburg, South Africa.

The characteristics of post-depositional F affecting the Witwatersrand Basin are important when considering the nature and origin of the Au and U mineralisation, because the nature of F determines their metal-carrying capacity, which, in turn, determines the role played by these F in remobilising and reprecipitating the mineralisation. An analysis of the post-depositional F (trapped in late-stage quartz veins) affecting the Witwatersrand sediments (Drennen, in preparation; Meyer et al., 1991) facilitates the evaluation of syngenetic as opposed to epigenetic models for the origin of the Witwatersrand mineralisation and the occurrence of authigenic and allogenic mineral phases. (Authors' abstract)

DUAN, Zhenhao, MØLLER, Nancy and WEARE, J.H., 1995a, Molecular dynamics equation of state for nonpolar geochemical fluids: Geochim. Cosmochim. Acta, v. 59, p. 1533-1538. Authors at Dept. Chemistry, Univ. California, San Diego, La Jolla, CA 92093.

Remarkable agreement between molecular dynamics simulations and experimental measurements has been obtained for CH_4 for a large range of intensive variables, including those corresponding to L/V coexistence. (From authors' abstract by E.R.)

DUAN, Zhenhao, MØLLER, Nancy and WEARE, J.H., 1995b, Equation of state for the NaCl-H_2O-CO_2 system: Prediction of phase equilibria and volumetric properties: Geochim. Cosmochim. Acta, v. 59, p. 2869-2882. Authors at Dept. Chemistry, Univ. California, San Diego, La Jolla, CA 92093.

An equation of state (EOS) has been developed for the NaCl-H_2O-CO_2 system which consistently predicts various properties including PVTX, immiscibility or phase equilibria, solubilities, and activities with an accuracy close to that of experimental data from 300 to ~1000°C and 0-6000 bar with NaCl concentrations to ~30 wt % of NaCl (relative to NaCl + H_2O) or to ~50 wt % with less accuracy. (From authors' abstract by E.R.)

DUAN, Zhenhao, MØLLER, Nancy and WEARE, J.H., 1995c, Molecular dynamics simulation of water properties using RWK2 potential: From clusters to bulk water: Geochim. Cosmochim. Acta, v. 59, p. 3273-3283.

DUAN, Zhenhao, MØLLER, Nancy and WEARE, J.H., 1995d, Comment on "Measurement of the PVT properties of water to 25 kbars and 1600°C from synthetic fluid inclusions in corundum" by J.P. Brodholt and B.J. Wood: Geochim. Cosmochim. Acta, v. 59, p. 2639. Authors at Dept. Chemistry, Univ. California, San Diego, La Jolla, CA 92093.

DUARTE-GARZA, H.A., HOLSTE, J.C., HALL, K.R., MARSH, K.N. and GAMMON, B.E., 1995, Isochoric pVT and phase equilibrium measurements for carbon dioxide + nitrogen: J. Chem. Eng. Data, v. 40, p. 704-711.

DUBESSY, J., BAKKER, R., FRANTZ, J. and ZHANG, Y., 1995, High temperature Raman spectroscopic study of H_2O-CO_2-CH_4 mixtures in synthetic fluid inclusions using the Labram spectrometer (Dilor) some first insights on molecular interactions (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 66-67. First author at CREGU, BP-23, 54501-Vandoeuvre-lès Nancy Cedex, France.

An experimental investigation of the Raman spectrum of H_2O-CO_2-CH_4 system is necessary for the evaluation of the feasibility of the determination of bulk F composition from Raman spectra above Th.

Synthetic FI in the H_2O-CO_2 system have been prepared by the classical technique and those in the H_2O-CO_2-CH_4 system by the gas loading technique. Heating of the I was carried out using the Chaix-Mecca stage attached to the stage of the microscope of the Labram spectrometer (Dilor). (From authors' abstract by E.R.)

Four compositions, with a wide range of ratios of CO_2, CH_4 and H_2O were studied, and the sensitivity to composition of several spectral ratios was determined for various densities. A high-sensitivity spectrometer is required. (E.R.)

DUBINSKA, Elzbieta, JELITTO, Jacek and KOZLOWSKI, Andrzej, 1995, Origin and evolution of the granite/serpentinite reaction zones at Wiry, Lower Silesia: Acta Geologica Polonica, v. 45, no. 1-2, p. 41-82 (in English).

Contact schists between Variscan hybridal granitoid apophyses and older serpentinite at Wiry, Lower Silesia, are composed of phlogopite and chlorite, and their alteration products (vermiculite and chlorite/smectite with asymmetric Fe location, and three-component interstratified mica/vermiculite/chlorite), as recognized by means of XRD examination and computer simulations. The peak contact metamorphism yielded disseminated tremolite-to-pargasite amphiboles, and minor apatite. Its conditions, determined from Al content and FI in hornblende, achieved 2.6 kb and 560°C. The parent solutions had Ca-Na-Cl composition of variable Ca and Na proportions; the variations were related to albitization of the adjacent Strzegom granitoids. The layer silicates assemblage may be considered as an equivalent of a predecessor of weathering silicate nickel ores from the worldwide-known deposit at the neighboring ultrabasic massif of Szklary. (Authors' abstract)

DUBLYANSKY, Y. V., 1995, Speleogenetic history of the Hungarian hydrothermal karst: Environmental Geol., v. 25, p. 24-35. Author at Inst. Mineralogy and Petrography, Acad. Sci. Russia, Siberian Div., Univ. Ave. 3, 630090, Novosibirsk, Russia.

The hydrothermal karst of Hungary displays at least two principal stages of development in two differing environments. Caves of an early stage were formed within a deep zone of low thermal gradient. These caves (vugs) are small (tens of centimeters) and lined with scalenohedral crystals of calcite that are often in association with barite. Calcite yields FI T of 55-95°C and is depleted in ^{18}O (-11.2 to -17.6‰ PDB). The caves were formed by ascending thermal waters charged with CO_2. Solubility of $CaCO_3$ in such a system gradually increases with the ascent of the F (solutional zone) but drops sharply at a depth of -250 m to -500 m below the water surface (depositional zone). Caves formed in the solutional zone may be shifted into the depositional zone due to tectonic uplift, and calcite lines their walls. Large caves (tens to thousands of cubic meters) of a late stage were formed within a shallow zone of high thermal gradient immediately below and above the thermal water table. The calcite of the phreatic crusts has a rhombohedral habit, displays lower FI T (35-55°C and less), and a depletion in ^{18}O of -9.5 to -14.6‰ PDB. Several powerful cave-forming processes may operate there including convection, mixing/cooling corrosion, and condensation corrosion. Due to differences in the rate of tectonic uplift, rate of hydrothermal system decay, and hydrogeologic pattern, these caves were either filled with water for a long period of time (phreatic calcite crusts are formed) or partly dewatered early in their history (waterline and subaerial speleothems are formed). The zones of thermal cave formation recognized in Hungary may have a universal character. Very similar features are found in other hydrothermal karst areas of the world (Kirghizia, Algeria, South Dakota). (Author's abstract)

DUBOIS, M., ROYER, J.-J. ZIMMERMANN, J.-L. and CHEILLETZ, A., 1994, Paleoheat-emission and evolution of the composition of hydrothermal fluids with time in the Soultz granite (Rhine graben, Alsatia, France): Studies of fluid inclusions (abst.): 15th Mtg. of Earth Sciences [15^e Réunion des Sciences de la Terre], 26-28 April 1994, Nancy, France, p. 52.

The granite of Soultz-sous-Forêts, located in the western part of the Rhine graben and of which no equivalent is known to outcrop, has been sampled in >800 m of cores from drilling EPS1 between 1416 and 2227 m. It is a porphyric monzogranite with megacrystals of orthoclase; K/Ar age determinations on biotite give 320 ± 8 Ma. Four main zones have been studied: the unaltered granite (1607 m), the altered granite (2070 m), a cataclastic zone (2073 m) and a vein of quartz with geodes (2175 m). FI in quartz of these different zones are essentially aqueous (filling degree 10-20%), with salinities between 2 and 15 eq. % NaCl and Th between 125 and 270°C. They belong to the system H_2O-NaCl. Three main F have been recognized: (i) an aqueo-carbonic F (F1) with Th >350°C, identified as a magmatic or post-magmatic F; (ii) a hot hydrothermal F (F2) with 2.1 to 7.3 eq. % NaCl and Th of 170-270°C, showing considerable dilution attributed to meteoric water entering the basement; (iii) a cold hydrothermal F (F3) with 4 to 15 eq. % NaCl and Th between 125 and 150°C, interpreted as an isomolar mixture of two F with different salinities.

The F sampled in drilling GPK1 between 2 and 3.5 km has a composition similar to the hydrothermal F (F3): It is compatible with a mixture between a brine of the Bühl type (a drilling on the eastern margin of the graben) and a low-salinity F of meteoric origin of F2 type. This mixing model agrees with the actual hypotheses on F circulation in the sedimentary cover and in the basement, based on geochemistry (Pauwels et al., 1993) and on numerical models (Flores and Royer, 1993). (Authors' abstract, translation courtesy Dr. E.A.J. Burke)

DUKE, E.F., 1995, Contrasting scales of element mobility in metamorphic rocks near Harney Peak Granite, Black Hills, South Dakota: GSA Bull., v. 107, no. 3, p. 274-285. Author at Engineering and Mining Experiment Station and Dept. Geology and Geological Engineering, South Dakota School of Mines and Technology, Rapid City, SD 57701.

Outcrop-scale and regional dispersion patterns of rare elements help establish origins of F components, mechanisms of F flow, and the scale of element mobility in metamorphic rocks near the Harney Peak Granite. Enrichment of granite-derived elements (Sn, B, W, Li, Cu, F, P) adjacent to a quartz vein 3.5 km north of the granite indicates that fracture-controlled flow was one mechanism for movement of magmatic F. Graphitization of wall rocks and CO_2-CH_4 FI in vein quartz show that C was also transported by the vein-forming F. Mixing of H_2O-rich magmatic F and CO_2-CH_4-bearing metamorphic F within a concealed intrusive below the vein is proposed, based on the observation of late-stage graphite in several exposed pegmatite bodies in the area. Other wall-rock alteration includes small relative gains of Rb, K and Al toward the vein, and relative losses of Na, Sr, Ca, Si, Fe, Mg, Mn, and possibly Ti. (Author's abstract)

DUNAI, T.J., HILTON, D.R., TOURET, J.L.R., and MARKL, G., 1995, Granulite formation and mantle CO_2—Evidence from the Lofoten and Vesterålen islands, Norway (abst.): Eos, v. 76, no. 46, p. F678.

Granulite facies metamorphism on the Lofoten and Vesterålen island occurred at 1.8 Ga synchronous to the emplacement of large bodies of mangeritic/charnockitic and gabbroic/anorthositic intrusions. It has been postulated that during metamorphism large quantities of magmatic CO_2 were introduced into the area which promoted the generation of water-poor mineral assemblages typical of granulites. To evaluate the provenance of the CO_2 (crystal vs. mantle) we present a combined He, Ne, Ar and microthermometric study of carbonic FI found in granulite facies garnets, spinels and diopsides.

Samples have abundant high-density CO_2 I ($\rho > 0.9$ g/cm^3) which contain He with $^3He/^4He$-ratios between 0.13 and 0.3 times the atmospheric ratio (R_a). These ratios are significantly higher than typical for radiogenic/nucleogenetic production in crustal lithologies (≤ 0.02 R_a). Possible sources of ^3He include mantle, atmosphere, cosmic rays and nucleogenetic reactions. Atmospheric components may be excluded on the basis of radiogenetic $^{40}Ar/^{36}Ar$- and non-atmospheric He/Ne-ratios ranging between 530-1500 and 120-3200, respectively. Cosmogenic ^{3}He can be excluded because of short exposure histories (max. post-glacial) of sampling sites and significant nucleogenic ^{3}He would require Li-brine I for which we find no evidence. We conclude that the ^{3}He-excesses are indicative of mantle origin of the trapped F. This finding is further corroborated by the $CO_2/^3He$-ratios found in the I ($8 \cdot 10^8$-$3.4 \cdot 10^9$) that fall in the range typical of mantle-derived F. We note that the $^3He/^4He$-ratios measured today must be minimum estimates of the ratios at the time of entrapment as shown by elevated $^{21}Ne/^{22}Ne$-ratios (≤0,048) recording evidence of α–particle implantation ($^{18}O(\alpha,n)^{21}Ne$) into the FI.

The results of this study mandate that the CO_2 that infiltrated into this lower crustal segment 1.8 Ga ago is of mantle derivation. (Authors' abstract)

DUNN, T., 1995, Experimental reequilibriation of melt inclusions in clinopyroxene xenocrysts from Mt. Adams, Washington volcanics (abst.): Eos, v. 76, no. 17, p. S269. Author at Dept. Geology, Univ. New Brunswick, Fredericton, NB E3B 5A3, Canada.

Basaltic to andesitic volcanics at Mt. Adams, Washington, ranging in age from ~160 to 7-3.5 ka, contain augite xenocrysts, that have very similar major and trace element compositions despite their age differences. In addition, the pyroxenes all contain MI that contain a variety of secondary phases (plagioclase, apatite, orthopyroxene, ilmenite and magnetite) and often have negative crystal faces. The MI are rhyolitic in composition and show a remarkable degree of similarity amongst the samples.

In order to use the MI to determine the compositions of the original trapped M, it is necessary to reequilibrate the I with their host augite crystals at conditions equivalent to those at which the I were trapped. The host-pyroxene compositions provide minimum T constraints of 890 to 1030°C. Compositions of coexisting magnetite and ilmenite in the MI constrain the T to be >~1025°C and yield an O fugacity approximately at the QFM buffer. Based on these results, rehomogenization experiments were done on separated augite crystals at 1000, 1050 and 1100°C. The extent of equilibration between the rehomogenized I and the host-augites was evaluated by computing Fe-Mg exchange K_d's from the M and their host augite crystals. M compositions were reconstructed, based on the assumption that the equilibrium K_d falls with the range 0.22-0.29.

The reconstructed M compositions suggest that the augites in the older rocks (160 and 111 ka) may have crystallized from dacitic magmas ($SiO_2 = 65\%$), while the younger samples (56 to 7-3.5 ka) contain augites that apparently crystallized from rhyodacitic to rhyolitic magmas ($SiO_2 = 70$-72%). Glasses based on the reconstructed M compositions have been synthesized and their crystallization phase are being determined at P = 0.5 GPa in order to determine if these M have augite (similar in composition to the observed augites) in their crystallization sequences. (Author's abstract)

DURISOVA, J., STRNAD, L., BOIRON, M.C. and PERTOLD, Z., 1995, Character of paleofluids in gold-bearing quartz veins in gneisses of the Moldanubian zone: The Kasperske Hory gold deposit (Czech Republic) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 68-69. First author of Czech Geol. Surv., Klarov 3, 11821 Praha 1, Czech Republic.

The aim of the study was to characterize F linked to the formation of Au-bearing quartz lodes (veins) hosted by biotite paragneisses, quartzites and calc-silicate rocks and to correlate these F with the tectonic and metamorphic evolution.

FI in quartz are common and similar in all structural types of veins, but are small (<5 μm), and multistage quartz deformation and recrystallization (with FI decrepitation and refilling) make observations difficult. Three types of FI were identified:

(i) CO_2-rich I: They occur mostly in clusters or in short nonpenetrative healed cracks in quartz grains (early FI). The CO_2-rich phase is L ($TmCO_2$ varies from -65.3 to -56.8°C) with an admixture of CH_4 (1-18 mol %) and N_2 (0-15 mol %). Most I seem to be monophase at room T (H_2O phase invisible), two phase I were observed in quartz from dilation structures (H_2O phase ≤40 vol %). The H_2O phase in these FI is 3 to 9 wt % NaCl eq. solution. FI usually decrepitate before homogenisation (Th 214 to 315°C). Density of the CO_2-rich phase varies considerably in the range 0.39-0.99 g/cm^3 ($ThCO_2$ between -25.5 and +22.0°C) and this is probably due to variations in P. The highest densities have been found in shear veins (C structures) indicating P ≤0.32 GPa at 350, whereas I in quartz from extension veins indicate a significantly lower P (0.15 GPa). The great P difference (~0.1 GPa) has been documented also between FI in the same sample (in C veins). These P values were calculated using the data on composition-molar volumes of monophase CO_2-rich I (H_2O phase invisible) assuming 10 vol % of H_2O phase. If leakage of water from these FI took place in the early ductile deformation stage, the actual P could have been higher.

(ii) H_2O I: This type follows FIP across several quartz grains (late FI). Inclusions contain low saline solutions (2-8 wt % NaCl eq.) and homogenize from 160 to 280°C.

(iii) N_2-rich I: These one-phase gaseous I (Th -142 to -132°C to gas) occur along FIP, some of them are of the same orientation as the H_2O I. Nitrogen prevails (68 mol %) over CH_4 (25 mol %) and CO_2 (7 mol %), density of the admixture is very low (0.08 g/cm^3) indicating very low P (25 MPa at 300 assuming presence of 5 vol % of invisible H_2O phase in FI).

There is geological evidence of shear deformation and contemporaneous vein formation. Considering that retrograde mineral assemblages in host gneisses (biotite, muscovite, chlorite) were formed at T ~400°C then the contemporaneous CO_2-rich I provide a P constraint between 0.4 and 0.16 GPa. It follows that the shear zone and the quartz veins originated at considerable depths (13-6 km under lithostatic P). Nevertheless, the CO_2-rich F being apt to volume increase during decompression probably caused F overpressures in the shear zone and helped dilation. It is not clear if Au precipitated from CO_2-rich or from later H_2O solutions. The study of orientation of FIP in vein quartz has not shown clear relation to the main geological structures. This is in agreement with the late origin of H_2O- and N_2-rich FI which could represent unmixing events in a late brittle regime. (From authors' abstract by E.R.)

DURISOVÁ, J., STRNAD, L., PERTOLD, Z., PUDILOVÁ, M. and BOIRON, M.C., 1995, Gold-bearing quartz veins in a regional shear zone: Kasperské Hory gold deposit (Bohemian Massif): *in* Pasava, Krîbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 109-112. First author at Czech Geol. Surv., Prague, Czech Republic.

Origin of Au-bearing quartz veins occurring in a shear zone in high-grade Moldanubian rocks is discussed using data from structural geology, FI and isotope study. The veins originated in an extension regime from CO_2-rich metamorphogenic F (T = 500-400°C, P = 450-100 MPa) and were subject to polyphase brittle deformation. Water solutions and N_2-rich F circulated in the shear zone at low T (150-280°C) and P (≤25 MPa). (Authors' abstract)

This is the full paper for the previous item, with somewhat different authorship. (E.R.)

DUTROW, B. and NORTON, D., 1995, Evolution of fluid pressure and fracture propagation during contact metamorphism: J. Meta. Geol., v. 13, p. 677-686. First author at Dept. Geology and Geophysics, Louisiana State Univ., Baton Rouge, LA 70803.

Rock fracture enhances permeability and provides pathways through which F migrate. During contact metamorphism, F contained in isolated pores and fractures expand in response to T increases caused by the dissipation of heat from magmas. Heat transport calculations and thermomechanical properties of water-rich F demonstrate (1) that thermal energy is a viable mechanism to produce and maintain pore F P (P_f) in a contact metamorphic aureole; (2) that the magnitude of P_f generated is sufficient to propagate fractures during the prograde thermal history (cause hydrofracture) and enhance permeability; and (3) that P_f-driven fracture propagation is episodic with time-scales ranging from years to thousands of years.

P_f cycling and oscillations may explain several petrological features. If pore F are trapped at various positions along a P cycle, the large amplitude of P_f variations for small fractures may account for different P recorded by FI analysed from a single sample. (From authors' abstract by E.R.)

DUTROW, Barb, ROSENBERG, N.D., TRAVIS, B.J. and SPERA, F.J., 1995, Dynamics of hydrothermal convection in layered brine systems: Implications for mineralization (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 281.

Indexed under FI. (E.R.)

DZUNG, D.H., 1995, Characteristics of hydrothermal and epithermal gold mineralization in Viet Nam: Proc. IGCP Symposium on Geology of SE Asia, Hanoi, XI: J. Geol. [Vietnam], series B, no. 5-6, p. 354-363. Author at Geol. Surv. Viet Nam, 6 Phan Ngu Lao, Hanoi, Vietnam.

The principal conclusions for the classification of primary Au types and FI study can be summarized as follows: The exploration results show that the potential of primary Au deposits in Vietnam is not only the hydrothermal Au type but also the epithermal type. Current and future exploration must be focused in the search for near-surface deposits suitable to open-pit mining methods.

FI data reveal dominant hydrothermal F T for main mineralizing event to be 252°-294° with apparent salinities of 29 to 30 eq. Wt % NaCl and relative P of 70 atm. F T rarely exceeded 300°. Late stage deposition of gangue minerals from ore solutions occurred between 140°C and 252°C. The low salinity and low T I associated with the veins at the Lang Neo, Na Pai, Thu Duc-Chau Thoi, Vit Thu Lu and Pin Ho, Binh Lieu deposits may well represent the epithermal origins. (From authors' text by H.E.B.)

EADINGTON, Peter, LISK, Mark, KREIGER, Frank, HAMILTON, Joe, DAS, Machiketa and PERSON, Mark, 1994, Measurements of salinity of paleoformation waters in sedimentary basins for better evaluation of oil migration and reserve estimation (abst.): Program, AAPG Int'l Conference and Exhibition, Kuala Lumpur, Malaysia, Aug. 21-24, 1994, p. 1141. First author at CSIRO Div. Petroleum resources and APCRC, North Ride, Australia.

Irreducible water salinity is important in determining hydrocarbon reserves since relative hydrocarbon saturation is determined indirectly as the difference between reservoir porosity and the water volume determined from its electrical conductivity. Formation water salinity may range from 0-300,000 ppm, corresponding to electrical conductivities of 0-200 mmho/cm. This range in conductivities indicates the potential errors in determining hydrocarbon volume that might arise from using inappropriate salinity estimates.

Current formation waters in Mesozoic basins from Australia and Papua New Guinea generally have low salinities. Further, these Mesozoic sections typically contain siliciclastic sediments deposited when the plate was at high latitudes, and connate waters are expected to have low salinities. Irreducible water is therefore usually assigned low salinity.

Gondwanan Mesozoic basins are often underlain by lower Paleozoic sequences containing carbonates and evaporites. FI investigations have identified hypersaline paleogroundwaters from some Mesozoic reservoir sandstones in some Australian and Papua New Guinean basins. Cross-formational flow of brines prior to or contemporaneous with oil charge is inferred. The brines probably became immobilized as irreducible water during hydrocarbon accumulation. The electrical resistivity log data would then indicate smaller irreducible water volume than estimated from assumed low salinity, and hydrocarbon volumes would be greater than estimated.

Where hydrocarbons occur in a sedimentary sequence containing evaporites, both hydrocarbons and hypersaline formation waters may use the same migration path to access stratigraphically younger rocks. Determining salinity gradients in current or paleoformation waters can provide a vector to map oil migration. (Authors' abstract)

EATON, G.F., CRISS, R.E., FLECK, R.J., BOND, W.D., CLELAND, R.W. and WAVRA, C.S., 1995, Oxygen, carbon and strontium isotope geochemistry of the Sunshine Mine, Coeur d'Alene mining district, Idaho: Econ. Geol., v. 90, no. 8, p. 2274-2286.

The Pb-Ag ores of the Sunshine mine occur within steeply dipping, tabular, west-northwest-trending veins of siderite gangue. The $\delta^{18}O$ values of crosscutting quartz veins (13.4-15.5) and the surrounding wall rocks (10.7-15.5) are several per mil too low to be in isotopic equilibrium with the siderite at the T of differs from [?]325°C determined from FI studies. At this T the calculated $\delta^{18}O$ values for the precipitating F range from 7.8 to 12.4 for the siderite and 6.9 to 8.9 for the quartz. The high $\delta^{18}O$ values calculated for these F reflect their exchange with the high ^{18}O values metasedimentary rocks of the Belt Supergroup in higher T F source regions. Detailed sample traverses across two 1- to 3-m wide siderite veins show that: (1) some veins are composite; (2) siderite in structurally simple veins is most enriched in ^{13}C and ^{18}O adjacent to the walls, resulting in U-shaped spatial trends; and (3) the $\delta^{18}O$ values of metasedimentary wallrocks are substantially lower than those of the siderite I the veins and increase adjacent to them. These small-scale variations account for the lack of a simple relationship between $\delta^{18}O$ and depth in the vein systems. These data also indicate that the vein F were hotter and considerably higher in ^{18}O than the F in equilibrium with adjacent wall rock. (From authors' abstract by E.R.)

EDMONDS, H.N. and EDMOND, J.M., 1995, A three-component mixing model for ridge-crest hydrothermal fluids: Earth Planet. Sci. Lett., v. 134, p. 53-67.

EDON, M., RAMBOZ, C., CHOI, C.G., DISNAR, J.R., FRANCE-LANORD, C., GABLE, R. and VOLFINGER, M., 1995, Thermobarometric conditions of repeated uplift of Triassic evaporites in the southeast basin, France. Environmental impact of halokinesis on the basin in the Oxfordian (black marls):Hydrocarbon genesis, metal transport, faunal development (abst.): Soc. Geol. de France Meeting, November 1995, Abstracts, p. 69 (in French). First two authors at CRSCM-CNRS, 1A Rue de la Ferollerie, 45071 Orleans-la-Source, France.

A FI study of salt diapirs and nodules in Oxfordian pseudobioherms from Beauvoisin shed light on repeated transfers of material from the deep basin and its substrate to the surface. Minerals in the diapirs contain three populations of H_2O-NaCl-CO_2 FI, distinguished by Tm NaCl and Th values, and corresponding to three halokinetic phases of Callovian-Oxfordian, late Cretaceous-Eocene and Miocene ages. Phase properties of the second population indicate a process of decompression and a minimum Pt of 1.5 kb, indicating trapping under sublithostatic conditions at the base of the Triassic. In the first population, a minimum T >250°C indicates the existence of a convective thermal anomaly at the base of the Triassic section in the Oxfordian. The nodules contain saddle dolomite, calcite and barito-celestite with FI having five times the salinity of seawater. Sr isotopes, $\delta^{13}C$ values and REE content confirm precipitation of these minerals from a mixture of seawater and hydrothermal F derived from evaporites. Nodule centers containing free and FI hydrocarbons with a degree of maturity inconsistent with that of organic matter in the black marl host, as a result of: (1) bacterial production *in situ*; (2) local production due to passage of hydrothermal F; or (3) ascent of hydrocarbons from deep reservoirs. PIXE analyses on FI from diapirs show high base metal content [Translator: The ppm given appear to be in error.] and Cl/Br = 980. In nodules, FI in saddle dolomite and barito-celestite contain variable Cu, Fe and Zn; FI in calcite contain no metals These results indicate precipitation from a mixture of variable proportions of seawater and evaporite-derived hydrothermal F. Nutrients supplied by the hydrothermal F may have favored the development of the abundant faunas of the pseudobioherms. (Abridged from authors' abstract and translated by C.J. Eastoe)

EDON, M., RAMBOZ, C., CHOI, C.G. and VOLFINGER, M., 1995, Geochemical evidences for diapir-related fluid injections at the Oxfordian sea-bottom (SE basin, France) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 202.

Celestite is a characteristic mineral of cap-rocks. These crystals have REE patterns with a positive Eu anomaly and contain FI with high Th. These data are consistent with mineral precipitation from hot saline F (>100°; 9-15 wt % eq. NaCl) with a deep source. Besides, the C-Sr-isotopic composition of these minerals point out an evolved diagenetic F source with a Triassic component. (From authors' abstract by H.E.B.)

EDON, M., RAMBOZ, C. and GABLE, R., 1995, Halokinesis in the Jurassic of the Southeast Basin (France): Evidence for a thermal anomaly in deep Triassic rocks: Comptes Rendus de l'Academie des Sciences, Serie II. Sciences de la Terre des Planetes, v. 321, p. 185-192 (in French, English summary).

Indexed under FI. (E.R.)

EDON, M., RAMBOZ, C., VOLFINGER, M., CHOI, C.G. and ISABELLE, D., 1995, PIXE evidences for deep metal-rich evaporitic fluid emission at the Oxfordian sea-bottom (SE Basin, France) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v.

18-1, p. 70-72. First author at CNRS-CRSCM, la rue de la Férollerie, F-45071, Orleans, France.

Cl, Ti, Cu and Zn were detected in one secondary carbonic and hypersaline FI in evaporitic quartz. The F composition at 25°C can be calculated: 78.09 H_2O-160 CO_2-20.30 NaCl (wt %). The F density is estimated to be ~1.19 g.cm^3. Thus, the elementary ratio of Zn, Cu and Ti relative to Cl are known (Zn/Cl = 0.0116, Cu/Cl = 0.0217, Ti/Cl = 0.0235) and concentrations can be calculated relative to that of Cl: Zn = 1400 ± 300, Cu = 2700 ± 320, Ti = 2900 ± 370 (ppm).

These PIXE results attest metal mobilization by evaporitic F. (From authors' abstract by E.R.)

See also Edon et al., FIR, v. 26, p. 45-46. (E.R.)

EGERT, Ernesto and KASANEVA, Stabro, 1995, The San Cristobal gold district, Antofagasta, Chile: Australasian Inst. Mining and Metallurgy, Publication Series, 9/95 [PACRIM 1995], p. 197-202.

Indexed under FI. (E.R.)

EGLE, S., HOERNES, S., KIESL, W. and de WIT, M., 1995, Fluid migration in the Cape Fold Belt and the Karoo basin, South Africa (abst.): Mitt. Österr. Miner. Ges., v. 140, p. 403-405 (in German).

Stable isotopes and FI were studied along two traverses from the Cape Fold Belt towards the Karoo Basin to reveal the relationship between F flow and U mineralization. The folded Cape and Karoo sediments are cut by four dike generations composed mostly of quartz and calcite, which relate to the Cape orogenesis at ~250 ± 20 Ma: (i) early dikes parallel to bedding; (ii) discordant shear zones; (iii) dikes perpendicular to bedding; and (iv) discordant dikes. Their ages decrease from (i) to (iv). All dikes display secondary F flow, manifested by resorbed, broken quartz or calcite crystals which are cut by veins of authigenic quartz, calcite and chlorite. Mineral parageneses indicate 250-300°C for the secondary F flow. Next to the U ore deposit the presence of epidote points to higher T.

Th are between 150-170°C (the highest value being 210°C) for both Cape and Karoo samples. Quartz-calcite O isotope thermometry yields 230-260°C, intersecting the isochore at 1.5-2 kb. FI in basement rocks gave higher T than in the cover rocks with a maximum Th = 420°C. The Cape and Karoo sediments display an O isotope distribution of +7 to +13‰ (SMOW) with a maximum at 11‰. Their correlation with country rock isotopic composition indicates a rock-buffered system, as also evidenced by C isotopes (host rock =9.8 to +8.5‰ (PDB), vein calcite -18.7 to -4.8‰ (PDB)). The O isotopic composition of the F is calculated at -4 to +2‰ SMOW indicating a meteoric nature. This is supported by FI displaying δD of -50 to -94‰ (SMOW) and final Tm of -0.5°C. Although no O isotope variation is observable within the dikes, a cathodoluminescence study yielded heterogeneous quartz crystals which may represent various quartz generations. Laser ablation O isotope analysis will be applied to solve this problem. (From the authors' abstract, translation courtesy Dr. Bernhard Buehn)

EL KAZZAZ, Y.A.H.A., 1995, Tectonics and mineralization of Wadi Allaqi, south Eastern Desert, Egypt: unpub. PhD thesis, Univ. Luton, UK.

Neoproterozoic volcanic, sedimentary and volcano-sedimentary rocks of central Wadi Allaqi were deformed and metamorphosed to greenschist facies during the Pan-African orogeny. A Au mineralized quartz vein system was emplaced syntectonically along the first deformation (D1) shear zones. Data from structures, petrography, FI and stable isotopes of O and H tend to support a metamorphic provenance for the auriferous F. The petrological, geochemical and structural evidence strongly support a back-arc basin environment for the sedimentary development of central Wadi Allaqi before the Pan-African Orogeny. (From author's abstract by E.R.)

EL TOKHI, M.M., 1995, Fluid inclusion studies on the Pan-African migmatites of Wadi Feiran, southern Sinai, Egypt: Comptes Rendus de l'Academie des Sciences, Serie II. Sciences de la Terre des Planetes, v. 321, series IIa, p. 571-578 (in English).

FI in the leucosomes of Wadi Feiran migmatites show that CO_2, H_2O and (H_2O-CO_2) F were likely to have been present when partial melting began in these rocks. Low salinity, aqueous, and to a lesser extent CO_2-rich, F are the most abundant. The present study suggests that high density CO_2 I were formed at the earliest stage, while H_2O I were formed at a later stage. In an intermediate stage, low density CO_2 and H_2O-CO_2 I were formed. At the early stage of uplift and during the M crystallization, the CO_2-bearing V were trapped at grain boundaries. At the late stage of uplift, H_2O released at the time of crystallization of the M was trapped as I. (Author's abstract)

EMERY, Dominic and ROBINSON, Andrew, 1993, Inorganic Geochemistry: Applications to Petroleum Geology: Blackwell Scientific Publications, Oxford, 254 p.

Chapter 3, Fluid Inclusions, presents a detailed, thorough discussion of the principles and interpretation of microthermometry, the non-destructive analysis of individual I, and the bulk analysis of petroleum I. (H.E.B.)

EMMERMANN, Rolf, 1995, Adventures in deep drilling: An interim statement on the settlement of the Continental Deep Drilling Program of West Germany: Die Geowissenschaften (Weinheim, Zeitschrift), v. 13, no. 4, p. 114-128 (in German, English summary).

Indexed under FI. (E.R.)

ENJOJI, Mamoru and FUKAZAWA, Takashi, 1995, "Crystalline" inclusions in quartz of granitic rocks from Okayama, Japan: Ann. Rept., Inst. Geosci., Univ. Tsukuba, no. 21, p. 53-56.

The characteristic features of quartz in some granitoids are preliminarily reported, with special reference to the modes of distribution, morphological and chemical features of the I. For the study, granitic rocks from Okayama City, one of the representative granite in Japan, were used. (From authors' abstract by H.E.B.)

ENNACIRI, A., BARBANSON, L. and TOURAY, J.C., 1995a, Ore forming brines from the Co-As district of Bou Azzer (Anti-Atlas, Morocco): A fluid inclusions study (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 73-75. Authors at Equipe Ressources, Environnement et Matériaux (EREM), URA 1366 du CNRS - ESEM - Univ. d'Orléans, Rue Léonard de Vinci, 45 072 Orléans Cedex 2, France.

The Bou Azzer-El Graara area has produced ~1000 tons of cobalt by [per?] year either from veins or from "contact deposits" of complex Co-Ni-As minerals.

Th LV of PI in quartz is 120-180°C; Tm NaCl is 150-230°C. Salinity 30-40 wt %; $CaCl_2$/NaCl = 1 to 1.3 (wt). FI have been studied in quartz and calcite grown either during mineralization or during a late stage.

Excepting metastable I, P and S FI in quartz and calcite display a halite dxl. Identified trapped phases (optical microscopy, SEM-EDS, Raman microprobe) are muscovite or sericite, feldspars (albite or K-feldspar) and barite. SEM analyses of evaporated brines from broken I indicate trapped solutions belonging to the system H_2O-NaCl-$CaCl_2$, with additional KCl and $BaCl_2$. Minor amounts of N_2 and CH_4 have been detected by Raman microprobe in the bubbles.

With regard to mineral paragenesis and FI data, Co-As ore deposits from the Bou Azzer district appear very similar to the well known mines of Cobalt, Ontario, Canada. An important question to be addressed is the origin of the brines, which cannot derive from the solubilization of ancient evaporites. (From authors' abstract by E.R.)

See also next item. (E.R.)

ENNACIRI, A., BARBANSON, L. and TOURAY, J.C., 1995b, Mineralized hydrothermal solution cavities in the Co-As Aït Ahmane mine (Bou Azzer, Morocco): Mineral. Deposita, v. 30, p. 75-77. First author at URA no. 1366 du CNRS et GDR "Métallogénie et Matériaux Minéraux" ESEM, rue Leonard de Vinci, F-45072 Orléans, France.

In the F33 Aït Ahmane Cobalt-deposit (Bou Azzer, Anti-Atlas, Morocco) a new type of "contact mineralization" is described. It is carbonate hosted but displays similar depositional sequence and FI patterns to the well-known vein mineralization from the same mine. Field studies suggest that such a "contact mineralization" formed early by infilling solution cavities in formerly calcified serpentinite. (Authors' abstract)

This is the full paper for the previous item, with a modified title. (E.R.)

EUGSTER, O., NIEDERMANN, S., THALMANN, C., FREI, R., KRAMERS, J., KRÄHENBÜHL, U., LIU, Y.Z., HOFMANN, B., BOER, R.H., REIMOLD, W.U. and BRUNO, L., 1995, Noble gases, K, U, Th, and Pb in native gold: J. Geophys. Res., v. 100, no. 24,677-24,689. First author at Physikalisches Inst. Univ. Bern, Bern, Switzerland.

We present determinations of the noble G and Pb isotopic abundances and of K, Th, and U concentrations of native Au. Our results demonstrate that Au is an excellent carrier for crustal volatiles, but direct dating of Au using the U, Th-^{4}He, ^{40}K-^{40}Ar, and U fission Xe methods was not successful for various reasons. The main significance of this work is the great sensitivity of Au for trapped G as well as for G that were produced *in situ* which gives the prospects of using Au and its F and solid I for the study of paleogas composition. Numerous nuclear effects characterize the noble G inventory of placer Au from Switzerland and Italy, vein Au from Italy, South Africa, and Venezuela, and lode Au from South Africa. The degassing patterns obtained by mass spectrometry show a low-T release of volatiles ~500°C from FI mainly in vein Au and a high-T release from solid I and the Au itself. The low-T volatiles represent species that were trapped when the Au crystallized. We investigated the following trapped species: the isotopes of He, Ne, Ar, Kr, Xe, and Pb, and the abundances of K, U, Th, H_2O, and CO_2. The crustal G trapped by Au comprise ^{3}He from ^{6}Li(n,α)^{3}H → β^- → ^{3}He, ^{4}He and ^{40}Ar from the U, Th, and K decay, and Xe from ^{238}U fission. We observe ^{4}He/^{40}Ar = 3.9 for the radiogenic trapped G of Tertiary Au and a ratio of 1.4 for Archean Au. These ratios are consistent with the production ratios from U and K at the respective times and demonstrate that Au can be used as a sampler of ancient atmospheric G. The concentrations of U and Th range from a few parts per billion to a few parts per million, and those of K and Pb range up to some tens of parts per million. The antiquity of trapped Pb is indicated by the Pb-Pb model age of ~3000 Ma for the Pb extracted from vein Au and quartz of the Lily gold mine (South Africa). Au also contains noble G produced *in situ* by U, Th, and K decay. We obtained ^{4}He up to the extremely high concentration of 6.8×10^{-2} cm^3 STP/g (STP: atmospheric pressure and 0°C) for Au separated from a specimen of the Witwatersrand West Rand gold fields, indicating that this Au has a large U content. (Authors' abstract)

EVANS, M.D., 1995, Fluid inclusions in veins from the Middle Devonian shales: A record of deformation conditions and fluid evolution in the Appalachian Plateau: GSA Bull., v. 107, no. 3, p. 327-339. Author at Dept. Geology and Geography, Georgia Southern Univ., Statesboro, GA 30460.

FI microthermometric analysis of multiple vein sets from the Middle Devonian shales provides insight into deformation conditions and F evolution in the Appalachian Plateau during, and since, the Alleghanian orogeny. The data illustrate a dynamic system in which deformation conditions and F compositions changed continually during basin subsidence in response to orogeny and postorogenic uplift and denudation. Two types of I are present in the veins: (1) hydrocarbon I that contain CH_4, C_2H_6, CO_2, higher hydrocarbons (>2 carbon atoms), and bitumen and (2) two-phase aqueous I that contain very saline (≤27 wt % NaCl eq.) NaCl-$CaCl_2$ brines. The veins formed in response to stresses associated with the Alleghanian orogeny during subsidence of the Middle Devonian shale section in the central Plateau province. Each vein set contains I of hydrocarbons that are thermally more mature than those in the previously formed set. (From author's abstract by E.R.)

EWBANK, G., MANNING, D.A.C. and ABBOTT, G.D., 1995, The relationship between bitumens and mineralization in the South Pennine Orefield, central England: J. Geol. Soc. London, v. 152, p. 751-765.

Like many examples of MVT mineralization, the South Pennine Orefield is well-known for the occurrence of hydrocarbons within hydrothermal mineral veins. Bitumens from this area along with oils from the East Midlands have been characterized using standard organic geochemical techniques and compared with potential source rocks. Lower Namurian mudstones from the Widmerpool Gulf and the Gainsborough and Goyt Troughs were rejected as possible sources for the bitumens and oils on the grounds of lack of sufficient thermal maturity and/or essential biomarker correlation. Lower Namurian mudstones with type II kerogen from the Edale Gulf are proposed to offer a likely hydrocarbon source for the area, with a minor, more localized contribution from organic-rich type II mudstone partings within the Dinantian limestones. Simple geochemical models, consistent with recent sequence stratigraphic interpretation, suggest a late Carboniferous age for hydrocarbon generation, where geothermal gradients were slightly higher (c. 50°C km^{-1}) than the present day.

Microthermometric analysis of FI from fluorite and calcite allowed three F types to be distinguished. One Na-Ca-Cl bearing F was discerned to be dominant throughout the orefield, being of low T (uncorrected Th = 70-110°C) and high salinity (c. 20 eq. wt % NaCl). A second high salinity Na-Ca-Cl bearing F (uncorrected Th = 70-120°C, c. 24 eq. wt % NaCl), distinguished from the first by varying Na-Ca contents, was observed in the westernmost extremities of the orefield. A third NaCl bearing F of higher T (Th = 100-145°C) and lower salinity (4 wt % NaCl) was detected in the northernmost part of the orefield. Hydrocarbon-bearing I were not observed in any of the three F in this study. S isotopic analyses performed on a selection of sulphides, sulphates and bitumens to gauge the role of organic matter in sulphate reduction reactions proved inconclusive. The mineralization is thought to have occurred as several events. That in the north is thought to be derived from the dewatering of the Edale Gulf towards the end of the Carboniferous, whilst other mineralization events occurred from the early Permian onwards, with the ore F having more distal sources, predominantly from the east with a minor input from the west.

The main phases of hydrocarbon generation and mineralization appear to be unrelated. (Authors' abstract)

FAIZLIEV, A.P. and FOZILOV, M.M., 1995, Physico-chemical formation parameters of the main endogenous deposits of Tajikistan: APIFIS Newsletter 1995, Univ.. Science and Technology Beijing, p. 21-23.

A brief review of 26 ore deposit types, listing only Th and P, but with no specific deposit or locality names. (E.R.)

FANLO, I. and FERNANDEZ-NIETO, C., 1995a, Hydrothermal fluid evolution in the F-Pb-(Zn) mineralization of Parzan (Bielsa mining district, Central Spanish Pyrenees) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 76-77. Authors at Dept. Cristalografía y Mineralogía, Univ. Zaragoza, Spain.

The Parzán deposit is a single vein enclosed between the Bielsa granite and Triassic red bed sequence. The vein is an open-space filling; phyllic alteration has been observed in the granite hanging wall. The mineral assemblage mainly consists of yellow-orange fluorite and galena, and minor siderite, pyrite, sphalerite, chalcopyrite and quartz.

On fluorite, Te ranged from -45 to -65°C; Tm ice -7.3 to -22.1°C (sal. estimated at 10.8-24.1 wt % eq.). Tm hydrohalite -25.6 to -21.3°C. Th 117-185°C (180-200°C for quartz).

A Cryo-SEM-EDS study (in fluorite) indicates the F are high in Na, Ca and Cl, plus minor K. The $CaCl_2$/NaCl ratios vary between 0.65 and 1.

Field data, the absence of any correlation between Th and Tm ice, and REE and Sr isotope data rule out F mixing.

See also Fanlo et al. FIR, v. 26, p. 48, and next item. (E.R.)

FANLO, I., SUBÍAS, I. and FERNÁNDEZ-NIETO, C., 1995b, Genesis of Parzán Pb-F-(Zn) vein, Spanish Western Pyrenees: Evidence from fluid inclusions, REE distribution and S and Sr isotopes: *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 349-352.

The study of FI, REE distribution and stable and Sr isotopes in the ore and gangue minerals from Parzán vein lead to a geochemical model which can be integrated into the tectonic framework. Result[s] of this study indicate that ore formation is related to early Mesozoic extension tectonics which control brines migration on basin-margin faults. A plausible source for metals in Hercynian basement, comprising Palaeozoic rocks and hydrothermally altered granites. (Authors' abstract)

Full paper for previous item. (E.R.)

FARLEY, K.A., 1995, Rapid cycling of subducted sediments into the Samoan mantle plume: Geology, v. 23, no. 6, p. 531-534. Author at Div. Geological and Planetary Sciences, MS 170-25, California Inst. Technology, Pasadena, CA 91125.

Harzburgite xenoliths from the Samoan hot spot carry extraordinarily enriched Sr-Nd-Pb isotopic ratios previously attributed to metasomatism by a carbonatitic F derived from recycled sediments. [The author] describes here the G composition and microthermometric properties of FI that have trapped this unusual agent. The I are dominantly pure CO_2 and were apparently formed at the base of the crust. They have high $^3He/^4He$ ratios (12 times the atmospheric ratio), inconsistent with the radiogenic values expected for recycled sediments. Furthermore, I $C/^3He$ ratios of $\sim 3 \times 10^9$ are indistinguishable from typical mantle values and are far lower than those in sediments ($>10^{11}$). These striking observations imply that little of the He and C in the metasomatic F was derived from the recycled source required by the Sr-Nd-Pb isotopes. The metasomatic F is probably a product of mixing within the Samoan hot spot of a volatile-rich high $^3He/^4He$ plume melt and recycled sediments. The retention of high $^3He/^4He$ ratios in such a mixture requires very rapid cycling of the sedimentary component through the mantle (probably $<10^7$ yr), rather than the billions of years often envisaged. This time scale indicates involvement of material recently returned to the mantle at the nearby Tonga Trench, and pelagic sediments near the trench have approximately the requisite, geochemical signature. The unique isotopic characteristics of the Samoan plume likely arise from its unusual tectonic setting at the northern terminus of subduction in the Tonga Trench. (Author's abstract)

FARLEY, K.A., POREDA, R.J. and ONSTOTT, T.C., 1994, Noble gases in deformed xenoliths from an ocean island: Characterization of a metasomatic fluid, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 159-178. First author at Div. Geological and Planetary Sciences, MS170-25, Caltech, Pasadena, CA 91125.

New noble G measurements have been made on Samoan ultramafic xenoliths in order to characterize the composition and nature of entrapment of a postulated mantle metasomatic agent. The new measurements were performed on G extracted from severely tectonized harzburgites and dunites by both bulk crushing and laser microprobe. The tectonized specimens have the highest noble G concentrations yet reported from mantle materials and attest to deformation in a highly G-charged environment. The noble G isotopic systematics are similar to those observed in undeformed specimens from the same locality, and are consistent with mixing between a mantle component (e.g. $^3He/^4He$ 12 R_A, $^{40}Ar/^{36}Ar > 10{,}000$) and an atmospheric contaminant. Within the xenoliths, the mantle component is spatially associated with features previously attributed to metasomatism (e.g., Hauri et al., 1993). Although this metasomatic component has many characteristics suggesting derivation from material returned to the mantle by subduction, its relatively high $^3He/^4He$ ratio is enigmatic. Whatever its source, this F appears to have existed within the Samoan mantle over fairly large temporal and spatial scales, and plays an important role in the geochemistry of Samoan basalts.

Just as with the mantle component, the deformed xenoliths are also enriched in the atmospheric contaminant. This enrichment suggests pervasive penetration of air into the ubiquitous microfractures and decrepitated FI of the deformed specimens.

In addition to source and contamination effects, the noble G within these xenoliths record variable degrees of elemental fractionation. While the G-rich (deformed) xenoliths have ^4He-$^{21}Ne^*$-$^{40}Ar^*$ systematics close to long-term closed-system behavior, the comparatively G-poor samples have lost up to 90% of their He without concomitant loss of neon and argon. This likely represents diffusive loss of He after FI entrapment. (Authors' abstract)

FARROW, C.E.G., 1995, Geology, alteration, and the role of fluids in Cu-Ni-PGE mineralization of the footwall rocks to the Sudbury igneous complex, Levack and Morgan townships, Sudbury District, Ontario: Unpub. PhD thesis, Carleton Univ., Ottawa, Ontario, Canada, 407 p.

Indexed under FI. (E.R.)

FAYEK, Mostafa and KYSER, T.K., 1995, Characteristics of auriferous and barren fluids associated with the Proterozoic Contact Lake lode gold deposit, Saskatchewan, Canada: Econ. Geol., v. 90, p. 385-406. Authors at Dept. Geological Sciences, Univ. Saskatchewan, Saskatoon, Saskatchewan S7N 0W0, Canada.

The four discernible vein types in the deposit (two devoid of Au and two containing Au mineralization) permit the detailed study of F responsible for Au mineralization vs. Barren F, which is critical to Au exploration. Estimated O isotope T based on assumed equilibrium of vein minerals from the various stages of veining indicate that barren veins (stage I and II) had T ~450°C, precipitating quartz with $\delta^{18}O$ values from 10.5 to 10.9‰. Auriferous F (stage III and IV veins), however, had lower T ranging from 270° to 360°C and precipitated quartz with $\delta^{18}O$ values ranging from 11.8 to 13.5‰.

The majority of the FI trapped within vein quartz are of secondary origin. P FI trapped during the precipitation of stage I, II and III veins are not preserved. However, P FI in sphalerite associated with Au and similar SI in stage III quartz indicate that the F associated with stage IV veins had salinities of 2.5 to 6.3 wt % NaCl eq. and low CO_2 content (i.e., L CO_2 not visible). Th of these F range from 225° to 300°C, and in conjunction with O isotope equilibration T, indicate trapping P of the Au-bearing F of 500 to 1500 bars (1 bar = 100 kPa).

Rb-Sr and Ar-Ar systematics of muscovite indicate that stage IV veins were deposited ~100 m.y. after the crystallization of the Little Deer Lake pluton. The low CO_2 contents of FI directly related to Au and alteration minerals associated with Au indicate that the mechanism by which Au precipitated was most likely wall rock-F interaction. (From authors' abstract by E.R.)

FEITZINGER, G., PAAR, W.H., TARKIAN, M., RECHE, R., WEINZIERL, O., PROCHASKA, W. and HOLZER, H., 1995, Vein type Ag-(Au)-Pb, Zn, Cu-(W,Sn) mineralization in the southern Kreuzeck Mountains, Carinthia Province, Austria: Mineral. Petrol., v. 53, p. 307-332.

FI in quartz from open space filling in the several deposits show the following: (E.R.)

	Th	sal. (%)
Drassnitz	210-365	2-7
Plattach	165-250	4-8
Niedermülleralm	165-220	1-5
Grakofel	180-330	1.1-13.3

FERKOUS, Kamel, RAMBOZ, Clairette, BENY, Claire, BOULLIER, A.M. and LEBLANC, Marc, 1994, Fluid circulation in the lithospheric shear zone at In Ouzzal East (Hoggar, Algeria): Gold deposition (abst.): 15th Reunion Sci. de la Terre, p. 73 (in French). First author at ORGM, 8 rue des Aures, El-Harrach DZ16000, Algeria.

The Amesmessa Au deposit is situated SW of Hoggar. It is located in a N-S shear zone resulting for a late Pan African dextral movement. This major zone separates a Proterozoic domain to the east from a granulite block containing a great variety of magmatic rocks to the west. It shows an important deformation gradient, from mylonites to the east to ultramylonites in the west (greenschist to amphibolite facies). The blue quartz in the granulite leptynites is rich in aqueous FI: the water probably favored the deformation of these rocks.

The vein network comprises two diachronous quartz generations: early subvertical N-S veins ($\alpha = 70°W$), [and] vertical later E-W veins. The N-S veins partly show ductile deformation, which changed to a regime which was ductile-brittle, and then brittle. The free Au was emplaced during this later phase, associated with pyrite and galena. A hydrothermal carbonate alteration developed uniquely in the ultramylonites, where the protolith is very variable. The E-W veins were formed after the ductile deformation; they are sterile. We have studied the microstructures and P and S FI (microthermometry and Raman) in the quartz from a N-S vein within a granulite ultramylonite. Three generations of FI were identified:

—The quartz grains or subgrains deformed ductilely contain CO_2 FI without visible H_2O, isolated or aligned along NE-SW vertical microplanes. They contain ≤20% CH_4, and their density varies between 0.8 to 1.

—The N-S to NE-SW planes ($\alpha = 35$-$85°E$ to SE) contain H_2O-CO_2 I, slightly saline, with traces of CH_4 (ThL = 270°C; H_2O-10 mol % CO_2; d = 0.91).

—The NE-SW planes ($\alpha = 70°SE$) and the later orthogonal

NW-SE directions ($\alpha = 35\text{-}50°SW$) contain aqueous FI with compositions close to the H_2O-NaCl system (~20 wt % NaCl eq., ThL ~200°C, traces of CH_4 detected). This F, undersaturated in SiO_2, is probably responsible for Au deposition in economic quantities. (Authors' abstract; translation courtesy of Dr. A.P. Gize)

FERRY, J.M., 1995, Fluid flow during contact metamorphism of ophicarbonate rocks in the Bergell aureole, Val Malenco, Italian Alps: J. Petrol., v. 36, p. 1039-1053. Author at Dept. Earth and Planetary Sciences, Johns Hopkins Univ., Baltimore, MD 21218.

Calcite-dolomite thermometry and mineral-F equilibria in the invariant assemblages record T = 440-540°C at P = 3.5 kb. Equilibrium metamorphic F were very H_2O rich with $XCO_2 = 0.001\text{-}0.027$. Time-integrated flux (q) was computed from measured reaction progress in 28 samples for models of both horizontal and vertical down-T flow. Generation of metamorphic F by decarbonation-dehydration reactions within the ophicarbonates explains larger average flux 1-2 km from the intrusion compared with more distal points. (From author's abstract by E.R.)

FINCH, A., 1995, Metasomatic overprinting by juvenile igneous fluids, Igdlerfigsalik, South Greenland: Contrib. Mineral. Petrol., v. 122, p. 11-24.

FINCH, A.A., PARSON, Ian and MINGARD, S.C., 1995, Biotites as indicators of fluorine fugacities in late-stage magmatic fluids: The Gardar Province of South Greenland: J. Petrol., v. 36, p. 1701-1728. Authors at Dept. Geology and Geophysics, Univ. Edinburgh, West Mains Rd, Edinburgh EH9 3JW, UK.

The major element chemistry and fluorine contents of biotites from the Gardar alkaline province of South Greenland provide an insight into the F contents of late-stage F associated with the magmatism. Phase equilibrium and textural considerations suggest that most or all biotites grew subsolidus in a pervasive deuteric F $\delta^{18}O$ values suggest that these F were largely magmatic in character and that extensive reactions with envelope F did not occur. Metasomatic resetting of F in biotites in early intrusive units in the aureole of later units can be demonstrated. It is possible that the higher F in biotites in the undersaturated centres reflects different speciation in the F rather than higher fluorine contents, with strongly bound $SiF_4{}^2$ complexes more common. (From authors' abstract by E.R.)

FIRDAOUS, K., BOULLIER, A.-M., BOIRON, M.-C. and ROBERT, F., 1994, Fluid inclusions and a seismic valve in mesothermal gold deposits (Abitibi, Quebec) (abst.): 15th Mtg. of Earth Sciences [15^e Réunion des Sciences de la Terre], 26-28 April 1994, Nancy, France, p. 52.

Three major groups of FI occur in quartz-filled shear and extension veins in the region of Val d'Or (Abitibi, Quebec). Textures and orientations of microfractures show that these F were emplaced alternately and that they are all contemporaneous with the formation of the veins, with the exception of some late aqueous F: [1] Aqueo-carbonic I of low salinity (1-6 eq. % NaCl, < 5% CH_4 and N_2, Th = 211.5 and 425°C L or V) have a general density of 0.47 to 1.0 g/cm^3; [2] Carbonic I (<5% CH_4 and N_2) homogenize to the L (-49.2 to +28.8°C, density 0.52 to 1.03 g/cm^3); and [3] Aqueous I (system H_2O-NaCl-$CaCl_2$) consist of two groups by their Th: one has Th <160°C and the other Th > 180°C. Salinity of the former varies from 1. 7 to 31 eq. % NaCl, giving densities between 0.58 and 1.26 g/cm^3.

The aqueo-carbonic and the carbonic F have highly variable densities, due to variable F P (200-300 MPa) at a T considered to be constant (T ~400°C). On the contrary, hot aqueous F must be distinguished which could have resulted from the unmixing of the primary aqueo-carbonic F and the late cold aqueous F supersaturated with NaCl; the latter could represent shield brines.

The results are compatible with the seismic-valve model, which invokes sudden variations in F P, associated with seismic activity. The unmixing of a parent aqueo-carbonic F into two immiscible F could happen at the moment of a sudden P drop, in an episodic manner during the formation of the Au-bearing veins. This interpretation would explain the coexistence and the contemporaneity of the three groups of F. More detailed studies, however, are necessary to confirm this interpretation. (Authors' abstract, translation courtesy Dr. E.A.J. Burke)

FIRDAOUS, K., BOULLIER, A.M., BOIRON, M.C. and ROBERT, F., 1995a, Evidence from fluid inclusions for P.V.T.X. evolution of hydrothermal solutions in gold-quartz veins at the Sigma mine (Abitibi, Quebec) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 185.

A FI study has undertaken on Archean Au-quartz veins from the Sigma mine (Abitibi, Quebec) in order to precise the composition and PVT properties of vein-forming F.

Four types of F have been recognized from microthermometric studies and Raman spectroscopy analysis for one sample of a fault vein and three samples of extensional veins:

- aquocarbonic F (10 to 85% vol. CO_2, $-63.7°C < TfCO_2 < -56.7°C$, $-49.2°C < ThCO_2 < +30.9°C$, $211.5°C < Th < 425°C$, 1 % eq. wt NaCl < salinity < 6% eq. wt NaCl, 5 mol % $\leq CH_4 + N_2 < 30$ mol %, 0.47 g/cm^3 < density < 1.0 g/cm^3);
- carbonic F ($-63°C < TfCO_2 < -56.7°C$, $-49.2°C < ThCO_2 < +28.8°C$, 5 mol % $\leq CH_4 + N_2 < 30$ mol %, 0.52g/cm^3 < density < 1.03 g/cm^3);
- aqueous F (10 to 60% vol. V H_2O, ± NaCl solid, $78°C < Th < 380°C$, 0.5% eq. wt NaCl < salinity < 34% eq. wt NaCl,). 0.58 g/cm3 < density < 1.26 g/cm3;
- CH_4-N_2-rich F (20 to 75% vol. V $CH_4 + N_2$, $10.6°C < Tfc < 15.2°C$, $326°C < Th < 393.7°C$), 20 mol % $< CH_4 < 72$ mol %, 28 mol % $< N_2 < 80$ mol %.

Microthermometric and Raman data may be interpreted by the trapping of two immiscible F (a carbonic-rich and a water-rich F) from a parent H_2O-CO_2-CH_4-(N_2)-low salinity F during the formation of the vein. Calculated isochores for these F indicate Pf fluctuations between 100 and 300 MPa in extensional vein and between 100 and 200 MPa in the fault vein at 350°C. These data are consistent with the fault-valve model (Sibson et al., Geology, 16, 551). (Authors' abstract)

FIRDAOUS, K., BOULLIER, A.M., BOIRON, M.C. and ROBERT, F., 1995b, Nature of fluid inclusions and evidence for P.V.T.X. evolution of hydrothermal solutions in gold-quartz veins in the Archaean Abitibi greenstone belt, Quebec (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 78-79. First author at CRPG-CNRS, BP 20, F-54501 Vandoeuvre-lès-Nancy cedex, France.

Four types of F have been recognized from microthermometric studies and Raman spectroscopy for one sample from a fault vein and three samples from extensional veins:

- *aquocarbonic* F (10 to 85 % vol CO_2, $-63.7°C < TfCO_2 < -57.7°C$, $-49.2°C < ThCO_2 < +30.9°C$, $211.5°C < Th < 425°C$, 1% eq. wt NaCl < salinity < 6% eq. wt NaCl, 5 mol % $< CH_4 + N_2 < 30$ mol %, 0.47 g/cm^3 <density < 1.0 g/cm^3);
- *carbonic* F ($-63°C < TfCO_2 < -56.7°C$, $-49.2°C < ThCO_2 < +28.8°C$, 5 mol % $< CH_4 + N_2$ 30 mol %, 0.52 g/cm^3 < density < 1.03 g/cm^3);
- *aqueous* F (10 to 60 % vol V H_2O, ± NaCl solid, $78°C < Th < 380°C$, 0.5% eq. wt NaCl < salinity $\leq$ 34% eq. wt NaCl, 0.58 g/cm^3 < density < 1.26 g/cm^3:
- CH_4-N_2-rich F (20 to 75% vol V $CH_4 + N_2$, 10.6°C < Tfc [sic] < 15.2°C, $326°C < Th < 393.7°C$), 20 mol % $< CH_4 < 72$ mol %, 28 mol % $< N_2 <80$ mol %. Such F has been only observed in extensional veins.

In all extensional veins examined, healed microcracks contain different FI types depending on their orientations: CO_2-CH_4-(N_2) and H_2O-CO_2-NaCl-CH_4-(N_2) FI occur in subhorizontal planes, parallel to the vein walls, whereas H_2O-NaCl-$CaCl_2$ FI occur in subvertical planes, perpendicular to the vein walls. In fault veins, the separation of FI types in microcracks of different orientations is not as pronounced.

Microthermometric and Raman data may be interpreted by the trapping of two immiscible F (a carbonic-rich and a H_2O-rich F) from a parent H_2O-CO_2-CH_4-(N_2)-low salinity metamorphic F during the formation of the vein. Calculated isochores for these aquocarbonic and carbonic F indicate Pf fluctuations between 100 and 300 MPa in extensional veins and between 100 and 200 MPa in the fault vein at 350°C. These data are consistent with the fault-valve model which implies F P drops related to seismic activity.

It should be noted that two groups of H_2O-NaCl FI have to be distinguished: those with Th > 200°C, and those with Th < 180°C. Inclusions of the high T group are interpreted to result from unmixing of the parent H_2O-CO_2-CH_4-(N_2)-low salinity and by mechanical separation from the coexisting carbonic phase due to their different wetting properties. The composition of low T aqueous F is similar to Canadian Shield basement brines that percolated down the crust, and which may have been trapped in latest open vertical microcracks. Their P-T trapping conditions are between 120 to 160°C and 80 to 150 MPa. (From authors' abstract by E.R.)

See also Firaous et al., FIR, v. 26, p. 49. (E.R.)

FIRST, D.M., HERRINGTON, R.J., GIZE, A.P. and SPIRO, B., 1995, Hydrocarbons at the Lahóca-Recsk (Cu-Au) deposit, Hungary: Evidence for basinal brine and magmatic fluid mixing: Abstracts Vol., Mineral Deposits Studies Group Ann. Mtg., 1995, Univ. Manchester, 18-20 Dec. (unpaginated).

The Lahóca-Recsk deposit is the near-surface epithermal expression of the Upper Eocene Recsk porphyry Cu complex, and is located on the NE flank of the Mátra Mts., Hungary. The system is a rare European example of significant porphyry Cu and high sulphidation mineralisation hosted by a large hydrothermal system, similar to more widely known examples in the Pacific Rim, e.g., Lepanto, Philippines. The complex formed at the margin of the Hungarian Palaeogene Basin, during a period of subduction related to the closure of the Tethys Ocean. The epithermal mineralisation is hosted by an intensively altered andesitic stratovolcanic pile. Low sulphidation vein-type epithermal mineralisation partially surrounds the high sulphidation of the Lahóca and Lejatkna ore bodies.

Significant volumes of hydrocarbons are known from the deposit, and are found intimately associated with the mineralisation and alteration. They occur as crude oils, bitumens and paraffin waxes. Petrological and field studies indicate that the hydrocarbons ingressed into the hydrothermal system during the formation of the deposit. It would appear that most of the oil observed in the deposit today migrated into the system during the waning phase of hydrothermal activity, accounting for its preservation in vughs and voids within the partially silicified Laóca and Lejatkna ore bodies. Oil has probably continued to flow into the deposit until the present along permeable fissures. A lateral zonation of the late stage hydrocarbons has been clearly identified, and probably indicates thermal distillation of a crude oil, by hydrothermal F flowing through a major E/W structure known as the Parád Fault.

Organic geochemistry (GC-MS) and C isotope results infer [imply?] that the oil throughout the deposit had a common source. The presence of significant amounts of oleanane, a pentacyclic triterpene, in the oil would indicate a Cretaceous or younger source rock. It therefore would imply that the oil was not derived from Triassic basement black shales that hosts the Recsk porphyry Cu deposit. The oil must have been derived from either basal organic rich units of the Middle Eocene Padrag Marl Formation, or Upper Cretaceous flysch formations—"Gosau" facies. Although for a Palaeogene source rock the time frame is relatively short (<8 my), and burial depth not great, it is still believed that oil generation could occur, due to a regionally high geothermal gradient (thin lithosphere and large scale magmatic, and hydrothermal activity) enhancing the maturation process.

FI and petrological studies have clearly identified several episodes of hydrocarbons emplacement into the deposit. Hydrocarbon FI occur cogenetically with low to moderate saline (0.5-9.0 NaCl eq. wt %) aqueous I, having comparable Th, in gangue minerals (quartz, calcite and barite) intimately associated with ore mineralisation.

If the reasonable assumption is made that the metals in the porphyry complex are largely magma derived from hypersaline F, then significant mixing of these metalliferous F must have occurred prior to mineral deposition, as indicated by the FI results. The hydrocarbons almost certainly migrated into the deposit with basinal brines. It would therefore be rational to conclude that these dilute brines mixed with the magmatic F. (From authors' abstract by E.R.)

FITZSIMONS, I.C.W. and MATTEY, D.P., 1994, Carbon isotope constraints on volatile mixing and melt transport in granulite-facies migmatites: Earth Planet. Sci. Lett., v. 134, p. 319-328.

Migmatites at Brattstrand Bluffs, East Antarctica, comprise granulite-facies mineral assemblages produced by high-T metamorphism of pelitic sediments. These rocks preserve an advanced stage of partial melting, with recrystallized melt accounting for ~25% of outcrop area. Many of the melt veins contain cordierite, which traps volatile molecules within open channels in its mineral framework and can be used to monitor the syn-metamorphic volatile contents of the melts. We have analysed the isotopic composition of cordierite channel CO_2 by step-heating mass spectrometry. Channel CO_2 in cordierite from Brattstrand Bluffs has not been significantly affected by retrograde isotope exchange as it preserves high-T C fractionations with coexisting graphite. Cordierite samples from the same locality have similar isotope compositions (±0.69‰), reflecting efficient mixing of partial melt and dissolved volatiles on a metre scale. However, samples from different localities have distinct $\delta^{13}C$ values (-10 to -20‰), and indicate that there was little mixing of melt or volatiles on a scale of ~100 m despite the high degree of partial melting. The 10‰ variation between localities reflects mixing of variable proportions of isotopically light biogenic C with C from a heavier reservoir. Although this mixing can be interpreted in terms of C influx from an external source, CO_2 was not a driving force for granulite metamorphism in this case as granulite assemblages occur at all localities irrespective of isotope systematics. CO_2 played a complex but passive role during metamorphism and melting at Brattstrand Bluffs, where the dissolution of H_2O into partial melt bodies was the dominant dehydration mechanism. (Authors' abstract)

FLEET, M.E. and WU, T.-W., 1995, Volatile transport of precious metals at 1000°C: Speciation, fractionation, and effect of base-metal sulfide: Geochim. Cosmochim. Acta, v. 59, p. 487-495.

FOGEL, R.A. and RUTHERFORD, M.J., 1995, Magmatic volatiles in primitive lunar glasses: I. FTIR and EPMA analyses of Apollo 15 green and yellow glasses and revision of the volatile-assisted fire-fountain theory: Geochim. Cosmochim. Acta, v. 59, p. 201-215.

FOMIN, Yuri, DEMIKHOV, Yuri, SHIBETSKY, Yuri and GOSTYAEVA, Natalya, 1995, Gold-bearing epigenetic systems of the Ukrainian greenstone belt, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 667-669. First author at Dept. Metallogeny IGMO, Nat'l Acad. Sci., Kiev, Ukraine.

Au-Fe and Au-Ag-polymetallic ore deposits have been recognized along the Chertomlyk shear zone in the Archean Ukrainian greenstone belt. In spite of different commodities, both types of ore deposit are similar in major mineralogical, FI and isotopic characteristics. These results support the concept of hydrothermal introduction of Au into the systems. Au ores were formed over P-T range of 1 to 0.8 kb and 180-230°C under reduced conditions (log fO_2 -39 to -38) from weakly alkaline (pH 6-8) F. (Authors' abstract)

In quartz and carbonate minerals of ore breccias and veins, the minerals were shown by their O isotope distributions to be nonequilibrium and to belong to different paragenetic associations. The T were calculated from O isotopic ratios of host minerals and their FI waters to be 200-300°C and 180-270°C, respectively. Quartz from Au-Fe and Au-Ag-polymetallic ore veins and zones was formed at the same T (200-230°C). The barren quartz was deposited at higher T (230-300°C) than ore quartz samples. The T calculated independently using $\delta^{13}C$ of CO_2-bearing FI and carbonate minerals range from 120 to 340°C. These data correlate well with results of Au-Fe ore deposit thermobarometric investigations (Fomin et al., 1994). (From authors' text by E.R.)

FONAREV, V.I. and KREULEN, R., 1995, Polymetamorphism in the Lapland granulite belt: Evidence from fluid inclusions: Petrology, v. 3, no. 4, p. 340-356.

Full paper for abstract in FIR, v. 27, p. 40. (E.R.)

FORTES, P.T.F.O. and GIULIANI, G., 1995, Fluid phases related to the massive sulfide ore bodies from Mina III gold deposit, Crixas greenstone belt, Goias state, Brazil: Comptes Rendus de l'Academie des Sciences, Serie IIa. Sciences de la Terre des Planetes, v. 320, no. 12, p. 1171-1178 (in French, English abstract).

The study of quartz-hosted FI associated with the massive sulfide ore bodies from Mina III Au deposit revealed the contemporaneous trapping of early FI characterizing three F systems of complex and variable composition: (1) carbonic, aquo-carbonic and aqueous F in the H_2O-NaCl-CO_2-CH_4-N_2 system (types C1, CL1, LC1 and L1), (2) halite-sylvite-bearing aquo-carbonic F in the H_2O-NaCl-KCl-CO_2-CH_4-N_2 system (type S), and (3) "carbonaceous" F in the CH_4-N_2 ± H_2O ± H_2S ± C_2H_6 system (types C'1 and CL'1). The P-T trapping conditions for the F (1) and (2) are estimated at 1.5-2.0 kb, 375-475°C and the significance of F (3) is discussed. (Authors' abstract)

FOUGT, Henrik, 1992, A fluid inclusion study of a large pegmatite body from the Evje area, southern Norway, *in* J.R. Wilson, ed., Magma Chamber Processes III: Geoskrifter 42, Proceedings of a meeting held 6 Nov. 1992, Dept. Earth Sciences, Univ. Aarhus, p. 9.

A vast number of large pegmatite bodies, in addition to monzonitic and granitic dikes, are associated with the late Sveconorwegian "Høvringsvattan complex" in the Evje area of southern Norway. Many of the pegmatites have been mined for feldspar, quartz or exotic minerals. After detailed field work in 1990 and 1991, it became clear that there was a relationship in time and space between the pegmatites and the monzonites. It was often impossible to distinguish which one was earlier or later. The obvious solution was that the timing of their emplacement overlapped, or their emplacement took place under conditions that allowed *in situ* interaction along mutual contacts.

A profile through one of the old quarries has been sampled for FI studies in order to describe the P-T conditions at the time of pegmatite emplacement. The cooling-heating experiments are currently in progress. One of the ideas being pursued, in cooperation with Peter Stockmarr, is that the pegmatites and monzonites are a result of L immiscibility in a Høvringsvatn granite-like magma. (Author's abstract)

FOUGT, H., STENDAL, H. and KONNERUP-MADSEN, J., 1995, Geological setting and fluid inclusions in quartz veins from a gold mineralized shear zone in the Early Proterozoic Ketilidian orogen, South Greenland (abst.), *in* P.M. Ihlen, M. Pedersen and H. Stendal, eds., Gold Mineralization in the Nordic Countries and Greenland, Symp. held at Geological Inst., Univ. Copenhagen, 19-20 Oct. 1995, Volume of Extended Abstracts: Geol. Surv. Greenland Open File Series 95/10, p. 36-38.

FOUKE, B.W., ZWART, E.W., EVERT-ANOUT, J.W. and SCHLAGER, Wolfgang, 1995, Carbonate platform stratal geometries and the question of subaerial exposure: Sedimentary Geol., v. 97, p. 9-19.

Integrated petrographic, geochemical and FI analyses indicate that the most prominent exposure unconformity at the southern margin of the Vercors carbonate platform in SE France does not coincide with the major break in depositional geometry. While many bedding planes contain some evidence of meteoric alteration, one of these bedding surfaces is unique in that it exhibits several generations of overprinted meteoric calcite cements (bladed to blocky morphology, precipitation in biomolds, extinct to zoned cathodoluminescence, low Mg and $\delta^{18}O$, variable $\delta^{13}C$, freshwater FI) that are crosscut by marine borings. The surface containing the most extensive record of meteoric diagenesis does not stratigraphically coincide with the surface representing the most significant lateral shift in depositional facies. (From authors' abstract by E.R.)

FOUQUET, Y., DUBOIS, M., MARIGNAC, C. and RAMBOZ, C., 1994, Contribution of fluid inclusions to the knowledge of the hydrothermalism in the Lau Basin (Pacific Ocean) (abst.): 15th Mtg. of Earth Sciences [15^e Réunion des Sciences de la Terre], 26-28 April 1994, Nancy, France, p. 105 (in French).

An active chimney with anhydrite (BL12, Vai Lili, 1720 m) and two chimneys with sulfides (NL08-06, White Church, 1850 m and NL16-02, Hiné Hina, 1900 m) have been studied. The FI in anhydrite show P-corrected Th of 290-340°C, coherent with T measured at the vent; the F are supersaturated with halite. Sphalerite from NL08-06 is zoned, Th increases from the core towards the margin; the F are a mixture of a NaCl brine (H) and seawater (SW). The barite around this sphalerite has no FI. On the other hand, FI in barite from NL16-02 consists of a mixture between SW and a F with NaCl-$MgCl_2$, hot, more saline and Mg-richer than SW; the transition from the association barite-pyrite-sphalerite to only barite is marked by decreasing average Th and salinity. In this way, at least two hydrothermal F (which have circulated at different depths and eventually have undergone unmixing) are mixed with seawater in the chimneys of the Lau Basin. (Authors' abstract, translation courtesy Dr. E.A.J. Burke)

FOWKES, A.J. and PARKINSON, R.T., 1972, The analysis of gaseous inclusions in glass using a quadrupole mass spectrometer: Glass Technology, v. 13, no. 4, p. 126-xxx. Authors at Pilkington Brothers Ltd., Central Analytical Laboratories, St. Helens, Lanc., UK.

A quadrupole mass spectrometer has been adapted to analyse bubbles in production and research glasses. It can handle sample sizes in the range 0-2 mm in diameter (1-4 nl of gas at stp) to 8 mm in diameter (90,000 nl of gas at stp), and has detected H_2, He, CH_4, N_2, CO, O_2, A, CO_2, COS, H_2S, and SO_2 in bubbles from a variety of sources. The preparation of synthetic bubbles for use as laboratory exchange samples, or as reference samples is described. The mass spectrometer can be rapidly converted for general gas analysis when required. Some typical results are recorded and discussed. (Authors' abstract)

FOWLER, A.D., 1994, The role of geopressure zones in the formation of hydrothermal Pb-Zn Mississippi Valley type mineralization in sedimentary basins, *in* J. Parnell, ed., Geofluids: Origin, Migration and Evolution of Fluids in Sedimentary Basins: Geol. Soc. (London) Spec. Publ. No. 78, p. 293-300. Author at Dept. Earth Sciences, Univ. Ottawa, 770 King Edward Ave., Ottawa, Ontario K1N 6N5, Canada.

Geopressure zones immediately subjacent to platform carbonate rocks can be modeled to serve as proximal sources of hydrothermal F for epigenetic Pb-Zn deposits in sedimentary basins. In some geopressure zones of the Gulf of Mexico, geothermal gradients can be as high as 10°C 100 m-1. This arises because the water-saturated geopressured shale masses act as thermal insulators. Geopressure zones may have sufficient F P to rupture overlying strata, providing a vertical conduit for hot mineralized brine to migrate directly into carbonate host rocks. (Author's abstract)

FRANZSON, Hjalti, 1995, Geological aspects of the Svartsengi high-T field Reykjanes peninsula, Iceland, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 497-500. Author at Nat'l Energy Authority, Reykjavik, Iceland.

The stratigraphy of the Svartsengi high-T geothermal reservoir is characterized by faulted sequence of lavas and intercalating hyaloclastites. The faults trend NE-SW and NNW-SSE. Alteration and FI measurements show that the present T is lower than at earlier stages in the hydrothermal system. Melting T in FI show lower salinities of earlier geothermal F. Aquifers are primarily along stratigraphic boundaries in the upper 600 m of the strata but are mostly associated with intrusions <~800 m depth. The main upflow zone is believed to be along a NNW-SSE fault in the central part of the field. (Author's abstract)

FI (140) were studied in calcite, quartz and anhydrite from 596, 834, and 1314 m depths in well 12. PI where identified showed in general higher T than the secondary ones, implying a cooling trend with time. A general cooling of the reservoir, of ~20°C around 600-1000 m in depth is inferred and a more drastic cooling of >40°C below 1200 m depth. This cooling conforms with the cooling estimate based on alteration. Tm ice values scatter widely, from ~-0.2°C to ~-1.6°C. The present salinity of the Svartsengi F is ~2/3 that of seawater, and its estimated melting point is ~-1.2°C, with an additional -2°C from CO_2 in the F. Most of the Tm values indicate less salinity than present reservoir F composition. These results show that the early geothermal F were less saline and the field is progressively becoming more saline with time. It is believed that the freshwater component of the F may have originated during the last glaciation when the Reykjanes peninsula was covered and surrounded by icesheet, preventing seawater access into the bedrock. (From author's text by E.R.)

FREI, Robert, 1995, Evolution of mineralizing fluid in the porphyry copper system of the Skouries deposit, northeast Chalkidiki (Greece): Evidence from combined Pb-Sr and stable isotope data: Econ. Geol., v. 90, p. 746-762. Author at Inst. Crystallography and Petrography, Swiss Fed. Inst. Technology, Sonnerggstrasse 5, CH-8092 Zurich, Switzerland.

The porphyritic syenite of the Skouries deposit intruded the metamorphic basement of the Serbomacedonian Massif in the NE Chalkidiki peninsula at 19 Ma. Following its emplacement (stage I), the porphyritic syenite suffered a pervasive potassic alteration (stage II, ~590°-640°C). Two later veining stages with propylitic characteristics (stage IIIA, ~480°C; stage IIIB, ~380°C) [in part from FI Th] brought in most of the Cu, which was deposited in the form of chalcopyrite. Quartz sulfide-(calcite) veins transect the porphyritic syenite as well as the country rocks in a narrow (<50 m wide) halo around the stock only. The range of $\delta^{18}O$ values from 3.5 to 7.6‰ for the F in equilibrium with vein quartz is within the typical range of early ore-forming F associated with porphyries, representing magmatic F that may, to some extent, have interacted with the igneous wall rock. A subsequent late propylitic alteration (stage IV, ~210°C), more localized and patchy, affected the country rocks and the porphyritic syenite and deposited disseminated pyrite and chalcopyrite. The $\delta^{34}S$ values from vein and disseminated sulfides range from -2.1 to +0.3‰, indicative of a magmatic origin for the S.

Age-corrected $^{87}Sr/^{86}Sr$ from I F in vein quartz range from 0.7086 to 0.7099 for veins within the country rock and from 0.7061 to 0.7080 in veins transecting the porphyritic syenite. Values for porphyry feldspars range from 0.7079 to 0.7081 and country rock from 0.7135 to 0.7342. These data confirm the Pb isotope trends and indicate that Sr contamination took place where the veins crosscut the country rocks. F in veins within the porphyry could ascend rapidly from deeper levels without reacting with the porphyry and thus show an unaffected magmatic Sr isotope signature.

Pb and Sr isotopes in I F are shown to be extremely sensitive tracers for elucidating the hypogene leaching processes in the Skouries porphyry system. (From author's abstract by E.R.)

Dms include sulfates, halite, opaque (cpx?) sylvite, and hematite. (E.R.)

FREZZOTTI, M.L., BURKE, E.A.J. and GHEZZO, C., 1995, CO/CO_2 fluid inclusions in aluminous metasedimentary xenoliths in siliceous lavas from Mt. Amiata (Tuscany, Italy) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 80-81. First author at Dip. Scienze della Terra, Via delle Cerchia, 3 53100 Siena, Italy.

CO/CO_2 I have been observed in aluminous metasedimentary xenoliths in rhyodacitic lavas from Mt. Amiata. These xenoliths record complex processes of magma-rock interactions and show a composite zoned pattern.

Two different types of FI occur in the newly formed minerals in the different zones of the xenoliths:

(1) Pure CO_2 in plagioclase and orthopyroxene occur in the most external zones with very low contents of graphite.

(2) CO/CO_2 I occur in sanidine in the cores with higher contents of graphite.

These CO/CO_2 I in the newly formed sanidine crystals are isolated large (≤30 µm) monophase V I, occupying ≤5 vol % of the crystals. During freezing runs initial melting was observed at ~-59.5°C and final melting occurred between -57.7 to -57.0°C. Homogenization, always to the vapour (L+V->V), was recorded only in a few I between 18.5 and 26°C. Raman analyses (with prolonged measurement times because of extremely low densities) of the I with the lowest melting point give a composition of 8 to 10 mol % CO and 92 to 90 mol % CO_2. Because of the paucity of PVTX data for the L V equilibrium in the system CO/CO_2, it is not possible to determine the bulk molar volume from these results.

Van Bergen (Contrib. Mineral. Petrol., v. 86, 1984) proposed that the pure CO_2 I in the rims of the metasedimentary xenoliths from Mt. Amiata were formed by oxidation of graphite at contact-metamorphic conditions, as he observed a decrease of the abundance of graphite from the cores towards the host lavas. T in the cores were much lower, ~350-400°C (obtained from graphite peak ratios in Raman spectra). The resulting lower O fugacity conditions failed to oxidize the graphite completely and caused CO/CO_2 F. (From authors' abstract by E.R.)

FREZZOTTI, M.L., DI VINCENZO, G. and GHEZZO, C., 1994, Fluid regimes in Cambro-Ordovician granitoids from northern Victoria Land, Antarctica: Proc. 4th Mtg. Earth Sciences in Antarctica, Siena, 1993, Terra Antarctica, v. 1, p. 43-45. Authors at Dip. Scienze della Terra, Univ. Siena, Via delle Cerchia 3, 53100 Siena, Italy.

Examination of F, solid and MI in Cambro-Ordovician granitoids from the northern Victoria Land (Antarctica) revealed evidence of different F regimes, during late crystallization conditions, and the overall subsolidus evolution in the three main granite intrusive series. Magmatic $CO_2 + H_2O$ F were present during the crystallization of peraluminous granites. On the other hand, there is no evidence for magmatic CO_2 in the metaluminous suites (high-K calcalkaline and shoshonitic series). In the peraluminous granites, different O fugacity conditions lead to substantially different F composition during the hydrothermal (carbothermal) evolution: F in the synkinematic suite have a CO_2 regime >700°C, a water regime ≤≈400°C and a CH_4 regime >400°C; in the postkinematic Tinker type granites, F are CO_2-H_2O mixtures, progressively richer in H_2O. These different F regimes suggest that CO_2 may have played an important role in the genesis of the peraluminous granitoid rocks in the middle-lower crust. (Authors' abstract)

FRIMMEL, H.E., 1995, Factors controlling the composition of the Witwatersrand fluids: Proc. Symp. Economic Significance of Metamorphism and Fluid Movement within the Witwatersrand Basin, Econ. Geol. Research Unit Info. Circ. 296, p. 16-19. Author at Dept. Geological Sciences, Univ. Cape Town, Rondebosch 7700, South Africa.

The aims of this contribution are (I) to present evidence of economically significant responses of the Witwatersrand rocks to F infiltration; (ii) to constrain the important factors controlling the F composition using petrological (mineral parageneses), geochemical (minerals and FI), and textural (high resolution and cathodoluminescence imaging, CLI) information, and (iii) to place different generations of F into a regional geological context based on recently acquired age data. (From author's abstract by H.E.B.)

FRYER, B.J., JACKSON, S.E. and LONGERICH, H.P., 1995, The design, operation and role of the laser-ablation microprobe coupled with an inductively coupled plasma-mass spectrometer (LAM-ICP-MS) in the earth sciences: Canadian Mineral., v. 33, p. 303-312. First author at Dept. Geology, Univ. Windsor, Windsor, Ontario N9B 3P4, Canada.

The coupling of a laser-ablation microprobe (LAM) to an Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) has produced a relatively simple and inexpensive multi-element, high-sensitivity trace-element microbeam analytical system with characteristics ideally suited to research in the Earth Sciences. The LAM should be designed to allow for flexibility in sampling a wide variety of materials of various physical sizes and shapes, at variable, but small-scale, spatial resolution. The data acquisition and processing protocols of the LAM-ICP-MS system must allow the use of time-resolved analytical data for routine analytical work. Raw analytical data must be acquired and stored for processing on a time-scale appropriate to the rate of laser sampling and the scale of chemical variation in the sample (normally, integrated data for each mass, at least each second, during sample ablation). Robust calibrations, with reference materials (NIST trace-element glasses) and suitable internal standards contained in both the sample and reference material, allow quantification of the concentrations of many petrogenetically important trace elements. Relative fractionation of elements does occur during the analysis, and understanding of these phenomena is required before the full potential of LAM-ICP-MS can be realized. Despite this current limitation, the method is now capable of unique applications in mineralogical and geological research. Of particular importance is its ability to characterize, not only the chemical concentration of trace elements at ppm to ppb levels in minerals, but also the nature of their distribution. Time-resolved analysis of the analytical data allows distinction between trace elements incorporated in the host crystal-structure and those located in other phases (inclusions, etc.) (Authors' abstract)

FUERTES, M., MARTIN-IZARD, A. and MANGAS, J., 1995, Fluid inclusions in quartz, beryl and apatite from the Forcarey-Sur pegmatite field (Spain) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 82-83. First author at Dept. Geology, Univ. Oviedo, 33005 Oviedo, Spain.

The pegmatite field is associated with two-mica or muscovite peraluminous synkinematic granites. The pegmatites and pegmoaplites belong to the LCT (Cerny, 1993) family, and within this to the rare-elements type. The FI study was undertaken using microthermometry on quartz, beryl and apatite from a replacement aplitic unit of a pegmatite of the group E. This aplitic unit is rich in cassiterite and columbite-tantalite. Only one type of I F has been defined: complex aqueous I (H_2O-NaCl-CH_4-CO_2). These I show two phases at room T. CH_4 homogenisation cannot be observed, and its presence has been detected by formation of hydrate, which melts at 10.8°C to 16°C. CO_2 nucleation T (-105°C/-118°C) was observed in 10 I, and CO_2 melting T was measured in three I (-60.7°C, -60°C, -59°C). These data are consistent with the presence of CH_4. The fact that CO_2 and CH_4 phase transitions cannot be observed is probably due to their low density.

Tm ice was close to the eutectic for NaCl-H_2O. The exclusion of NaCl from the clathrate lattice results in artificially high salinities in the aqueous phase of the I while CH_4 hydrate is present. Based on volumetric relations and Th, three subtypes of I have been distinguished, but clearly no significant differences exist among the FI populations in quartz, beryl and apatite. Three discontinuous trapping stages of FI can be distinguished with progressively lower Th. This F may have been responsible for the albitic metasomatism of the pegmatitic body and associated Sn-Nb-Ta mineralization. Similar FI have been described in metasomatic minerals in border unit of the Tanco zoned granitic pegmatite (Thomas et al., Geochim. Cosmochim. Acta, 54, 1990). (From authors' abstract by E.R.)

FUJIMOTO, Koichiro, 1995, Crustal fluids in subduction zones: Chishitsu News, v. 4, p. 28-32 (in Japanese).

Indexed under FI. (E.R.)

FUKUDA, Masami and MORIIZUMI, Jun, 1995, Radiocarbon dating of methane obtained from air in the ground ice in Siberian permafrost (abst.): Eos, v. 76, no. 46, p. F237.

Highly concentrated CH_4 in air bubbles which were stored in ground ice indicated the warm climate in the past. The concentration of stable ^{13}C stands at <-70 ‰ indicating the source of CH_4 as production under anaerobic condition. Concentrations of ^{14}C suggested the age of them as ~4000 yBP. (From authors' abstract by H.E.B.)

FULIGNATI, P., GIONCADA, A. and SBRANA, A., 1995, The magma chamber related hydrothermal system of Vesuvius: First mineralogical and fluid inclusion data on hydrothermalized subvolcanic and lavic samples from phreatomagmatic eruptions (extended abst.), *in* Volcanoes in Town, Roma 27-30 Sept. 1995: Periodico di Mineral., v. 64, p. 185-187. Authors at Dip Scienze della Terra, Univ. Pisa, Via S. Maria 53, I-56126 Pisa, Italy.

This presents the first results of mineralogical and FI studies on samples representative of different levels of the volcano basement, showing various hydrothermal paragenesis. (From authors' abstract by H.E.B.)

FURUNO, M., ITOH, K. and MARIKO, T., 1995, Polymetallic and gold-silver mineralizations in and around the Akenobe ore deposits, southwest Japan: Mining Geol., v. 42, p. 33-46 (in Japanese, English abstract).

The mineralizations are related to the acidic to intermediate magmatism during the Cretaceous to Paleogene. A series of the mineralizations from polymetallic to Au-Ag were recognized by the field survey, microscopic observations of ores and the electron microprobe analyses. The ore mineral assemblages suggest that the Au-Ag ore was formed at a late stage ((Cu-)Sn-W stage) of the polymetallic ore depositions. Ag content in tetrahedrite-tennantite, ranging from 0 to 24 wt %, tends to increase towards the Au-Ag zone from the polymetallic zone. The T estimated based on electrum compositions for the Au-Ag ores are 260-310°C which are similar to FI Th of the ores formed at the late stage of the polymetallic ore deposition. (Authors' abstract)

FUZIKAWA, Kazuo and ALVES, J.V., 1995, Interpretações sobre o comportamento e as mudanças de fase de uma inclusão aquo-carbônica durante a criometria: Rev. Esc. de Minas, Ouro Preto, v. 49, no. 2, p. 123-126 (in Portuguese, English abstract). Authors at Centro de Desenvolvimento da Tecnologia Nuclear, Belo Horizonte, MG.

Numerous studies on the aquo-carbonic system have been published in the last years. However, this vast literature may sometimes be a complicating factor to the understanding and interpretation of the phase changes that occur during microthermometry of an I containing this F. A step by step description of the behaviour and the phase changes of an aquo-carbonic I during cryometry is given, drawing attention to the important ones and to those that might lead to erroneous conclusions. (Authors' abstract)

GAMMONS, C.H. and WILLIAMS-JONES, A.E., 1995, The solubility of Au-Ag alloy + AgCl in HCl/NaCl solutions at 300°C: New data on the stability of Au (I) chloride complexes in hydrothermal fluids: Geochim. Cosmochim. Acta, v. 59, p. 3453-3468.

GANSECKI, C.A. and LOWENSTERN, J.B., 1995, Pre-eruptive volatile compositions of the Lava Creek Tuff magma, Yellowstone Plateau volcanic field (abst.): Eos, v. 76, no. 46, p. F665.

The Lava Creek Tuff (~1000 km^3) is the youngest of the three major Yellowstone Plateau ignimbrites, with associated fallout deposits that blanketed much of the U.S. ~0.6 Ma ago. The ignimbrite is thermally and compositionally zoned high silica rhyolite (75-77% SiO2; 820-900°C). Water concentrations of this unit had not previously been determined, but were expected to be low because of the high magma T and absence of hydrous minerals in the bulk of the ignimbrite.

MI in phenocrysts, if intact, are presumed to preserve volatiles dissolved in the melt phase of the pre-eruptive magma body. We conducted Fourier transform infrared (FTIR) spectroscopic analysis of doubly polished MI in quartz phenocrysts from the Lava Creek Tuff, in order to determine CO_2 and H_2O concentrations and speciation. The I are 40 to 100 μm in diameter and are clear, glassy, and bubble-free. Total H_2O concentrations from the earliest-erupted Plinian fallout are 3.2 to 3.9 wt % (ave. 3.38±0.22 wt %). This is lower than water contents of similar fallout units (Bishop Tuff, 5.1-6.8 wt %, Anderson et al., 1989; Lower Bandelier Tuff, 4-5.5 wt %, Dunbar and Hervig, !992), indicating that total dissolved pre-eruptive water content is not the most important control on magma explosivity. CO_2 concentrations have a much wider range, from 93 to 770 ppm. Major element and Cl compositions of the glasses analyzed by electron microprobe reveal no significant variations between I, so magma mixing does not seem a likely explanation for the range of values. The H_2O and CO_2 concentrations are consistent with a trend of open- or closed-system decompression degassing from 2.3 kb to 1 kb. (Authors' abstract)

GAO, Z.L. and KWAK, T.A.P., 1995a, Turbidite-hosted gold deposits in the Bendigo-Ballarat and Melbourne zones, Australia. I. Geology, mineralization, stable isotopes, and implications for exploration: Int'l Geol. Rev., v. 37, p. 910-944.

FI data is given, but see Part II (next item) for the complete FI story. (H.E.B.)

GAO, Z.L. and KWAK, T.A.P., 1995b, Turbidite-hosted gold deposits in the Bendigo-Ballarat and Melbourne zones, Australia. II. Nature of ore fluids: Int'l Geol. Rev., v. 37, p. 1007-1038. First author at PO Box 56, Norseman 6443, Western Australia, Australia.

F in mesothermal, turbidite-hosted, Au vein deposits in central Victoria, Australia, are characterized by T ranging from 180 to

310°C and salinities of <10 wt % NaCl eq. From west to east there is a general decrease in T, averaging ~300°C in the western Bendigo-Ballarat Zone (BBZ), 270°C in the eastern BBZ, and 230°C in the Melbourne Zone (MZ). Pre-mineralization veins generally are lower in T than those hosting mineralization, whereas post-mineralization veins have the lowest average T. Salinities are low, <10 wt % NaCl eq.; those in deposits in the MZ are slightly lower than those in the BBZ. Salinities are variable in a given deposit or even a single vein period, but there is a weak trend of dilution toward late mineralization and post-mineralization stages. Some pre-mineralization veins have higher salinities (to 9 wt %) than mineralized veins.

F in the BBZ have C-O-H compositions, whereas those in the MZ are C-O-H-N. In the BBZ, the CH_4:CO_2 ratio in the G phase of FI varied from 74:26 to 1:99. In the MZ, similar values occurred, as well as high N_2, to 69% of the G phase. Minor hydrocarbons (such as C_3H_6) occur, suggesting low values of H. For most of the deposits there is a trend of increasing concentration of CH_4 and CO_2 during mineralization. Average CH_4-CO_2 ratios for the western BBZ (Maxwells and Cambrian deposits) are 0.56 and 0.33, and for the eastern BBZ (Wattle Gully), 0.23.

One or more periods of immiscibility occurred, especially in BBZ deposits during mineralization, but not in pre- or post-mineralization veins. Average P present during mineralization were as follows: western BBZ (Maxwells deposit and New Cambrian deposit), 1200 and 1400 bars; eastern BBZ (Wattle Gully deposit), 800 bars; and MZ (Brunswick and Bailieston deposits), 300 and 900 bars. O fugacities between the HM and QFM buffers varied from 10^{-43} to 10^{-41} at Brunswick and from 10^{-38} to 10^{-30} at Maxwells, New Cambrian, and Wattle Gully. (Authors' abstract)

GAO, Z.L., KWAK, T.A.P., CHANGKAKOTI, A., HUSSEIN, E. and GRAY, J., 1995, Supergene ore and hypogene nonore mineralization at the Nagambie sediment-hosted gold deposit, Victoria, Australia: Econ. Geol., v. 90, p. 1747-1763. First author at Dept. Geology, La Trobe Univ., Bundoora, Victoria 3083, Australia.

The deposit is confined largely to shears and siltstones and shales. Five stages of protore vein genesis have been identified. The first two (A, B) are barren crenulated massive quartz. Primary Au mineralization occurs in stibnite-bearing quartz stockwork stringers which belong to the third (C) and fourth (D) quartz veining stages, whereas the fifth consists of unmineralized small veins (E). FI studies on the two Au mineralization stages C and D yield Tt and P of 280° ± 25°C and 1000 to 1200 bars, and 200° ± 30°C and 700 to 1000 bars, respectively. The mineralization F contain H_2O, CO_2 (0-69 mol %), CH_4 (0-21 mol %), and trace N_2, with wt % NaCl eq. Values in the range of 0 to 10.2 wt %. Calculated $\delta^{18}O$ values (15.0-6.8‰) and measured δD data (-88 to -99‰) of the hypogene F indicate a meteoric origin. These F underwent extreme ^{18}O enrichment by reacting with country rocks (metamorphic or igneous). (From authors' abstract by E.R.)

GARCIA, E., LOPEZ-GA, J.A., VINDEL, E. and BOIRON, M.C., 1995a, Fluid migration in microfissured granites: A fluid inclusion study of W-Sn veins in the Spanish Central System (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 84-85. First author at Dpto. Cristalografía y Mineralogía, Univ. Complutense, 28040 Madrid, Spain.

The geometry of the ore F migration was investigated in the (W-Sn) mineralized granites from the Spanish Central System. F trapping occurred in the San Rafael granites by means of a complex succession of opening and reopening of microfracture network. NE-SW ductile-brittle cracks contains quartz-wolframite, are thus connected with FIP-bearing low density carbonic aqueous (0.3-0.7) F, and high density aqueous F (0.8-1.0). A later drop in XCO_2 is recorded in N140-160'E, N-S and E-W FIP. The replacement of wolframite by scheelite and sulphide deposition can be related with this stage. A latest F is represented by small aqueous I with relatively low Th. crosscutting along N-S, E-W, NE-SW and NW-SE all the precedent FI planes. (From authors' abstract by E.R.)

GARCIA, E., LOPEZ-GA, J.A., VINDEL, E., BOIRON, M.C. and CATHELINEAU, M., 1995b, Reconstruction of paleofluid migration in microfissured granites: application to W-Sn veins of the Spanish Central System (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 189.

Four types of F have been identified: (1) An early high-T (Th 250°-400°C) brine displays a preferential N45°E orientation; (2) NaCl-H_2O-CO_2-(CH_4) rich V F of moderate density (0.55 to 0.7) and Th between 320° and 390°C oriented according to N20°-35°E; (3) aqueous NaCl- H_2O I (Th 100°-350°C) with variable salinities (1 to 8 wt % NaCl) trapped along two preferential FIP N20°-30°E and N60°- 90°E; finally, (4) the latest F is represented by small aqueous I with relatively low Th displaying N-S orientation. The FIP display similar orientation at the scale of a quarry (sampling distance 0.5-10m). The FIP results indicate that the significant change of the F composition is associated with different crack orientations and the nature of the deposited ore minerals. NNE-SSW cracks containing quartz-wolframite and minor sulphides are thus connected with FIP bearing the complex-aqueous F and postdate NEE-SWW cassiterite-quartz veins probably related to early high salinity F. (From authors' abstract by E.R.)

GARCIA-VEIGAS, J., AYORA, C., ORTI, F., ROSELL, L., ROUCHY, J.M. and LUGLI, S., 1995, The Messinian salt from the Mediterranean: Solute concentration of fluid inclusions in halite from the Central Sicily basin (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 86-87. First author at Serveis Científico-Tècnics, Univ. Barcelona, Martí i Franquès s/n., E-08028 Barcelona, Spain.

Deep boreholes and seismic profiles have defined three major stratigraphic units forming the Messinian evaporites: (1) lower sulfates and marls, (2) salt layer, (3) upper sulfates, marls and salt lenses.

The study is mainly based on the evolution of the solute concentration in brines trapped as PI in halite. The solute content in the FI have been compared with the result of the numerical simulation of evaporation processes in different scenarios of an open basin.

The results of bromine analysis in the bulk trapped F clearly differentiate between two units in the Salt Member: a lower unit including the kainite beds, which shows contents that increase towards the potash zone reaching a maximum of 150 ppm, and an upper unit in which contents decrease towards the top attaining values <13 ppm. Low values, in general <70 ppm, suggest salt recycling by normal or only slightly concentrated seawater.

The results of FI microanalysis by Cryo-SEM-EDS also record the same two saline units. The lower one is characterized by concentrated brines (high Mg, low Na contents), whereas the upper unit shows less concentrated brines (lower Mg, higher Na). In the lower unit the chemical evolution model that best matches the contents analyzed in FI is the evaporation of seawater recharge without polyhalite precipitation, in which a small amount of $CaCl_2$ brine replaces an equal volume of seawater inflow. It follows that polyhalite inhibition to crystallize as a primary mineral plays an important role in the formation of economic deposits of kainite. In the upper unit the chemical evolution model that best reproduces the salinity decrease found in the FI is the evaporation of seawater inflow saturated in halite (salt-recycling).

Thus, the geochemical study of halite samples confirms the marine origin of the mother brines and their relationship to the SO_4-rich evaporation trend with the inflow of seawater slightly modified by a $CaCl_2$-rich inflow. In particular, the microanalysis of FI demonstrates that the salt dissolution and reprecipitation which occurred towards the top of the Saline Member in the Caltanissetta Basin originally attributed to a meteoric water influence was due to the inflow of seawater into the basin. Therefore, the very low bromine contents found at the top of the saline sequence do not really imply any significant contribution of continental waters. (From authors' abstract by E.R.)

GARCIA-VEIGAS, J., ORTI, F., ROSELL, L., AYORA, C., ROUCHY, J.-M. and LUGLI, S., 1995, The Messinian salt of the Mediterranean: Geochemical study of the salt from the central Sicily Basin and comparison with the Lorca Basin (Spain): Bull. Soc. Geol. France, v. 166, no. 6, p. 699-710.

See previous item. (E.R.)

GASCOYNE, M., STROES-GASCOYNE, S. and SARGENT, F.P., 1995, Geochemical influences on the design, construction and operation of a nuclear waste vault: Appl. Geochem., v. 10, p. 657-671. Authors at Whiteshell Laboratories, Pinawa, Manitoba R0E

1L0, Canada.

The design, construction and operation of a vault for used nuclear fuel in crystalline rock may be influenced by a number of geochemical factors. During vault construction, the geochemistry of the rock may cause changes to the design and construction methods used. High salinity F in the rock matrix could limit the ability of radar surveys to detect fractures in the surrounding rock and may also cause unacceptably high total dissolved solids loadings in water discharged from the facility. (From authors' abstract by E.R.)

GATTER, I. and BLAMART, D., 1995, Fluid inclusion and C-O stable isotope studies of the epithermal polymetallic occurrences of the Matra Mountains (NE Hungary) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 292.

The West part of the Internal Carpathian Volcanic Arc (NE Hungary) contains epithermal occurrences associated with the Neogene magmatic activity. In order to access the T and the nature of the F involved during the hydrothermal activity, FI and C-O stable isotope studies have been performed. The Matra Mts. (80 km NE from Budapest) were an andesitic stratovolcano, formed during three volcanic cycles. The main hydrothermal activity took place after the second cycle as attested by the presence of two main generations of quartz (apophysis and vein) and calcite veins. Both systems are mineralized in Py, Cpy, Sph and Gal. From the results it can be concluded that: (1) The thermal history of the area is complex. (2) The $\delta^{18}O$ values of the F vary from 10.3 to -3.3‰ and reflect repetitive mixing processes. (3) During the main hydrothermal activity, the F have $\delta^{18}O$ values of 3 to 6; they interpreted as a mixture of meteoric water ($\delta^{18}O$ -3 to 0‰), found in the late stage of the precipitation of the calcite, with magmatic F (9-10.3‰) associated with the early hydrothermal activity. (Authors' abstract)

Data listing Th, $\delta^{18}O$, $\delta^{13}C$, and $\delta^{18}O$ for seven samples omitted. (E.R.)

GENG, A., ZEEH, S. and BECHSTÄDT, T., 1995, Diagenesis and pore- fluid evolution in the Rhine graben and adjacent areas: the Muschelkalk Group, Southwest Germany (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 198.

Petrographic and geochemical analysis of carbonate cementation within the Middle Triassic Muschelkalk Group inside and outside of the Rhine graben enable us to estimate the timing, T, and geochemistry of diagenetic F that affected the diagenetic processes.

Early diagenetic marine cementation (generation A and B) include acicular calcite cements that infill primary porosity. Early burial sparry calcite cements (generations C and D) include both prismatic/columnal and equant cements. Following saddle dolomite cements represent deeper burial diagenesis at elevated T (150 to 164°C).

Late diagenetic calcite cements were formed post-Cretaceous and can be subdivided into two types: Generation E1 which occurs in uplifted areas and Generation E2 which occurs in the Rhine Graben. There is a strong geological significance that generation E1 was precipitated near the surface from meteoric waters, which is supported by the stable isotope data ($\delta^{18}O$ = -11.38 to -7.80‰; $\delta^{13}C$ = -2.01 to +2.44‰). FI studies indicate Tf between 60 and 90°C. The calculated paleofluid composition from which this cement was precipitated show that cement E1 is not in isotopic equilibrium with Tertiary/Quaternary meteoric water. Interaction between meteoric water and the host rock might explain this deviation. Cement generation E2 shows $\delta^{18}O$-values from -17.34 to -11.30. There is strong relation between the $\delta^{18}O$-value and the depth from which the samples originate. Cement E2 is also not in isotopic equilibrium with calculated subrecent pore water (Pliocene-Pleistocene oil field brines) and an origin from subsurface brines during Oligocene/Miocene time is suggested. (Authors' abstract.)

GENGE, M.J., JONES, A.P. and PRICE, G.D., 1995, An infrared and Raman study of carbonate glasses: Implications for the structure of carbonatite magmas: Geochim. Cosmochim. Acta, v. 59, p. 927-937.

GERDES, M.L., BAUMGARTNER, L.P. and PERSON, M., 1995, Stochastic permeability models of fluid flow during contact metamorphism: Geology, v. 23, p. 945-948.

GERDES, M.L., BAUMGARTNER, L.P., PERSON, Mark and RUMBLE, Douglas, III, 1995, One- and two-dimensional models of fluid flow and stable isotope exchange at an outcrop in the Adamello contact aureole, Southern Alps, Italy: Am. Mineral., v. 80, p. 1004-1019. First author at Dept. Geology and Geophysics, Univ. Wisconsin, Madison, Wisconsin 53706.

Localized depiction of ^{18}O and ^{13}C in a thin subhorizontal marble layer in the Adamello contact aureole, Southern Alps, Italy, resulted from F infiltration focused along a crosscutting dike. The presence of clinozoisite and garnet in tile 5-15 cm thick marble layers near the granodiorite dike indicates H_2O-rich F conditions ($XCO_2 \approx 0.01$).

The O and C isotope profiles were compared with one- and two-dimensional models of advective-dispersive isotope transport. Individually the isotope profiles fit one-dimensional transport models well. The results emphasize that isotope distributions resulting from multidimensional flow may fortuitously fit one-dimensional transport models if isotope tracers are considered independently. The use of multiple tracers coupled to F-composition constraints is therefore essential to discriminate between various transport models. (From authors' abstract by E.R.)

GETMANSKAYA, T.I., DANDAR, S. and KEMPE, U., 1995, The new data on genesis of Chovd Gol and Mushguu ferberite deposits (Mongolian Altai): Proc. Russian Mineralogical Society, pt. CXXIV, p. 12-20 (in Russian; English abstract).

Genesis of the W-Sb-(Hg) formation deposits received little attention because of their usually small reserves and limited abundance. But often they are represented by rich and high quality ores. Detail study of Chovd-Gol and Mushguu deposits has shown that their scheelite-ferberite-antimony ores have been formed by poorly-mineralized solutions (3.4-5.6% wt NaCl eq.) under 100-170°C. Content and distribution of REE in scheelites of these deposits distinguish them sharply from scheelites in other genetic type deposits. (From authors' abstract by E.R.)

GHAZBAN, Fereydoun, 1995, Epigenetic dolomitization in the Lower Cretaceous carbonates, west central Iran: geochemical evidence (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-423.

Petrographic and geochemical characteristics indicate that the dolomitizing F were derived from Jurassic shales with T of ~105±5°C, salinities ≤10 to 15 wt % NaCl, $\delta^{18}O$ = -7.0 to 0.0‰ and $^{87}Sr/^{86}Sr \geq 0.7090$. The movement of F were probably related to tectonic thrusting and compression and uplift during the late Cretaceous. (From authors' abstract by H.E.B.)

GHAZI, A.M., McCANDELSS, T., RUIZ, J. and VANKO, D.A., 1995, Laser ablation ICPMS for determination of trace elements in individual fluid inclusions: A new quantitative approach (abst.): Eos, v. 76, no. 17, p. S287. First author at Dept. Geology, Georgia State Univ., Atlanta, GA 30303.

Laser ablation ICPMS allows *in situ* elemental analysis of individual FI. We report details of a potential new approach for quantitative elemental analysis of single FI and some preliminary data obtained from I in natural halite. Quantification was performed for Sr, Rb, Cu and Mo, using a set of "artificial FI" which were prepared by drawmg solutions of varying concentrations into 4 µm micro capillary tubes.

Data were obtained with a Finnigan MAT SOLA equipped with a system 266 Nd:YAG laser. The laser operates in the UV region (266 nm) which is more desirable than IR because it couples better with transparent materials such as halite and quartz. The laser was operated in Q-switched mode at 8.5 volts and a repetition rate of four pulses per second. The technique consisted of continuously firing a laser focused to 20-25 µm spots on the capillary tubing until the beam reached the artificial FI. After the F was reached, the content of tubing was entrained in the flow of Ar, which transported the material to the ICP torch where ionization takes place. The average volume of F released per pulse of laser is ~100 picoliter. The quadrupole mass spectrometer was set to continuously acquire data using the Faraday detector for 1000 ppm and 500 ppm solutions and the Secondary Electron Multiplier (SEM) for the 250 ppm solution.

We tested the technique by analyzing FI from natural rock salt from the Palo Duro Basin, Texas. The I are two phase, varying from 50 micron to 250 micron in diameter. Our preliminary results show that conrentrations of Sr and Rb in I is variable, ranging for both Sr and Rb vary between 60 and 100 ppm. (Authors' abstract)

GIGGENBACH, W.F., 1995, Composition of magmatic components in hydrothermal fluids: Mineral. Assoc. Canada Short Course, v. 23, p. 247-261.

Discusses the significance of FI evidence to the topic. (H.E.B.)

GILES, A.D. and MARSHALL, B., 1995, The misuse of fluid inclusions in deformed metamorphosed and metamorphogenic (pre- and syn-tectonic) ore deposits: *in* Pasava, Kribek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 865-868.

Full paper for abstract in FIR, v. 27, p. 45. (E.R.)

GIORDANO, T.H. and KHARAKA, Y.K., 1994, Organic ligand distribution and speciation in sedimentary basin brines, diagenetic fluids and related ore solutions, *in* J. Parnell, ed., Geofluids: Origin, Migration and Evolution of Fluids in Sedimentary Basins: Geol. Soc. (London) Spec. Publ. No. 78, p. 175-202. First author at Dept. Geological Sciences, New Mexico State Univ., Las Cruces, NM 88003.

The nature, distribution, and interactions of dissolved organic ligands in the shallower zones of sedimentary basins are highly variable and poorly understood. Better understood is the chemistry of dissolved aqueous carboxylic acid species in the deeper regions of sedimentary basins. In most oil-field brines, acetate is generally the dominant organic ligand and is followed in level of concentration by longer chained aliphatic monocarboxylic acid anions. The total concentration of dicarboxylic acid anions is probably lower than previously reported and likely <500 mg l^{-1} with succinate and glutarate being the dominant species. The highest concentrations of organic acid anions are present in formation waters at 80-120°C. Based on the available field and laboratory evidence, the concentrations of organic anions are controlled mainly by the rates of their generation from kerogen and their destruction thermally or by bacteria. An extensive compilation of experimentally determined stability constants and other thermodynamic data for a large number of non-humic organic ligands is available for T ~25°C. However, corresponding high-T data are available for only a few species of interest; most notably, acetate complexes of some rock- and ore-forming metals and protonated species of several carboxylate ligands. Simulations of speciation in oil-field brines show that significant amounts of Ca, Mg, Fe, and Al can be complexed by carboxylate ligands, in the pH range 4-6, if ligand concentrations are on the order of 10-100 mg l-1. Calculated speciation in model ore F for MVT deposits and red-bed related base metal deposits show that optimum conditions for Pb and Zn transport by organic ligand complexation are oxidized ore F with total reduced inorganic sulphide concentration <10-9 molal. (Authors' abstract)

GIORGETTI, G., FREZZOTTI, M.L., CAROSI, R., MECCHERI, M. and TOURET, J.L.R., 1995, Carbonic fluid evolution in syntectonic veins in metapelites and marbles from Priestly Formation (Central Victoria Land, Antarctica) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 88-89. First author at Dip. Scienze della Terra, Univ. Siena, Via delle Cerchia 3, I-53100 Siena, Italy.

A FI study was performed in four quartz veins occurring in low/medium grade graphite-bearing metamorphic rocks of Priestly Formation, Wilson Terrane. Objectives of the present study were the characterization of the F circulating at the peak of metamorphism and the reconstruction of overall F evolution during the retrograde path of this formation.

A comparison was made of the $CO_2 + H_2O + CH_4$ ($\pm N_2$) F with the hosting metamorphic assemblage. Original equilibration of peak conditions led, during isobaric cooling, to I decrepitation, reequilibration at higher density, possible F immiscibility and, in many I, selective H_2O leakage. All this evolution did occur at a local scale, without large movements of the F masses. F in some veins were trapped at lower T (<400°C). Their preservation, and the fact that they were trapped in a single episode indicate that from this T downwards, the region did experienced an isochoric P,T path. (From authors' abstract by E.R.)

GIORGETTI, G., FREZZOTTI, M.L. and PALMERI, R., 1994, The composition and role of fluid phases in migmatites from the Geriache Inlet (Terra Nova Bay, northern Victoria Land, Antarctica): Preliminary results: Proc. 4th Mtg. Earth Sciences in Antarctica, Siena, 1993, Terra Antarctica, v. 1, p. 23-25. Authors at Dip. Scienze della Terra, Univ. Siena, Via delle Cerchia 3, 53100 Siena, Italy.

A FI study was performed in migmatitic rocks from the Gerlache Inlet (Northern Victoria Land, Antarctica). Four major groups of FI have been recognized with petrographic, microthermometric and Raman techniques. In mesosomes three populations are present: high-density, monophase (L) CO_2 I, with 1 mol % CH_4; low-density, CO_2-rich I, with 4 mol % N_2 and 2 mol % CH_4; finally, a tardive [sic] generation of H_2O-bearing F. In *leucosomes*, besides these three populations, a fourth type, mixed $CO_2 + H_2O$-bearing FI has been recognized. Density and distribution of this mixed $CO_2 + H_2O$ F are consistent with P-T conditions of the migmatitic event (4/4.5 kb-700/750°C); F composition confirms a H_2O activity of ~0.4/0.5, in agreement with petrological data. High-density CO_2-dominated F give indication of an isobaric cooling characterizing the retrograde evolution of these rocks at high T. (Authors' abstract)

GIRARD, J.-P. and BARNES, D.A., 1995, Illitization and paleothermal regimes in the Middle Ordovician St. Peter Sandstone, central Michigan basin: K-Ar, oxygen isotope, and fluid inclusion data: AAPG Bull., v. 79, no. 1, p. 49-69.

Hydrocarbon reservoirs occur in the Middle Ordovician St. Peter Sandstone in the central Michigan basin at depths of 1.5-3.5 km and are diagenetically altered. Latest diagenetic cements include saddle dolomite, pervasive microcrystalline illite and chlorite. and quartz. A K-Ar and $^{18}O/^{16}O$ study of the fine-grained authigenic illite in 25 samples from 16 wells covering a large area within the basin yields K-Ar ages ranging from 367 to 322 Ma and $\delta^{18}O$ values between 12.7 and 16.9‰ SMOW. The $\delta^{18}O$ values of diagenetic quartz overgrowths range from 15.2 to 18.9‰. FI T in the quartz cement range from 70 to 170°C, reflecting multiple generations of diagenetic quartz and/or precipitation over most of the diagenetic history. Reequilibrated FI in the saddle dolomite cement yield T ranging from 90 to 150°C.

A regionally significant episode of illitization occurred during the Late Devonian-Mississippian. T of illite formation are indirectly estimated to be in the range of 125-170°C, and most paleodepths of illitization are between 2.8 and 3.2 km. These results imply that (1) illite formed from ^{18}O-rich F, and (2) elevated geothermal gradients, i.e., >34°C/km, existed in the Michigan basin in the late Paleozoic.

The K-Ar ages and the $\delta^{18}O$ values are not correlated to present depths of the samples or paleodepths of illitization. Illites with young ages and low $\delta^{18}O$ values tend to be geographically distributed along the north-south branch of the buried Precambrian rift. The $\delta^{18}O$ values of the diagenetic quartz follow a similar trend. The spread of illite K-Ar ages and $\delta^{18}O$ values, and their geographic distribution, are best explained as reflecting abnormally high thermal regimes in the part of the basin located above the presumably highly fractured basement along the rift. (Authors' abstract)

GIRARD, J.P., LEGENDRE, O. and FOUILLAC, C., 1995, Diagenetic history of the Middle Jurassic Oseberg reservoir, Oseberg field, Norwegian North Sea: petrography, isotope geochemistry and fluid inclusion data (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 198-199.

A detailed multidisciplinary integrated study of the Middle Jurassic Oseberg reservoir in 13 wells of the Oseberg field, Norwegian North Sea, was carried out in collaboration with Norsk Hydro (Oseberg operator) and Oseberg partners. The results permitted precise reconstruct on of the timing, conditions and spatial variation of diagenetic transformations and to place constraints on the nature and origin of the diagenetic F.

Two-phase aqueous and hydrocarbon FI yielded Th of ≈70°C for ankerite, 85-105°C for quartz, and 90-110°C for calcite. Combination with modeled burial/thermal history indicates that late diagenesis (feldspar dissolution, kaolinite, quartz, calcite and dickite) essentially occurred during Tertiary, i.e., much later than the

Cimmerian (Late Jurassic) erosional event generally considered to have promoted extensive meteoric water flushing in many BRENT reservoirs of the North Sea. O and Sr isotope data, however, do indicate that meteoric water was (and still is) a major constituent of interstitial F early on in the diagenetic history. (From authors' abstract by H.E.B.)

GIRARD, J.-P., SANUAN, B., CZERNICHOWSKI-LAURIOL, I. and FOUILLAC, C., 1995, Reconstruction and geochemical modeling of the diagenesis of the Middle Jurassic Oseberg sandstone reservoir in the Oseberg field, Norwegian North Sea: Soc. Geol. de France Meeting on Diagenesis, 6-7 Nov. 1995, Extended Abstracts, p. 85-88. Authors at BRGM, Direction de la Recherche, BP 6009, 45060 Orléans Cedex 2, France.

A detailed multidisciplinary integrated study was carried out in order to: (1) reconstruct as precisely as possible the timing, T conditions and spatial variation of diagenetic transformations; (2) characterize the nature, origin and quantity of the different F involved in the diagenesis of the reservoir; (3) develop a quantitative geochemical model of the observed diagenesis by use of tools such as the EQ3/6 numerical code and the ALLAN™/NEPTUNIX code generator system.

Diagenetic T were determined from FI in ankerite, quartz and calcite. Two-phase aqueous I in ankerite yielded Th averaging 72°C (66-88°C). Similar I yielded Th averaging 94°C (85-105°C) in quartz overgrowths and 99°C (90-110°C) in calcite. Diagenetic quartz and calcite also contain hydrocarbon-bearing I (which yielded identical T) indicating that hydrocarbons were present in the reservoir when quartz and calcite formed. Raman spectroscopy indicates the presence of CH_4 in the V phase of aqueous I in quartz and calcite. This observation and the fact that the reservoir contains a gas cap suggest that the aqueous solution in the I is most likely CH_4 rich. As a consequence, Th values can be considered to approximate Tt. No evidence was found that FI may have been reequilibrated as a result of burial.

Combining the paragenetic sequence and the FI T with the thermal history of the Oseberg Formation derived from burial reconstruction and basin modeling permitted constraining the approximate ages and duration of major diagenetic events. (From authors' abstract by E.R.)

GIULIANI, Gaston, CHEILLETZ, Alain, ARBOLEDA, Carlos, CARRILLO, Victor, RUEDA, Félix and BAKER, J.H., 1995, An evaporitic origin of the parent brines of Colombian emeralds: Fluid inclusion and sulphur isotope evidence: Eur. J. Mineral., v. 7, p. 151-165. First author at ORSTOM, Inst. Français de Recherche Scientifique pour le Développement en Coopération, 213 rue La Fayette, 75480 Paris cedex 10, France.

The F trapped by emerald, dolomite and pyrite in the Colombian emerald deposits consist predominantly of Na-Ca brines with some KCl. The similarity of F composition in the eastern and western emerald zones demonstrates the homogeneity of the parent F. The Na-Ca-K chemistry of the brines provides strong evidence for an evaporitic origin of the parent hydrothermal F. Their origin was investigated by a S isotopic study of pyrite that coprecipitated with emerald. The $\delta^{34}S$ values of H_2S in solution in equilibrium with pyrite from six emerald deposits range from 14.8 to 19.4‰ whereas sedimentary pyrite from the enclosing black shales yield a $\delta^{34}S$ of -2.4‰. The narrow range in $\delta^{34}S(H_2S)$ between the different deposits suggests a uniform and probably unique source for the sulphide-sulphur. The high $\delta^{34}S(H_2S)$ values suggest the non-participation of magmatic or Early Cretaceous black-shale S sources. Saline diapirs occur in the emeraldiferous areas and the most likely explanation for high $\delta^{34}S$ involves the reduction of sedimentary marine evaporitic sulphates.

FI and S isotope data give a typical evaporitic sedimentary signature for Colombian emerald mineralization. This emerald-deposit type, unique in the world, corresponds to mesothermal deposits (300°C), formed in a sedimentary environment and produced through thermochemical reduction of sulphate-rich brines to hydrogen sulphide by interaction with organic-rich strata. (Authors' abstract)

GIULIANI, G., CHEILLETZ, A., RUEDA, F., FÉRAUD, G., and FRANCE-LANORD, C., 1995, The genesis of Colombian emerald deposits: An unique example of beryllium mineralization developed in a black shale environment: *in* Pasava, Krîbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 943-946. First author at Inst. Français de Recherche Scientifique pour le Développement en Coopération, Centre de Recherches Pétrographiques et Géochimiques, Vandoeuvre-les-Nancy, France.

The genesis of the hydrothermal emerald vein mineralization of Colombia has provoked a large debate during this century. A new model is developed for the mode of formation of Colombian emeralds, implicating the interaction of basinal F with evaporites and organic-rich black shales during décollement style tectonics related to the structural evolution of the Eastern Cordillera of Colombia before Miocene-Pliocene Andean surrection. (Authors' abstract)

See previous item. (E.R.)

GLEESON, S.A. and WILKINSON, J.J., 1995, ICP-AES analysis of fluid inclusions II: Comparison with other techniques (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 90. Authors at Dept. Geology, Imperial College of Science, Technology and Medicine, Prince Consort Rd., London SW7 2BP, UK.

This study compares the results obtained from standard microthermometry, decrepitation linked ICP-AES (D-ICP), crush-leach ICP-AES (CL-ICP), crush/leach ion chromatography (CL-IC) and laser ablation ICP-AES on P FI in zoned quartz crystals.

Microthermometric analyses on vein quartz have shown the mineralising F to be highly saline $NaCl-CaCl_2$ dominated brines, typical of modern day formation waters and many MVT deposits. Analyses of bulk leachates by ion chromatography and ICP-AES give comparable results for the major elements (Na, Ca, K). However, the two analytical techniques correlate less well for elements which are close to the detection limits of ion chromatography analysis, e.g., Sr. This is probably due to the large uncertainty on values near background.

The discrepancy between the crush-leach and decrepitation analyses is more problematic. When the major, minor and trace elements normalised to sodium are considered, crush-leach data is much less reproducible than D-ICP. A comparison of the two techniques shows that crush-leach generally gives slightly higher values, but this relationship shows no apparent systematic bias. Occasionally, crush-leach ICP and IC analyses give much higher, anomalous values than D-ICP that cannot be accounted for mechanisms such as preferential adsorption of multivalent ions. An alternative explanation is that these data may be due to contamination by dissolved microscopic solid phases; siderite, anhydrite, K-mica, sphalerite, galena are known to occur in the veins and, although not generally observed in the samples analysed, they may have contributed to anomalous Fe, Mn, Ca, K in the crush-leach data set. These preliminary data suggest that care must be taken when choosing samples for crush-leach analyses, as microscopic solid phases in quartz may give anomalous results. (From authors' abstract by E.R.)

GOLDHABER, M.B., ROWAN, E.L. and HATCH, J.R., 1995, Late Paleozoic Illinois basin brine migration: Confirmation from paleotracer studies and consequences for coal quality (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-23.

This study describes basin-wide geochemical data which confirm a major regional F-flow event in the Illinois basin during the early Permian. Previous FI studies on ZnS in coal from this area document that this phase formed from a brine whose T and salinity was similar to ore F. We hypothesize that this metal-enriched coal formed in a region where rocks of the Mississippian system pinch out permitting ore-bearing F to flow upwards into the overlying coals. This mechanism is supported by paleoflow calculations employing a finite difference modeling code. In addition to coal alteration and ore genesis, the basin-wide brine migration event had significant consequences for diagenetic alteration and organic maturation and hydrocarbon migration. (From authors' abstract by H.E.B.)

GONZALEZ-CASADO, J.M., CASQUET, C., MARTINEZ-MARTINEZ, J.M. and GARCIA-DUENAS, V., 1995, Retrograde evolution of quartz segregations from the Dos Picos shear zone in the Nevado-Filabride Complex (Betic chains, Spain): Evidence from fluid inclusions and quartz c-axis fabrics: Geol. Rundschau, v. 84, p. 175-186.

Synkinematic quartz veins are ubiquitous in the shear zone separating the Veleta unit from the Calar Alto unit in the internal part of the Betic Cordilleras. They have been studied with respect to quartz c-axis fabrics, microstructures and FI. Veins were probably generated during syn-metamorphic stacking of the units at P = 500-600 MPa and T = 400-500°C. Quartz displays two groups of microstructures in the shear zone: (1) older coarse-grained mosaics (CGM) resulting from exaggerated grain growth; and (2) younger fine-grained mosaics (FGM) developed at the expense of the former. The fine-grained mosaics show polygonal granoblastic and elongate mosaic microstructures in general, with ribbon microstructures often found near the boundary of the units. F contained in SI vary from high salinity brines to different types of CO_2-brine mixtures and low density CO_2 F. Differences in composition and P-T trapping conditions are indicated for the different types of I. Some FI are older than the FGM, whereas others are younger, thus constraining the P-T conditions at which the two microstructural events took place. FI evidence suggests conditions of $P_{fluid} > 170$ MPa and $T \geq 370\text{-}430°C$ for the CGM and $P_{fluid} \geq 20\text{-}80$ MPa and $T > 340°C$ for the FGM.

The quartz c-axis fabrics dealt with here correspond to the second recrystallization event, as little evidence of older fabrics is preserved in the shear zone. C-axis patterns vary across the shear zone from slightly asymmetrical type I crossed girdles in the hanging wall and footwall to more asymmetrical crossed girdles at the boundary of the units. This indicates a correlative increase in the magnitude of the heterogeneous shear strain in the same direction. Most of the deformation is concentrated at the top of the Veleta unit. The sense of movement is top to the west, in agreement with other kinematic markers.

The quartz c-axis fabrics resulted from dynamic recrystallization during simple shear. The retrograde P-T path inferred from FI analysis, along with other geological and geochronological evidence, indicates that this deformation is coeval with a reduction in the crustal overburden.

Geochronological and stratigraphic data show that the proposed Dos Picos extensional detachment, separating the Calar Alto and Veleta units, took place during the early Miocene, synchronous with the intense thinning of the Nevado-Filábride Complex and of the whole continental crust underlying the Alborán Basin. (Authors' abstract)

GORBACHEV, N.S. and KHODOREVSKAYA, L.I., 1995, Partitioning of chlorine between an aqueous fluid and a basalt melt at high pressures: The behavior of chlorine and water during magma degassing: Dokl. Ross. Akad. Nauk, v. 340, no. 5, p. 672-675 (in Russian).

GRAF, Thomas, KIM, J.S., MARTI, Kurt and NIEDERMANN, Samuel, 1994, Cosmic-ray-produced neon at the surface of the earth, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 115-123. Authors at Dept. Chemistry, Univ. California, San Diego, La Jolla, CA 92093.

Cosmic-ray-produced nuclides in terrestrial rocks can provide information on surface exposure time, erosion rates, and glacial cover. Trapped Ne isotopic abundances in quartz separates from Antarctic sandstones do not generally agree with those of atmospheric Ne, and the evolved signatures reveal incorporation of nucleogenic Ne as well as fractionated trapped components. (From authors' abstract by E.R.)

GRANEY, J.R. and KESLER, S.E., 1995a, Factors affecting gas analysis of inclusion fluid by quadrupole mass spectrometry: Geochim. Cosmochim. Acta, v. 59, p. 3977-3986. Authors at Dept. Geological Sciences, Univ. Michigan, Ann Arbor, MI 48109.

Quadrupole mass spectrometric (QMS) analysis of small amounts of I F (<1 mg) released by crushing and decrepitation requires methods to: (1) determine the amount of molecular fragmentation and the relative sensitivity to water and other gases, (2) evaluate differential adsorption of gases in the analytical system, (3) calibrate detector response to amount of released F, and (4) detect gas from noninclusion F sources.

Fragmentation of G during ionization in the source is P dependent. Because the amount of F released from individual I and crushed samples varies over a wide range, corrections are made for this P dependence during data reduction. This procedure is especially critical for water, the dominant component in most FI. Adsorption of H_2O is not quantitatively significant from decrepitated individual I (over a range of 1×10^{-6} to 1 mg) or crushed samples that contain $>1 \times 10^{-4}$ mg of H_2O. However, adsorption of H_2O onto newly created surfaces by crushing samples containing $<1 \times 10^{-4}$ mg of H_2O will result in lower mol % H_2O reported in the G analysis than present in I F during both release methods. N_2, O_2, and Ar from air in the inlet system are entrained into released I F. Gases including SO_2 and HCl can be generated when I F is released into vacuum. Thermal decomposition of minerals and organic compounds can produce CO_2, CH_4, CO, N_2, H_2, and other gases that mix with those released from I F. The relative contributions of G from I F vs. these other sources can be differentiated using real-time (direct) QMS analysis. (Authors' abstract)

See also next item. (E.R.)

GRANEY, J.R. and KESLER, S.E., 1995b, Gas composition of inclusion fluid in ore deposits: Is there a relation to magmas: Mineral. Assoc. Canada Short Course, v. 23, p. 221-245. Authors at Dept. Geological Sciences, Univ. Michigan, Ann Arbor, MI 48109.

Includes 72 analyses for H_2O, CO_2, CH_4, C_nH_{2n+2}, N_2, Ar, H_2S, SO_2 and HCl from various ore deposits, fumaroles and geothermal systems. G compositions of I F from different ore-deposit types reflect contributions from different sources, which include the atmosphere, radioactive decay, metamorphism and water/rock interaction, and magma degassing. (From authors' text by E.R.)

GRAY, Nigel, MANDYCZEWSKY, Alex and HINE, Richard, 1995, Geology of the zoned gold skarn system at Junction Reefs, New South Wales: Econ. Geol., v. 90, p. 1533-1552. First author at The Scots School, Bathurst, New South Wales, Australia.

The Sheahan-Grants, Frenchmans, and Cornishmens orebodies at Junction Reefs are typical Au skarns. Au ore is restricted to a pyrrhotite-pyrite-arsenopyrite-bearing distal skarn zone in which prograde pyroxene has been altered to a retrograde chlorite-quartz-carbonate assemblage.

Retrograde alteration and concomitant sulfide and Au deposition probably took place at T of between 250° to 345°C on the basis of the Th of low-salinity FI in quartz. Late, retrograde chlorite was apparently formed under reducing conditions within a similar T range. S from distal and proximal skarn and the Junction Reefs Monzodiorite stock lies within a narrow isotopic compositional range of from -1.0 to +1.8‰ and, as such, is inferred to be largely of magmatic derivation. (From authors' abstract by E.R.)

GREBENSHCHIKOVA, V.I., PROKOF'YEV, V.Yu. and TROSHIN, Yu.P., 1995, New data on the genesis of gold-ore veins in the Kommunar deposit, Kuznetskiy Alatau: Dokl. Ross. Akad. Nauk, v. 340, no. 2, p. 239-242 (in Russian).

GRECULA, Pavol, editor, 1995, Mineral deposits of the Slovak Ore Mountains, Volume 1, 829 p.: Mineralia Slovaca, Werferova 1, 040 11 Ksice, Slovakia.

According to a review by W. Pohl in Econ. Geol., v. 91, p. 482, 1996, the authors develop a comprehensive model of a metamorphogenic origin for these deposits, based in part on FI data. (E.R.)

GRINENKO, V.A., IVANOVA, G.F., USTINOV, V.I. and HÖLL, R., 1994, Isotopic characteristics of the mineralizing fluid at the Felbertal scheelite deposit, Austrian Alps: Geokhimiya, no. 6, p. 804-813 (in Russian; translated in Geochem. Int'l, v. 32, no. 1, p. 37-46, 1995).

Abstract in FIR, v. 27, p. 48. (E.R.)

GRISHINA, S. and KNIPPING, B.J., 1995, Fluid inclusions in evaporites—Some implications on the disposal of high-level radioactive wastes (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 91-92. First author at Inst. Mineralogy and Petrography, Univ. pr. 3, 630090, Novosibirsk, Russia.

Basalt intrusions in evaporites can be used as natural analogues for the disposal of heat-producing radioactive wastes in evaporites. Among other geochemical parameters mainly the study of single FI in salt minerals gives information on several relevant aspects, for example: evolution of F chemistry caused by increased T; extent of F migration in a T field; and extent of thermal alteration of the salt rocks.

Thus FI are studied in two different geological settings of basalt intrusions in evaporites:

(i) Basaltic sills of ≤300 m thickness intruded in Cambrian chloride-type evaporites in the Siberian platform (Russia).

(ii) Basaltic dykes of mostly <3 m thickness intruded in Permian sulfate-type potash deposits of the Werra-Fulda potash region (Germany).

The evaporites have in both cases undergone intense mineral reactions and material transports. Rock alteration and gas accumulation obviously related to the basalt intrusion were documented both in Siberia and Germany. The flat shape of the basaltic sills on the Siberian Platform enabled a description of the F chemistry as a function of distance from the intrusions, based on FI studies. A clear zonation of inclusion associations in the vicinity of the sills was found. Apart from the host rock composition, the metamorphism could clearly be recognised by different I characteristics like brine concentration, CO_2/H_2O ratio, CO_2 density, associated mineral I and organic compounds. The extent of the thermal influence of the intrusions is visually marked by the disappearance of (primary) chevron structures in the salt minerals, which occur at a four times greater distance above than below the basaltic sills. It may indicate mainly thermal metamorphism below the intrusion and intense upward directed F migration above the intrusion.

Only a minor amount of studied halite samples from the German Werra-Fulda potash region contain H_2O-free L-CO_2 I. Those preliminary results confirm the relative importance of F migration processes (solution metamorphism) compared to thermal metamorphism. (From authors' abstract by E.R.)

GROFF, J.A., HEIZLER, M.T., NORMAN, D.I. and McINTOSH, W.C., 1995, $^{40}Ar/^{39}Ar$ dating and conditions during gold mineralization in the Cretaceous and Tertiary for Carlin-type deposits along the Getchell Trend, Humboldt County, Nevada (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 67.

Indexed under FI. (E.R.)

GUILHAUMOU, N., CORDON, S., DURAND, C. and SOMMER, F., 1995, P-T conditions of silicification in diagenetic sandstones from the Brent Formation of Dunbar (North Sea) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 93-94. First author at Ecole Normale Supérieure, Laboratoire de Géologie, URA 1316 du CNRS. 24 rue Lhomond, 75230 Paris Cedex 05, France.

P-T conditions of the silicification can be derived from FI formed during overgrowth development, but two points remain questionable: the possibility of a resetting of the I and the interpretation of Th in terms of Tt.

In this study, Raman microanalyses were performed on two types of single aqueous I representative of quartz overgrowth conditions:

a type: Biphase I (generally <5 μm), in growth bands at the boundary between the detrital grain and the overgrowth. Aqueous I are mostly L (nearly 90%).

b type: Biphase I trails crosscutting the detrital grain and connecting with a-type. Aqueous I display highly variable phase ratios.

In both type of trails, H_2O and hydrocarbon-bearing I often coexist.

SEM-cathodoluminescence is used to distinguish detrital grain from overgrowths. It also allows to observe F circulation in cracks at the beginning of the silicification within the detrital grains that has formed b-type FI during healing. These observations suggest that a-type and b-type FI are contemporaneous with the early stage of the silicification.

Microthermometric study of a-type aqueous I leads to Th between 105 and 110°C in the four wells and Tm ice between -1.5 and -3°C.

Raman microspectrometric analyses were performed on aqueous I hosted in quartz overgrowth using 30 to 45 μm-thick polished sections. We used a confocal laser Raman Dilor spectrometer. Raman spectra obtained on the G phase of both types of FI show gaseous CH_4. CO_2 and heavier hydrocarbons are not detected in analytical conditions of analysis. The analysis success is attributed partly to the confocal system. When in use, it improves the lateral resolution, the depth of the analyzed field and the axial resolution, and this leads to better signal/noise ratio. The I signal is less disturbed by its environment and by the epoxy: indeed, the epoxy spectrum has C-H vibrations between 2850 and 3200 cm^{-1}, overlapping with the interval of the main CH_4 vibration band.

The remarkable stability of CH_4 stretching band position, involving nearly identical P conditions, supports the hypothesis of a- and b-type FI contemporaneity. These I, which belong to the same F system, show a progressive evolution from essentially L I (a) to highly gaseous I (b). Both contain CH_4, which indicates that the F was saturated with CH_4. These analytical results allow to derive P-T conditions of the beginning of siliceous overgrowth cristallisations. Since the brines entrapped are in the methane-saturated H_2O-NaCl (± KCl) system, Th should be considered as very close to Tt. Th display between 105 and 110°C for all samples which can be then interpreted as the T existing at the beginning of the silicification. Salinities display between 2.5 and 4 wt % eq. NaCl. The T are 15 to 20°C lesser than current Tf, [and] this seems to disagree with a present resetting of the I. An internal P value of 90 bars can be derived from the Raman band position of CH_4 at room T. The calculation of molar volumes using Peng Robinson equation of state allows determination of a real P value at time of entrapment. This leads to P-T conditions allowing emplacement of the beginning of main siliceous overgrowth at a burial depth in agreement with basin modeling. (From authors' abstract by E.R.)

GUILHAUMOU, Nicole and LARROQUE, Christophe, 1995, Fluid circulations in modern and ancient accretionary wedges: C.R. Acad. Sci. Paris, v. 321, Serie IIa, p. 939-957 (in French, English abstract).

Investigations on modern accretionary zones linked to subduction have shown that F circulations play an important role in the formation and evolution of accretionary wedges in subduction processes. Studies have recently been developed in ancient complexes where F characteristics are fossilized throughout the evolution within geochemical markers from syntectonically deformed veins. These studies provide additional data to those conducted by exploration and seismic on modern accretionary wedges. The F are expelled from the sediments mainly along the decollement zones and to a lesser extent diffused in microfractures. They originate at depth from 8 to 14 km, causing high T and overpressures in the sediments. Thermal anomalies are the rule along the deformation. However, there is a relative disequilibrium with the wall rocks which favour transient F-flow regimes instead of a permanent one. This is also attested by the successive generations of currently veining, showing differences in compositions in hydraulic breccias. Low salinity waters are involved in veins and in expelled F, implying a dilution mechanism of original seawater. Organic matter such as oil and CH_4 is an important constituent of the F phases entrapped in veins. CH_4 may increase the F molar volume and then the F P. Anomalous concentrations have been measured present-day within expelled F. It may result partly from the destabilization of G clathrates, mainly CH_4, as indicated by seismic data (Bottom Simulating Reflectors). CH_4 is mainly biogenic, but advections of thermogenic G are sometimes observed. Characterizations of palaeofluids along the whole deformation in ancient prisms may develop rapidly through the improvement of microanalytical techniques and particularly of those applied to FI characterization. Such studies are still rare and will afford very useful data additional to those obtained in active wedges. (Authors' abstract)

GUNDIMEDA, Madhukar, 1995, Environmental gas analysis of fluid inclusions in calcium carbonates from New Mexico including vein calcites from Los Alamos National Laboratory, using quadrupole mass spectrometer: Unpub. Masters thesis, New Mexico Inst. Mining and Technology, Socorro, New Mexico, 141 p.

The principal objective of this study was to determine the genesis of the carbonate fracture fillings present at shallow depths at LANL and at other hazardous and environmentally sensitive waste sites. To determine the genesis of the carbonate fracture fillings we analyzed volatiles included within the 100 samples of non-marine calcites including pedogenic calcites (non-indurated and indurated), ancient travertines, travertines deposited by active springs, calcretes, calcite concretions in sand, and hydrothermal vein calcites. We also analyzed 29 vein calcite samples from fracture fillings in tuffs at LANL and three travertine samples from Nevada Test Site. Volatile species in FI contained within these minerals were measured by quadrupole mass spectrometer after thermal decrepitation and mechanical crushing. The analyses of split samples by the two methods are different; analyses of thermally decrepitated carbonates indicate greater amounts of CO_2, N_2 and H_2. CO_2, N_2 and H_2 are products of pyrolysis of organic material; hence, analyses by thermal decrepitation were not considered in the interpretation of the results. Results from crushing indicate that the volatiles in the carbonates can be used to distinguish Ca carbonate formed in the vadose zone from the Ca carbonate deposited [by] groundwater. Cluster analysis separated the 126 analyses into two groups based on the H_2O content. The mean concentration of H_2O in group I and group II carbonates are 97.5% and 48.7%. The principal volatile present in the analysis of group II carbonates was CH_4. LANL vein calcites yielded analyses similar to group II carbonates, indicating a similar genesis. The CH_4-rich V in group II carbonates suggests formation in a O_2-depleted (micro-reducing) environment. (From author's abstract by E.R.)

GUNTER, W.D., WINCHAR, B. and PERKINS, E.H., 1995, Aquifer disposal of CO_2-rich greenhouse gases: Extension of experiment by modelling (abst.): Mitt. Österr. Miner. Ges., v. 140, p. 415 (in English). Author at Alberta Research Council, PO Box 8330, Edmonton, Alberta T6H 5X2, Canada.

In previous work, Gunter et al. (1993) suggested water-rock reactions in deep aquifers in sedimentary basins could sequester injected-CO_2-waste from industry, thereby reducing greenhouse G emissions. Experiments carried out at 105°C and 90 bars CO_2 P to test the validity of this mineral-trapping of CO_2 were unsuccessful due to sluggish kinetics of reaction. A computer model, PATHARC.94, was used to interpret an observed change in alkalinity and to predict the path and time necessary to reach equilibrium. Substantial trapping of CO_2 by formation of siderite, calcite and aqueous bicarbonate ions was predicted to occur in 6 to 40 years. When these results are extrapolated to the field, where the aquifers are at lower T, CO_2-trapping reactions are expected to take hundreds of years to complete. This is sufficient time for the trapping to occur as the residence time of a packet of F in a deep aquifer in a sedimentary basin is measured in thousands of years. (From authors' abstract by E.R.)

Although aimed at waste disposal problems, data and calculations pertinent to FI studies. (E.R.)

GURENKO, A.A. and CHAUSSIDON, Marc, 1995, Enriched and depleted primitive melts included in olivine from Icelandic tholeiites: Origin by continuous melting of a single mantle column: Geochim. Cosmochim. Acta, v. 59, p. 2905-2917. First author at GEOMAR, Abteilung Vulkanologie und Petrologie, Wischhofstrasse 1-3, D-24148 Kiel, Germany.

Here we present results of major and trace element studies of MI in high-Mg olivines taken from the most primitive tholeiitic lavas found on Iceland. The compositions of the MI indicate that they represent very primitive trapped M. Two populations of I, enriched and depleted, can readily be distinguished on the basis of major and trace elements. The compositions bracket the range of Icelandic primitive magmas, which we believe to be the result of mixing between these two endmembers.

These two primary M populations can be produced by critical (continuous) melting of a single mantle column, without the addition of material from the crust. In this model, the EM I represent mixtures between enriched and depleted instantaneous M in the ratio 0.6:0.4, respectively, where the first was formed in equilibrium with a garnet-bearing (≤6 wt % of garnet) mantle source of primitive composition at a low degree of melting (F = 5.5%) and with 2.7 wt % of critical M retained in residue. The most depleted I represent unmixed instantaneous M produced by 17-18% melting of a spinel lherzolite (either primitive or depleted composition) with slightly different amounts of critical M (3.0 to 3.5 wt %) depending on the type of the source. Thus, the complete range of Icelandic primary compositions can be produced by mineralogical variations in the mantle column in the framework of a dynamic melting model. (From authors' abstract by E.R.)

GUSTAFSON, L.B. and QUIROGA G., Jorge, 1995, Patterns of mineralization and alteration below the porphyry copper orebody at El Salvador, Chile: Econ. Geol., v. 90, p. 2-16. First author at 5320 Cross Creek Lane, Reno, NV 89511.

Three diamond drill holes, angled below the lowest haulage level at El Salvador, have doubled the vertical exposure of the deposit and revealed very different features of alteration and mineralization below this major porphyry Cu orebody.

Overall abundance of sulfide, sulfate, and K feldspar diminish with depth whereas albite increases. A sharp downward decrease in Cu values <0.1% Cu, within strongly quartz-veined and K feldspar-biotite-altered early feldspar porphyry, represents a barren core below the central chalcopyrite-bornite zone. It appears to correlate with the bottoming of intense crackling and of boiling during early vein formation, as evidenced by the variation in FI abundances in quartz. A deep zone of strong molybdenite with minor W but very low Cu contents occurs in one hole. It is associated with B and C veins cutting late L feldspar porphyry. These alteration-mineralization features are somewhat similar to those seen in deep zones at Butte, Montana, and Yerington, Nevada. (From authors' abstract by E.R.)

HAGEMANN, S.G., BROWN, P.E. and VALLEY, J.W., 1995, Oxygen isotope heterogeneity in gold-bearing paleohydrothermal systems (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-66.

The epizonal Wiluna lode-Au deposits are located near the northern end of the Archean Norseman-Wiluna greenstone belt in Western Australia. Au mineralization is structurally controlled via a network of strike-slip faults and related to a single, albeit complex, hydrothermal system. Two stages of mineralization with distinct metal associations are observed: Stage I Au-pyrite-arsenopyrite and Stage II Au-stibnite mineralization.

Microanalysis of O isotope compositions of quartz-comb crystals from Au-rich ore shoots centered along the strike-slip faults display considerable isotope heterogeneity. Detailed CO_2 laser-probe analyses on eight individual comb crystals (≤3 cm long and 1 cm wide) from different ore bodies reveal $\delta^{18}O$ zonation within and across individual growth zones of ≤5.00 and 5.78‰ respectively (total of 269 analyses). The analytical precision is better than 0.15‰ (1ø) for all samples. An individual comb crystal (1.8 x 0.8 cm) from the Essex Fault shows a range of $\delta^{18}O$ values from 6.20 to 10.70‰ with a mean of 7.56±1.10‰ (1ø, n = 58, 33 analyses per cm^2). Differences in $\delta^{18}O$ in the three growth zones (<5 mm in width) are 2.19, 1.83 and 4.53‰ from the base to the tip of the crystal. Petrographic and microthermometric analyses on the same comb crystal exhibit dominant primary H_2O-NaCl ± KCl FI with homogeneous T-X conditions despite the occurrence of I in different growth zones or their orientations in trails parallel, oblique or perpendicular to growth zones. A bi-modal distribution of low and high salinity FI is observed with 0.9 ± 2.5 eq. wt % NaCl (1ø, n = 104) and 16.3 ± 2.8 eq. wt % NaCl (1ø, n = 23) respectively. Total Th are 253° ± 51°C (1ø, n = 190) with only minor differences of ~30°C in mean T of individual growth zones. The bi-modal distribution of salinities and the occurrence of L- and V-rich I within the same trail or cluster suggests the possibility of widespread boiling during the entrapment of the I.

O isotope variations across growth zones of <4‰ could be accounted for by: (1) the observed T fluctuations of ~50°C, and (2) boiling and subsequent cooling from 275° to 225°C during the formation of the growth zones. O isotope variations >4‰ require substantial changes in F composition and/or large variations in F: rock ratios. The difference in $\delta^{18}O$ values within the same trail or cluster suggests the possibility of widespread boiling during the entrapment of the I. (Authors' abstract)

HAGGERTY, R., BOTTRELL, S.H., CLIFF, R.A. and REX, D.C., 1995, Constraints on the age and genesis of the Llanrwst and Llanfair-Talhaarn orefields, North Wales from K-Ar and Rb-Sr studies: Geol. Mag., v. 132, p. 387-398.

Indexed under FI. (E.R.)

HALAS, Stanislaw and DURAKIEWICZ, Tomasz, 1995, Technical note: Improved adsorbant trap for gases: Chem. Geol. (Isotope Geosci. Sect.), v. 122, p. 271-273. Authors at Inst. Physics, Maria Curie-Sklodowska Univ., 20-031 Lublin, Poland.

An improved method of trapping of gases on charcoal is described. The novel construction of the "cold finger" and electronic controller ensure reduced operation time and power consumption and increased flexibility of the charcoal trap. (Authors' abstract)

HALL, D.L. and LARESES, R.E., 1995, Improved interpretations of natural fluid inclusion assemblages for petroleum exploration applications through hydrothermal experimentation: American Association of Petroleum Geologists 1995, Ann. Mtg. Abstr., v. 4, p. 38.

HALL, D.L. and STERNER, S.M., 1995a, Experimental diffusion of hydrogen into synthetic fluid inclusions in quartz: J. Meta. Geol., v. 13, p. 345-355. First author at Battelle Pacific NW Laboratories, PO Box 999, Richland, WA 99352.

Quartz-hosted, synthetic CO_2-H_2O FI behave as open systems with respect to diffusional transfer of hydrogen during laboratory-simulated metamorphic reequilibration at 650, 750 and 825°C and 1.5 kb total P with fO_2 defined by the C-CH_4 buffer. Microthermometry and Raman spectroscopy show that the initial CO_2-H_2O I become CO_2-CH_4-H_2-H_2O I after diffusive influx of hydrogen from the reducing confining medium. Measurable changes are observed in I compositions after only 15 days of reequilibration, implying significant hydrogen mobility at still lower T over geological time spans. Results of synthetic I reequilibrium experiments have profound implications for the interpretation of natural FI data; failure to account for potential hydrogen migration in I from high-T geological environments may lead to erroneous estimates of P-T, and/or the compositions of metamorphic F. (Authors' abstract)

HALLBAUER, D.K. and BALABAN, A., 1995, The ionic composition of fluid inclusions in quartz and pyrite from selected Romanian deposits—An application of the crush-leach technique and capillary ion analysis: Presented at Third Symp. on Mineralogy, Baia Mare, Romania, August 1995, abstract reprinted in Newsletter of the Int'l Liaison Group on Gold Mineralization, no. 21, p. 24-25.

Based on rapid instrumental development in the last five years a new analytical technique for ionic species, capillary electrophoresis or capillary ion analysis (CIA) has become available as a low cost but fast analytical method for cationic and anionic species in aqueous solutions. Best suited for this type of analysis is the crush-leach technique which allows the analysis of F in mineral specimens of <0.5 g, with detection limits of ~5 ppb of elements in solution.

The technique adopted for the present study includes an initial step of crushing a sample to a size between 1 and 4 mm in diameter, hand-picking of a mineral concentrate, washing in deionised water and drying at 105°C for 8 hrs. The clean sample is mixed with 2.5 ml of a 50 μM solution of tetrabutylammonium-hydroxide (TBA) to prevent cation adsorption onto the fresh mineral surfaces, and crushed in an agate mortar until most components are in suspension. The clean solution is recovered by passing the sample through a 0.5 μM filter and washing with TBA solution to prepare a measured amount of between 10 and 20 ml. The solutions were then analysed for cations and anions by CIA.

The separation of ionic species by CIA is accomplished by (i) injecting a small sample, typically ±100 nl, into a fused quartz capillary; (ii) separation of the species in an electric field and within an electrolyte of high absorbance; and (iii) final detection by indirect UV absorption. Although similar to a separation and detection by ion chromatography, CIA offers in addition the injection of a sample by electromigration or electrolytic pre-concentration and thus an increase in detection limits.

The samples prepared for analysis included various quartz types and pyrite from the Rosia Poieni porphyry deposit, pyrite from Baia Sprie and Cavnic, quartz and pyrite from Trimpoiele, and quartz and pyrite from an exploration project, PDH-2.

The major cations detected include K^+, Na^+, Ca^{2+}, Mg^{2+}, Fe^{2+}, Zn^{2+} and as minor cationic components Co, Ni, Cu and Ba. Major anions of ligands detected were Cl^-, SO_4^{2-}, HCO_3^-, SiO_4^{4-} and less frequently $S_2O_3^{2-}$, HS^-, $HAsO_4^{2-}$, SeO_4^{2-}, MoO_4^{2-}, F^- and BO_3^{3-}. Both cations and anions were detected by the hydrostatic injection mode and pre-concentration by electromigration (EM).

The results so far indicate that the FI in quartz are dominated by Na-rich solutions, except for quartz from the Trimpoiele porphyry which is characterised by a Na-K-Ca chloride solution. It is also noteworthy that all three quartz types from the Rosia Poieni deposit, although they differ in colour, contain almost identical F of the Na-Cl type.

FI in pyrite are all characterised by an increased proportion of SO_4^{2-}, while some, like the pyrite from the Cavnic and PDH-2, contain significant amounts of $S_2O_3^{2-}$, indicating a lower level of O fugacity. The general content of HCO_3^- of all samples is relatively low. All F in quartz samples contain more Mn^{2+} than F from pyrite which are dominated by high Fe^{2+}. Only the F in the quartz from Trimpoiele contain more Zn^{2+} than other F.

These results strongly indicate that extensive changes took place in the composition of hydrothermal F between the deposition of quartz and associated pyrite. Also of interest is the presence of MoO_4^{2-} in pyrites from Cavnic, Baia Sprie, PDH-2 and Trimpoiele. The F of the pyrite from the Baia Sprie and PDH-2 contain additional and significant amounts of $HAsO_4^{2-}$. The pyrite from PDH-2 contains SeO_4^{2-} in addition to $HAsO_4^{2-}$ and $S_2O_3^{2-}$. Small amounts of F^- were recorded for the F of all pyrite samples.

So far the results of CIA support previous FI analyses. They also strongly indicate significant changes in F composition between the deposition of quartz and sulphide minerals. It is also envisaged that the application of CIA to FI analysis could be developed into an exploration tool utilising information extractable from core samples as well as from exposed parts of ore bodies. (From authors' abstract by E.R.)

HALLEY, S.W. and WALSHE, J.L., 1995, A reexamination of the Mount Bischoff cassiterite sulfide skarn, western Tasmania: Econ. Geol., v. 90, p. 1676-1693. First author at Renison Goldfields Consolidated, GPO Box 360, Charters Towers, Queensland 4820, Australia.

The Mount Bischoff Sn deposit occurs in a dolomite unit intruded by quartz-feldspar porphyry dikes of Devonian age. The dike rocks have undergone an early stage of potassic alteration which was overprinted to a variable degree by later greisenization. The alteration shows a zonation along and also across the dikes consistent with suggestions that the dikes were major F conduits. Within the dolomite, replacement occurred in two separate and distinct stages. During stage I, serpentine and chondrodite assemblages formed at 500° to 460°C from hydrothermal F with 30 to 36 wt % NaCl. A zonation from serpentine to chondrodite to magnesite reflects the lowering of the silica activity in the F as it reacted with the dolomite. During stage 2, quartz, talc, phlogopite, and carbonate assemblages formed at 320° to 360°C from hydrothermal F with ~2 m NaCl, 1.5 m CO_2, and 0.3 m CH_4. Cassiterite was precipitated predominantly within the quartz and talc assemblages during stage 2. FI and textures related to the stage 2 mineralization indicate that the F was boiling. Loss of H_2 in the V, combined with wall-rock reactions, precipitated Sn from the F.

The $\delta^{18}O$ values of the hydrothermal carbonates (16.4-19.3[‰]) indicate that the hydrothermal F was isotopically heavy and was probably highly exchanged with an ^{18}O-rich sedimentary rock. S isotope data show a bimodal distribution with values for stage 1 samples ranging between -1.9 to 0.0‰ and values for stage 2 between 1.5 to 4.5‰. The near-zero values for stage 1 sulfides suggest a primitive magmatic source whereas the heavier values for stage 2 suggest a sedimentary source.

To account for both the geologic and the isotopic constraints we propose that the Mount Bischoff deposit formed by a two-step enrichment-mineralization process. The first step involved the enrichment of the apical portions of the Meredith Granite with Sn, fluorine, B, and other incompatibles during late-stage fractionation. The second step involved reduced, nonmagmatic F entering the solidified granite, mixing with late magmatic F, and reacting with the granite, and then altering and extracting Sn and fluorine from the enriched zones. These F, driven by residual heat in the granite and focused by dikes and related faults, rose through these structures eventually encountering, altering, and mineralizing the dolomite by a combination of wall-rock and boiling-induced reactions. (From authors' abstract by E.R.)

HAMILTON, P.J., EADINGTON, P.J., BAI, G.P. and BAKER, Julian, 1995, Integrated fluid history investigatins in the Sydney and Gunnedah basins, Australia: American Association of Petroleum Geologists 1995, Ann. Mtg. Abstr., v. 4, p. 38.

HANGHØJ, Karen, ROSING, M.T. and BROOKS, C.K., 1995, Evolution of the Skaergaard magma: Evidence from crystallized melt inclusions: Contrib. Mineral. Petrol., v. 120, p. 265-269. First author at Geologisk Museum, Øster Voldgade 5-7, DK-1350 København K, Denmark.

Polymineralic aggregates composed of clinopyroxene, Fe-Ti oxide minerals, apatite and accessory K-feldspar, biotite, and amphibole are enclosed in cumulus plagioclase grains in the Middle Zone of the Skaergaard intrusion. The chemistry of the minerals in the aggregates, and the textural relations between the aggregates and the host plagioclase grains indicate that they represent I of the contemporaneous M of the Skaergaard intrusion. Through mass balance calculations a quantitative estimate of the M composition for this level in the intrusion can be obtained, and this estimate confirms that the silica content in the Middle Zone M was similar to, or possibly even lower than, the silica content in the initial Skaergaard M, and relatively enriched in Fe. (Authors' abstract)

HANOR, J.S., 1994, Origin of saline fluids in sedimentary basins, *in* J. Parnell, ed., Geofluids: Origin, Migration and Evolution of Fluids in Sedimentary Basins: Geol. Soc. (London) Spec. Publ. No. 78, p. 151-174. Author at Dept. Geology and Geophysics, Louisiana State Univ., Baton Rouge, LA 70803.

Subsurface saline waters in sedimentary basins can be divided into three groups based on their anionic composition and salinity: (1) Waters with anions other than Cl dominant. These include Na-HCO_3 and Na-acetate waters. Most such waters have salinities <10,000 mg l^{-1}; (2) Cl-dominated, halite-undersaturated waters having salinities between 10,000 and 250,000-300,000 mg l^{-1}. These include Na-Cl waters and, at higher salinities, Na-Ca-Cl waters; (3) Cl-dominated, halite-saturated waters with salinities typically in excess of 300,000 mg l^{-1}. Ca and K become increasingly dominant and Na decreases with increasing salinity.

Subaerial evaporation of marine and continental waters and the subsurface dissolution of evaporites both have the potential for producing the range of salinities and dissolved chloride concentrations observed for most subsurface brines, but not their major cation compositions. The broad systematic increase in dissolved Na, K, Mg, Ca, and Sr and decrease in pH and alkalinity with increasing salinity support the hypothesis that the approach toward thermodynamic buffering by silicate-carbonate ± (halide) mineral assemblages is a first-order control on subsurface F compositions, even at T well <100°C. The chemical potential of chloride or, alternatively, the aqueous concentration of anionic charge, is a master variable which ranks in importance with such other variables as P and T in driving F-rock exchange and controlling bulk F compositions. This variable is in turn controlled largely by physical processes of F advection and dispersion.

Dissolved organic acid anions are associated primarily with low salinity waters, but dissolved metals, such as Cu, Pb, and Zn are preferentially found in brines having salinities >200 g l^{-1}. The high chloride concentration and low pH of these saline waters may enhance solubilization of metals through chloride complexing. (Author's abstract)

HANSON, B. and DELANO, J.W., 1995, Experimental remelting of crystallized melt inclusions in quartz from Paleozoic bentonites (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 1, p. 52. First author at Dept. Geological Sciences, Univ. Albany, SUNY, Albany, NY 12222.

MI in quartz phenocrysts from Paleozoic bentonites are commonly vitreous with no dxls present. These pristine I can be used to geochemically "fingerprint" their host bentonites for use in stratigraphic correlation. MI in quartz phenocrysts from some bentonites, however, display varying degrees of crystallization. Some stratigraphically important bentonites contain only crystallized I. In the crystallized state, these I cannot be analyzed by electron microprobe for use in geochemical fingerprinting because they are not homogeneous samples of the magma from which the host quartz grew. If these I have remained geochemically closed systems since the time of their entrapment, the original M composition can be determined by heating the crystals above the liquidus T and allowing sufficient time for the M to diffusively rehomogenize.

Suites of quartz crystals containing crystallized I from individual Ordovician and Devonian bentonites were held in the hotspot of a 1-atmosphere furnace at 975-1075°C for periods of 120 to 330 hrs and quenched in air by rapid removal from the furnace. These I were then inspected for optical homogeneity under high magnification and analyzed by electron microprobe for SiO_2, Al_2O_3, K_2O, Na_2O, FeO, MgO, TiO_2, Cl, CaO, MnO. Analytical precision of typical analyses is <8% of the total abundances for MnO and MgO and <4% for all other elements based on counting statistics. Linescans across large I indicate that these I were chemically homogeneous within analytical uncertainty. Dilution of the M by SiO_2 resulting from melting of quartz at the I wall can be accounted for by normalizing the minor- and trace-elements to a single value of Al_2O_3. Because the original composition of the remelted I is unknown, all analyses are normalized to 11.5 wt % Al_2O_3 (a typical value for Al_2O_3 content of high-silica-rhyolite I in quartz). Multiple experiments performed on suites of I from individual bentonites at different T and durations yielded identical results. Suites of remelted I from different bentonites can be geochemically discerned.

Experimentally remelted I from Paleozoic bentonites have resulted in the geochemical characterization and possible stratigraphic correlation of important bentonites in the Devonian Helderberg Group in the Hudson Valley of New York. Results of revitrification experiments that have been performed on key bentonites in Ordovician shales from New York will also be presented. (Authors' abstract)

HANSON, B., PARK, Y. and DELANO, J.W., 1995, A model of the effect of boundary layer enrichment of incompatible elements on melt inclusion chemistry (abst.): Eos, v. 76, no. 17, p. S270. Authors at Dept. Geological Sciences, SUNY, Albany, NY 12222.

A numerical model for the growth of quartz in high silica rhyolite has been developed assuming that the growth-rate-limiting process is the diffusion of SiO_2 from the L to the surface of the crystal. The flux of SiO_2 to the surface of the crystal was calculated using the finite difference method, and computer-generated results are presented. In order to estimate *maximum* growth rate, we have assumed that supersaturation in SiO_2 happens instantaneously in the L and diffusion-controlled growth proceeds during the entire growth history of the crystal. Our maximum value for SiO_2 supersaturation ($\Delta C = 2$ wt %) was estimated by observing the natural range in SiO_2 content of MI in quartz from various ash-flow tuffs. A general equation relating diffusion-controlled growth rate of quartz to the choice of ΔC and diffusivity of SiO_2 has been developed using the results of the computer-generated data.

A similar finite difference technique was used in order to model the maximum boundary layer enrichment of incompatible elements in the L adjacent to the crystal-L interface using our calculated maximum growth rate for quartz. The calculations show that for incompatible elements that diffuse at a rate faster than $[\log D(SiO_2)]-1$ there will be no significant boundary layer enrichment at T, H_2O concentrations, and P appropriate for either the plinian or ignimbrite magmas of the Bishop Tuff. The only elements known to diffuse at such low rates in hydrous rhyolitic L are REE and Zr. These slowly-diffusing elements might, therefore, exhibit enrichment during quartz growth.

A simple model for the entrapment of MI has been developed in order to assess the effect of boundary layer enrichment on MI chemistry. The average concentration of enriched elements as a function of MI diameter and the position of I within crystals has been calculated for LREE. The calculated range in Ce concentration is similar to that displayed in data on I from the Bishop Tuff (Dunbar and Hervig, 1992). It is not clear, however, if the observed range in the natural samples is a result of boundary layer enrichment processes or chemical heterogeneity in the original M. (Authors' abstract)

HANSON, R.B., 1995, The hydrodynamics of contact metamorphism: Geol. Soc. Am. Bull., v. 107, p. 595-611.

HANSTEEN, T., LECHTENBERG, F., SACHS, P. and SCHMINCKE, H.-U., 1995, Evidence for high concentrations of Cs, Rb and Br in the subsolidus fluid phase of a granite: a SYXRF study of unopened fluid inclusions (abst.): Eos, v. 76, no. 46, p. F682.

The in-situ concentrations of halogens and trace elements in subsolidus FI in quartz from the mildly peralkaline Eikeren-Skrim granite (the Oslo Rift, Norway) have been investigated using synchrotron-XRF and microthermometry. Due to strong F oversaturation during the latest stages of crystallization, the granite contains abundant miarolitic cavities. Large amounts of magmatically derived F were retained in the miarolitic cavities at sub-solidus conditions. These F were trapped as I in euhedral quartz, and are also paragenetic with a nearly pure albitic feldspar. F unmixing occurred on a regional scale in the granite at 412 ± 51°C and 25 ± 6 MPa. The high-density F involved have salinities of 39 to 50 wt % eq. NaCl and contain halite, sylvite, calcite and aphthitalite ($(K,Na)_3Na(SO_4)_2$) as dms at ambient T. Cl contents estimated from phase proportions and microthermometric data range between 21 and 30 wt %. In-situ trace element analyses of unopened FI were performed at the synchrotron- XRF facility at HASYLAB/DESY in Hamburg (Germany) using a new capillary technique and beam diameter of 50μm. Our preliminary data show that the I contain ~300 ppm each of Br and Cs and ~600 ppm Rb. As compared to bulk-rock samples, this implies enrichment factors of roughly $3 \cdot 10^2$ for Cs and ~2-5 for Rb. The mole ratios of Br/Cl in the F are $\sim 2 \cdot 10^{-3}$.

These postmagmatic F were S rich, strongly enriched in Br and Cs, and moderately enriched in Rb. This has important consequences for the transport capabilities of aqueous F in high-T silicic systems. (Authors' abstract)

HARLEY, S.L. and SANTOSH, M., 1995, Wollastonite at Nuliyam, Kerala, southern India: A reassessment of CO_2-infiltration and charnockite formation at a classic locality: Contrib. Mineral. Petrol., v. 120, p. 83-94.

HASELTON, H.T., Jr., CYGAN, G.L. and JENKINS, D.M., 1995, Experimental study of muscovite stability in pure H_2O and 1 molal KCl-HCl solutions: Geochim. Cosmochim. Acta, v. 59, p. 429-442.

HAYASHI, Masao, TAGUCHI, Sachihiro and WATANABE, Koichiro, 1983, Pressure correction for the fluid inclusion thermometer at geothermal fields: J. Japan. Geothermal Energy Assoc., v. 20, p. 22-25 (in Japanese, English abstract).

The P correction for the Th is almost unnecessary in very active geothermal fields, since their F are composed of saturated or nearly saturated waters. On the other hand, the F in less active fields are compressed more or less so that the correction becomes necessary. This paper presents figures and a table required for the P correction of the Th and shows the procedures for calculating it. When the reservoir P is not measured using a P gauge, the total weight of the water column from the ground water level down to the reservoir should be calculated by integrating the density of water at each depth interval. The amount of P correction is ~6°C at 200°C, 8°C at 250°C, and 10°C at 300°C for every 10 MPa in the degree of compression, which is newly defined as the P difference between the F P and its saturated P. (Authors' abstract)

HAYNES, D.W., CROSS, K.C., BILLS, R.T. and REED, M.H., 1995, Olympic Dam ore genesis: A fluid-mixing model: Econ. Geol., v. 90, p. 281-307. First author at Western Mining Corp. Ltd., PO Box 157, Preston, Victoria 3071, Australia.

Numerical modeling shows that F mixing was probably the dominant ore-forming process in the Olympic Dam Cu-U-Au deposit. The mineral associations and their zonation, combined with FI and isotopic data, indicate that mixing of a hotter magmatic or deeply circulated meteoric water and a cooler meteoric water was probably responsible for ore genesis. FI salinities, and the absence of evidence for boiling during precipitation of associations II and III, are consistent with the cooler meteoric water having originated as saline ground water or playa lake water within the volcanic succession inferred to have been extensively developed above and in the vicinity of the Olympic Dam Breccia Complex.

Numerical chemical modeling was used to simulate mixing of a hotter saline water and a selection of cooler meteoric waters at 250° and 150°C, respectively. The modeling supports the hypothesis that precipitation of magnetite, hematite, sulfides, and uraninite resulted from coupled sulfate reduction and ferrous Fe oxidation. The pH decrease caused by hematite precipitation was sufficient to generate the large sericite ± chlorite halo observed in the Roxby Downs Granite. The modeling also supports the hypothesis that the cooler meteoric waters were oxidized and were derived from a provenance containing mafic volcanic rocks with or without a felsic volcanic component.

We conclude that association I precipitated in the early stages of each mixing event, followed by production of II as more cooler water mixed with the hotter water. We also conclude that the Olympic Dam Breccia Complex contains a major Cu-U-Au orebody because it formed within a reservoir of saline ground water in contact with mafic and felsic volcanics and subvolcanic intrusions. (From authors' abstract by E.R.)

HE, Jiang, MA, Dongsheng and LIU, Yingjun, 1995a, The metallization geochemistry and hydrothermal concealed explosion model of the Chatian mercury deposit in western Hunan: J. Guilin Inst. Technology, v. 15, no. 4, p. 319-327. Authors at Dept. Earth Sci., Nanjing Univ., Nanjing 210093, PRC.

Based on the geochemistry studies of ore-bearing formations, FI, stable isotopes of C, H and O, and low-T rock leaching experimental research, this paper indicates that lower Cambrian black rock series which lay below the ore-controlling strata keep [showed?] a large-scale depletion-of Hg in the Tongren-Fenghuang Hg deposit belt, and metallogenic sources mainly derived from lower Cambrian of the metallogenic belt. Low-T, high salinity and Cl-rich but S-poor [fluids] are characteristic of the Chatian Hg deposit. Hg may be mainly mobilized and migrated as the $HgCl_4^{2-}$ complex, partly as the $HgS(HS)^-$ complex. The metallogenic F chiefly originated from meteoric water, and the combination of low $\delta^{18}O$ with low $\delta^{13}C$ can direct the metallogenic center position. Finally, the authors suggest a comprehensive geochemical metallogenic model of the hydrothermal concealed explosion. (Authors' abstract)

See adjacent item. (E.R.)

HE, Jiang, MA, Dongsheng and LIU, Yingjun, 1995b, Geochemistry of mercury mineralization, Catian, west Hunan: Chinese J. Geochem., v. 14, no. 4, p. 361-370 (in English). Authors at Dept. Earth Sci., Nanjing Univ., Nanjing 210093, PRC.

The Tongfeng Hg zone is an important producer of Hg in China. The underlying Lower Cambrian black rock series is strongly depleted in Hg and is thought to be the major source bed for Hg mineralization. The Catian deposit, as the representative of the zone, was formed at low T, which is characterized by a meteoric Cl-rich and S-poor ore-forming solution of high salinity. A geochemical genetic model of buried hydrothermal explosion is proposed. (Authors' abstract)

Th values for quartz and calcite range from 117-187°C, and for early dolomite, 230°C. Salinities range from 6.7 to 12.3, and for early dolomite, 17.8%. Eleven analyses presented for gases and F, Cl, SO_4, K, Na, Ca and Mg.

See also adjacent item. (E.R.)

HE, Wenwu, LU, Jianpei, SUN, Jianhe and MA, Xian, 1995, Some metallogenic characteristics of Dongfengding gold deposit and their prospecting significance: Earth Sci. (Digiu Kexue), J. China Univ. Geosciences, v. 20, no. 2, p. 215-220 (in Chinese, English abstract). Authors at Dept. Mineral Resources, China Univ. Geosciences, Wuhan 430074, PRC.

The Dongfengding Au deposit is controlled by faulted zones. Its major mineral compositions are quartz, pyrite, barite and limonite, whose typomorphic characteristics have significance of genesis and prospecting. The ore-forming F is of medium-low T, low salinity [FI data], and low fugacity of O_2 and S_2. The metallogenic substance mainly comes from the Archeozoic metamorphic rock series in basement. Supergenesis makes the grade and fineness of Au increase greatly. (Authors' abstract)

HE, Zhili, 1995, Advances and trends in fluid inclusion research in China: APIFIS Newsletter 1995, Univ.. Science and Technology Beijing, p. 10-17.

A review of the institutions, equipment and procedures currently in use in PRC, including SEM and Raman, as well as plans for the future. (E.R.)

HÉBERT, R., ROBERTS, S., SANDERSON, D.J., SOLDEVILA, J. and GUMIEL, P., 1995, Amphibolite-facies metamorphic fluid and structural controls on gold deposition: The Tomiño gold deposit (Galicia, NW Spain) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 95-96. First author at Dept. Geology, Univ. Southampton, Southampton SO17 1BJ, UK.

The Tomiño Au deposit is hosted by a series of E-W trending quartz veins within the Urgal granite which intruded a metasedimentary formation. This study focuses on the characterization of the F responsible for Au mineralization and on the constraints they provide on the timing of the mineralization with respect to the geological history of the region. The veins contain two F types: an aqueous-carbonic and an aqueous F.

The first is an aqueous-carbonic F with low salinity (<6 wt % NaCl eq.; Th 260-380°C) and a volatile phase CO_2-dominated $(CO_{2(72-95)}$-$CH_{4(0.5-7.5)}$-$N_{2(1-27)}$ molar fraction; Tm -60 to -56.6, mode -57.2°C). The N_2 molar proportion of the gaseous phase, which is generally higher than CH_4, appears to decrease as the Au grade increases. Bulk composition of the F is primarily H_2O (7O to 96 molar %) and CO_2 (2 to 30 molar %), that leads to a bulk density varying between 0.4 and 0.95 $g.cm^{-3}$ depending on the degree of fill of the I. The second type of F is an aqueous F with a low-salinity (2-8 wt % NaCl eq.; Th 140-260°C).

The conditions of trapping, as determined by the intersection of the P-T conditions of metamorphism and the isochores of the F, are estimated at ~3-4.5 kb and 500 ± 50°C.

These data suggest that the Tomiño Au deposit was generated by metamorphic F. These F have been channeled within opening E-W fractures in the Urgal granite during ductile regional deformation. These channels may have caused local reductions in P which favoured the mineralization of Au and sulphides. The release of P, as the fractures opened in the granite, may have induced an unmixing process which favoured the Au precipitation. This phenomena could also explain the observed correlation between Au grade and degree of fill of the aqueous-carbonic I. The greater the unmixing (the more phase separation), the lower the degree of fill and the higher the Au grade. (From authors' abstract by E.R.)

HEDENQUIST, J.W., 1995, The ascent of magmatic fluid: Discharge versus mineralization: Mineral. Assoc. Canada Short Course, v. 23, p. 263-289.

A review of the processes that may occur, and the mechanisms involved, based in part on literature FI data. (E.R.)

HEDENQUIST, J.W., ARRIBAS, Antonio, Jr., MATSUHISA, Yukihiro and CINCO, J.C., Jr., 1995, The Far Southeast-Lepanto Cu-Au deposit, Philippines: Porphyry to epithermal transition: *in* Pasava, Kříbek and Žák, eds., Mineral Deposits: Balkema, Rotterdam, p. 451-454. First author at Geol. Surv. Japan, Tsukuba, Japan.

The Lepanto enargite-Au epithermal ore body overlies the Far Southeast Cu-Au porphyry ore body; both are contemporaneous at 1.5 to 1.2 Ma, though locally enargite cuts porphyry ore. Early K-silicate alteration formed from a hypersaline liquid of magmatic origin, while an overlying hypogene advanced argillic assemblage hosting the epithermal veins was formed by absorption of magmatic vapor by meteoric water, with the component of groundwater increasing away from the porphyry. A meteoric-water dominated hydrothermal system then overprinted the porphyry system with quartz-sulfide-illite veins, and was subsequently responsible for depositing the epithermal ore of enargite, followed by Au. (Authors' abstract)

HEIN, U.F., BUCZKO, U. and BEHR, H.J., 1995, The siderite vein mineralisation of North Devon/West Somerset (SW England): Genetic implications from fluid inclusions, chlorite thermometry, stable isotopes, and REE fractionation: *in* Pasava, Kříbek and Žák, eds., Mineral Deposits: Balkema, Rotterdam, p. 353-356. Authors at Inst. Geologie und Dynamik der Lithosphäre, Göttingen, Germany.

The siderite(-sulfide) vein mineralisation of North Devon/West Somerset was formed during three stages at T descending from 370°C to 265°C and related P between 1600 bar and 850 bar. FI compositions indicate mixing of deep seated metamorphic F with highly saline formation waters. (Authors' abstract)

HEIN, U.F., SCHÖTTLER, T. and BEHR, H.J., 1995, CH_4-rich inclusions in synkinematic veinlets along the Variscan front of Central Europe (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 98-99. First author at Inst. Geologie und Dynamik der Lithosphäre, Goldschmidtstr. 3, D-37077 Göttingen, Germany.

Throughout the studied localities early quartz and carbonate veinlets contain FI which can be related to veinlet formation. They may be affected by multiple deformation processes leading to secondary changes as partial leakage. Two types of *early* cogenetic I occur:

Two-phase aqueous I with Te -22°C and -3°C < Tm ice < 0.5°C contain Na-dominated low-salinity solutions. They homogenize to L at 112°C < Th(LVL) < 205°C with variable ranges at the individual localities. Their G bubbles are CH_4-saturated as verified by Raman analysis.

Monophase CH_4-rich I commonly exhibit CO_2-melting (-106°C < TmCO_2 < -62°C) before homogenizing to L and in a few cases critical (-83°C < Th(LVL) < -47°C). Microthermometric data result in compositions of $0.63 < XCH_4 < 0.95$ with two maxima at $XCH_4 = 0.73$ and $XCH_4 = 0.88$, respectively, which is in good agreement with Raman analysis.

The G I are interpreted as relics of dry G which was generated during burial of adjacent coal-bearing strata and expulsed along newly forming migration pathways during deformation and tectonic stacking. Thus, their composition reflects the generation T. By their textures the cogenetic aqueous and G I were trapped from heterogeneous H_2O-CH_4 mixtures and permit the reconstruction of maximum P-T reconstructions for individual localities. Tt hardly exceed 200°C which is in good agreement with independent "thermometers" as CAI-values and coalification data. Varying trapping P of 0.4 kb < p < 1.4 kb reflect local tectonic overstacking better than the depth of burial. A local-scale F flow must have occurred during folding and thrusting along the Faille du Midi, since gases of equal composition are found in all stratigraphic members from Silurian to Upper Carboniferous. This F flow followed local geothermal gradients of ≤60°C/km along the Variscan front. (From authors' abstract by E.R.)

HEINRICH, C.A., 1995, Geochemical evolution and hydrothermal mineral deposition in Sn (-W-base metal) and other granite-related ore systems: Some conclusions from Australian examples: Mineral. Assoc. Canada Short Course, v. 23, p. 203-220.

A review of the metal contents of granitic residual F, based mainly on published PIXE analyses. (E.R.)

HEINRICH, C.A., BAIN, J.H.C., MERNAGH, T.P., WYBORN, L.A.I., ANDREW, A.S. and WARING, C.L., 1995, Fluid and mass transfer during metabasalt alteration and copper mineralization at Mount Isa, Australia: Econ. Geol., v. 90, p. 705-730. First author at Dept. Erdwissenschaften, ETH Zentrum, 8092 Zürich, Switzerland.

Metabasalts surrounding the metasediment-hosted base metal deposit at Mount Isa have been modified by metamorphism, polyphase deformation, and several stages of hydrothermal alteration. Microthermometry, Raman microspectrometry and Br/Cl analyses of FI, and H, O, C, and S stable isotope measurements on vein minerals were used to characterize the hydrothermal F associated with the alteration events. All F are moderately to highly saline, variable Ca enriched with high Br/Cl compared to modern seawater, and isotopically most akin to modern evolved basin or low-grade metamorphic brines. (From authors' abstract by E.R.)

HEINRICH, Wilhelm and GOTTSCHALK, Matthias, 1995, Metamorphic reactions between fluid inclusions and mineral hosts. I. Progress of the reaction calcite + quartz = wollastonite + CO_2 in natural wollastonite-hosted fluid inclusions: Contrib. Mineral. Petrol., v. 122, p. 51-61.

Full paper for abstract in FIR, v. 27, p. 54. (E.R.)

HEINRICH, Wilhelm, HOFFBAUER, Radegund and HUBBERTEN, H.-W., 1995, Contrasting fluid flow patterns at the Buda del Diente contact metamorphic aureole, north-east Mexico: Evidence from stable isotopes: Contrib. Mineral. Petrol., v. 119, p. 362-376.

HEITHERSAY, P.S. and WALSHE, J.L., 1995, Endeavour 26 North: A porphyry copper-gold deposit in the Late Ordovician, shosonitic Goonumbla volcanic complex, New South Wales, Australia: Econ. Geol., v. 90, p. 1506-1532. Authors at Dept. Geology, Australian Nat'l Univ., Canberra, ACT 0200, Australia.

The following types of FI were observed in vein quartz: type A, I with <60 vol % V and no dxls; type B, I with >60 vol % V and no dxls; type C, I with <60 vol % V with a halite dxl; type D, I with

<60 vol % V and halite and sylvite dxls; type E, I with <60 vol % V and halite and sylvite dxls plus unknown phases. FI Th show a series of pronounced T peaks between ~350° and 800°C that are taken to reflect active periods of the hydrothermal system and quartz sulfide deposition. Peaks at 750° to 800°C in stages 4 and 6 appear to be closely related to the emplacement of QMP1 and QMP2, respectively. Peaks ~500° to 650°C in stages 4 and 5 reflect the main periods of sulfide deposition and development of stockwork veining in QMP1. The apparent coexistence of type B I with type C, D, and E I suggests P-T conditions consistent with the two-phase region (saline F plus V). Estimates of F compositions for type D I for most stages center around 15, 45 and 40 wt % H_2O, NaCl, and KCl, respectively, on the ternary projection. An increase in total salinity and in the ratio of NaCl to KCl is associated with stage 4.

The compositions of the hydrothermal biotite and the very saline compositions of type C and D I suggest separation of saline F and V from a silicate melt on the order of 800° to 1000°C. F separation was initiated prior to the melt becoming saturated in quartz and most probably prior to alkali feldspar saturation. (From authors' abstract by E.R.)

HEMMING, N.G., REEDER, R.J. and HANSON, G.N., 1995, Mineral-fluid partitioning and isotopic fractionation of boron in synthetic calcium carbonate: Geochim. Cosmochim. Acta, v. 59, p. 371-379.

HENRY, C.D., ELSON, H.B., HEIZLER, M.T. and CASTOR, S.B., 1995, Brief duration of hydrothermal activity at Round Mountain, Nevada, determined from $^{40}Ar/^{39}Ar$ geochronology (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 329.

Indexed under FI. (E.R.)

HERMS, P., APPEL, P., MÖLLER, A. and SCHENK, V., 1995, An anticlockwise P-T path of the Uluguru granulite complex, Tanzania, as recorded by fluid inclusions (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 99-100. Authors at Mineralogisch-Petrographisches Inst., Christian-Albrechts-Univ., Kiel, Olshausenstr. 40, D-24098 Kiel, Germany.

Metamorphism took place under high-P granulite-facies conditions (8-10 kb) during the Pan-African orogeny. Recent petrological investigations verify an anticlockwise P-T path for this terrane. The aim of the FI studies is to constrain the anticlockwise P-T path and to characterize the metamorphic F at different P-T stages. Samples have been selected in that way that they contain mineral associations which equilibrated at different stages of the P-T path.

FI which represent Stage I of the *prograde P-T path* are supposed to occur in quartz included in garnet porphyroblasts in a metapelite. Protected against later deformation P FI of CO_2-rich and CO_2-N_2 composition have been preserved in the armoured quartz grains. Early quartz crystals enclosed by the growing garnet have CO_2-N_2 I whereas quartz formed during garnet growth have pure CO_2 I.

During the *prograde P increase* (Stage II) some of the P FI leaked or imploded and mixing of CO_2-rich and N_2-rich F occurred. The FI re-equilibrated to lower N_2 compositions and higher F densities. CO_2-N_2 I with uniform low N_2 contents presumably formed after high-T deformation and recrystallization of the matrix quartz near to the peak of granulite-facies metamorphism.

Stage III of the P-T path is characterized by *isobaric cooling* at high P and is represented by garnet growth on posttectonic veins in a two-pyroxene granulite. FI are CO_2-rich (<0.5 mol % N_2) and have very high densities (1.15 g/cm^3). The isochores for these I mark the end of the isobaric cooling path before tectonic uplift and decompression.

Stage IV is characterized by the *retrograde uplift* with strong decompression. Most of the I decrepitated or re-equilibrated at this stage. Liberated CO_2-N_2 F in graphite containing metapelites must have changed their composition to N_2-CH_4 during cooling in a closed system if water was present and with graphite stable. FI in the metabasite remained CO_2-rich and only re-equilibrated to lower densities. Seldom H_2O-NaCl-($MgCl_2$-$CaCl_2$) I of low densities are found.

Local shear zones transformed the pyroxene granulite into biotite-hornblende-scapolite gneiss. The matrix quartz in this gneiss contains CO_2-N_2 I with 14-18 mol % nitrogen and low-density N_2-CH_4 I indicating T <500°C. H_2O-rich FI of low salinity (~5 wt % NaCl eq.) are rare and formed at very low T and P.

In conclusion, FI investigations on the specifically selected samples verify nicely the different P-T stages and thus confirm an anticlockwise P-T path for the Uluguru metamorphic terrane. (From authors' abstract by E.R.)

Slides of the meeting showed large, beautifully sharp negative I of CO_2 in quartz. (E.R.)

HERVIG, R.L., WILLIAMS, L.B., KIRKLAND, I.K. and LONGSTAFFE, F.J., 1995, Oxygen isotope microanalyses of diagenetic quartz: Possible low temperature occlusion of pores: Geochim. Cosmochim. Acta, v. 59, p. 2537-2543.

HICKMOTT, D.D. and BALDRIDGE, W.S., 1995, Application of PIXE microanalysis to macerals and sulfides from the Lower Kittanning coal of western Pennsylvania: Econ. Geol., v. 90, p. 246-254. Authors at Earth and Environmental Sciences Div., Los Alamos Nat'l Laboratory, Los Alamos, NM 87545.

Proton-induced X-ray emission (PIXE) microanalysis is shown to be capable of semiquantitative to quantitative standardless determination of trace element abundances in coal macerals and sulfides using an internal normalization protocol. Devolatilization of coal beds may be a plausible source of complexing ions and metals for ore deposit formation. Such F may be characterized by low Cl/Br relative to most hydrothermal F. (From authors' abstract by E.R.)

HILL, C.A., DUBLYANSKY, Y.V. and HARMON, R.S., 1995, Overview of calcite/opal deposits at or near the proposed high-level nuclear waste site, Yucca Mountain, Nevada: Pedogenic, hypogene, or both? (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 418-419.

Indexed under FI. (E.R.)

HOERNES, S., LICHTENSTEIN, U., van REENEN, D.D. and MOKGATLHA, K., 1995, Whole rock/mineral O-isotope fractionations as a tool to model fluid-rock interaction in deep-seated shear zones of the southern marginal zone of the Limpopo Belt, South Africa: South African J. Geol., v. 98, no. 4, p. 488-497.

Indexed under FI. (E.R.)

HÖGELSBERGER, H. and GRUM, W., 1995, Evolution of fluorite-hosted hydrothermal fluids in the Galway Bay area (Ireland): *in* Pasava, Krîbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 357-360. First author at Greenpeace Austria, Vienna, Austria.

The occurrence of FI hosted by fluorite in the Galway Bay area provides a good opportunity to study and compare hydrothermal activity both in a granitic batholith and its sedimentary cover rocks. Based on microthermometric and mass spectrometeric data, three different types of F can be characterized. (1) Juvenile F within granite-hosted fluorites show the highest Th with low salinities. Volatiles consist mainly of H_2O and small amounts of CO_2 and CH_4. It got mixed with a (2) CH_4-rich basinal brine. During a later stage the mineralization F have been diluted. (3) Very low salinities and low CH_4 are due to the influence of meteoric water. The considerable amounts of CO_2 are caused by the circulation through limestones. (Authors' abstract)

HOGG, A.J.C., PEARSON, M.J., FALLICK, A.E. and HAMILTON, P.J., 1995, An integrated thermal and isotopic study of the diagenesis of the Brent Group, Alwyn South, U.K. North Sea: Appl. Geochem., v. 10, p. 531-546.

Indexed under FI. (E.R.)

HOLLISTER, V.F. and SILBERMAN, M.L., 1995, Silver-gold and polymetallic quartz veins in the Bodie Mining District, east-central California—Are they related to a porphyry Cu-Mo system at depth?, *in* F.W. Pierce and J.G. Bolm, eds., Porphyry Copper Deposits of the American Cordillera: Arizona Geol. Soc. Digest, v. 20, p. 297-305. First author at Mission, British Columbia, Canada.

The Bodie Mining District is known principally for its epithermal base metal-poor quartz-adularia veins, hosted by dacitic volcanic rocks. A series of polymetallic Ag-rich veins are less well known. These veins consist of brecciated, silicified, quartz-cemented wall rock.

Hydrothermal alteration in the district extends over an area of >9 km^2. Low-T K-silicate altered and silicified rocks are present in the main Ag-Au bonanza ore zone in the central part of the northern third of the district. Argillic alteration with some zones of silicic and sericitic alteration occupies the axial part of the alteration zone to the south. Propylitic alteration assemblages occur peripheral to and below the central alteration zones.

FI and isotopic data from the low-sulfide, Ag-Au veins suggest that the veins formed at ~240°C from a low salinity ore F that was dominantly meteoric in origin. Reconnaissance examination of FI in quartz from the polymetallic veins indicates that a highly saline F is present. Some I in this quartz have ≤4 dms, and the O isotopic signature of the quartz is more enriched in the heavy isotope $\delta^{18}O$ than that found in the Ag-Au veins.

Taken together, the geochemical, geophysical, alteration-pattern, and FI data suggest that Bodie is underlain by an intrusive mass, probably of felsic composition (based on the Mo, Sn, and W anomalies), and that at least a deep stage of polymetallic Ag-rich veins formed from a F of high salinity, with characteristics similar to those found within and peripheral to porphyry Cu-Mo systems. (From authors' abstract by E.R.)

HOLNESS, M.B., 1995, The effect of feldspar on quartz-H_2O-CO_2 dihedral angles at 4 kbar, with consequences for the behaviour of aqueous fluids in migmatites: Contrib. Mineral. Petrol., v. 118, p. 356-364. Author at Dept. Geology and Geophysics, Univ. Edinburgh, King's Bldgs., West Mains Road, Edinburgh EH9 3JW, UK.

An investigation was made of the effect of trace amounts of feldspar (Na and/or K) on dihedral angles in the quartz-H_2O-CO_2 system at 4 kb and 450-150°C. In all systems the quartz-volatile F angle is >60°, whereas the quartz-melt angle is <60°. Of pertinence to the permeability of high-grade rocks to aqueous F. (From author's abstract by E.R.)

HOLNESS, M.B. and GRAHAM, C.M., 1995, P-T-X effects on equilibrium carbonate-H_2O-CO_2-NaCl dihedral angles: Constraints on carbonate permeability and the role of deformation during fluid infiltration: Contrib. Mineral. Petrol., v. 119, p. 301-313. Author at Dept. Geology and Geophysics, Univ. Edinburgh, King's Bldgs., West Mains Road, Edinburgh EH9 3JW, UK.

F-solid-solid dihedral angles in the NaCl-H_2O-CO_2-calcite-dolomite-magnesite system have been determined at P ranging from 0.5 to 7 kb and T from 450°C to 750°C. The results demonstrate that the permeability of carbonates to grain edge F flow is only possible at low P and for F of restricted H_2O-CO_2-NaCl compositions. However, geochemical evidence from metamorphic terrains suggests that pervasive infiltration does occur under conditions where impermeability is predicted. (From authors' abstract by E.R.)

HOLTZ, François, BEHRENS, Harald, DINGWELL, D.B. and JOHANNES, Wilhelm, 1995, H_2O solubility in haplogranitic melts: Compositional, pressure, and temperature dependence: Am. Mineral., v. 80, p. 94-108. First author at Centre de Recherches sur la Synthèse et la Chimie des Minéraux, CRSCM-CNRS, 1A rue de la Rérollerie, 45071 Orléans, France.

H_2O solubility has been determined in haplogranitic melts (system SiO_2-$NaAlSi3O_8$-$KAlSi_3O_8$, Qz-Ab-Or) in the range 0.5-8 kb and 800-1350°C. (From authors' abstract by E.R.)

HÖPPNER, M., 1995, Geologic, fluid inclusion, geochemical and stable isotope studies on the granite-related gold deposit of Eureka, northern Zimbabwe (abst.), *in* T.G. Blenkinsop and P.L. Tromp, eds., Sub-Saharan Economic Geology: Geol. Soc. Zimbabwe Spec. Pub. 3, p. 245-246.

HORIBE, Y. and CRAIG, H., 1995, D/H fractionation in the system methane-hydrogen-water: Geochim. Cosmochim. Acta, v. 59, p. 5209-5217.

HORITA, Juske, COLE, D.R. and WESOLOWSKI, D.J., 1995, The activity-composition relationship of oxygen and hydrogen isotopes in aqueous salt solutions: III. Vapor-liquid water equilibration of NaCl solutions to 350°C: Geochim. Cosmochim. Acta, v. 59, p. 1139-1151.

See FIR, v. 27, p. 56. (E.R.)

HORN, S. and SCHMINCKE, H.U., 1995, Pre-and post-eruptive magmatic volatiles of the 1000 AD eruption of Baitoushan Volcano (NE China/North Korea) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 25.

Matrix glasses determined by microprobe analysis yield 3000-4500 ppm Cl and 2000-4000 ppm F, whereas the corresponding MI contain slightly higher Cl (3500-5000 ppm) and F (3000-4000 ppm) values, independent of the type of their host crystals (fsp, cpx). In contrast, the S-content (≤500 ppm) is similar in matrix glasses and MI. The Br content of ~15 ppm in matrix glasses determined by synchrotron XRF is identical to Br-analyses by standard XRF. Pre-eruptive H_2O contents are estimated to have been ~5 wt % based on difference of total sum of oxides. The petrological method indicates relatively small amounts of volatiles other than H_2O to have been released during the paroxysmal eruption. We cannot exclude major excess volatiles (SO_2, halogens) to have entered the stratosphere, possibly derived from a free vapor phase. However, the S-content of the Baitoushan magmas were small compared to other large explosive eruptions (e.g., El Chichón, Redoubt, Pinatubo). Thus the climatic influence of the eruption is uncertain. (From authors' abstract by H.E.B.)

HOWE, S.S., AREHART, G.B., NIELSEN, P.A. and PERKOWSKI, Robert, 1995, Rift-related fluorite-quartz-barite-base-metal deposits in southwestern New Hampshire (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 1. p. 55. First author at Dept. Geology, Univ. Vermont, Burlington, VT 05405.

Small fluorite-quartz-barite-base-metal sulfide deposits occur near Westmoreland, Cheshire County, New Hampshire, ~30 km N of the northern terminus of the Deerfield Basin. Veins and breccia are localized along N- and NE-trending extensional faults near the contact between the middle to late Ordovician Ammonoosic Volcanics and granodioritic gneisses of the late Ordovician to Silurian Oliverian Plutonic Series in the Bronson Hill Anticlinorium.

Formation of euhedral, locally sceptered, quartz and lesser amounts of barite, galena, and chalcopyrite was followed by several alternating episodes of green, gray, and purple fluorite deposition and solution at the Wise and Stoddard mines. P and S L+V FI in green fluorite have very low salinities and Th = 220 ± 20°C and 180 ± 40°C, respectively, but additional samples examined recently under high magnification reveal a population of I containing isotropic cubic and weakly anisotropic tabular dms. These F also have very heavy δD values of 16 ± 1‰. Barite, galena, and chalcopyrite have $\delta^{34}S$ values of +12.2, -2.9, and -0.8‰, respectively. Quartz associated with galena, pyrite, and sphalerite from Surry Mountain to the east has very low salinity L+V I with Th = 170 ± 40°C, whereas barren quartz I have Th = 155 ± 25°C. $\delta^{34}S$ values of galena, pyrite, and sphalerite are tightly grouped between -0.6 and +2.3‰, although isotopic equilibrium was not established.

The data suggest that meteoric water leached S from the Ammonoosic Volcanics and younger felsic intrusive rocks, was heated by shallow igneous activity related to Triassic rifting, and that some of its reduced S underwent partial nonequilibrium oxidation to form sulfate, probably concurrent with its collection and repeated evaporation in ephemeral lakes, increasing its salinity and deuterium content. (Authors' abstract)

HRDY, Frank and KYSER, T.K., 1995, Origin, timing, and fluid characteristics of an auriferous event: The Proterozoic Jasper lode gold deposit, Saskatchewan, Canada: Econ. Geol., v. 90, p. 1918-1933. First author at Dept. Geological Sciences, Univ. Saskatchewan, Saskatoon, Saskatchewan S7N 0W0, Canada.

Two-phase S aqueous FI outline and dominate healed fracture planes in both barren quartz veins and in the less deformed portions of mineralized quartz veins. The F in these I have low salinities, generally not >7 wt % NaCl eq., and Th of 150° to 200°C. FI within dynamically recrystallized quartz tend to concentrate at quartz subgrain boundaries along with Au, and they are V rich, have complex gas and cation compositions, Th between 300° and 375°C, and characteristics of F-phase immiscibility.

These data are consistent with a model wherein earlier quartz veins were reactivated and partially recrystallized during a post-tectonic, Au-depositing F event. Au distribution was controlled by the development of fracture-controlled permeability and by H_2O-

CO_2 phase separation of a low-salinity, CO_2-rich, metamorphic F at 300° to 375°C, which was derived from a source similar to the igneous rocks spatially associated with the deposit. (From authors' abstract by E.R.)

See also Hrdy, FIR, v. 27, p. 56. (E.R.)

HUA, Renmin, WU, Peihong and CHEN, Kerong, 1995, A discussion on the origin of ore fluid of the Yinshan polymetallic deposit, Jiangxi, China: Geological Journal of Universities, v. 1, no. 1, p. 37-44 (in Chinese, English abstract). Authors at Dept. Earth Sciences, Nanjing Univ., Nanjing 210093, PR China.

On the basis of geological and geochemical characteristics of the Yinshan polymetallic deposit, Jiangxi province, and from the viewpoint of water-rock interaction and related isotope exchange, the present paper queries the validity of the conclusion that magmatic water was the main origin of ore-forming F in Yinshan deposit, which was proposed by some previous studies. O isotope compositions of altered rocks and F were determined for reverse calculation of water-rock isotope exchange. It shows that the ore F of Yinshan deposit originated from meteoric water instead of magmatic. This F was the product of interaction between the downgoing meteoric water and phyllitic wall rocks that had higher $\delta^{18}O$ values in deeper portion at higher T (≥400°C) and lower W/R ratio (≤0.05). As a result, the $\delta^{18}O$ value of the F had been greatly enhanced and could reach the value similar to magmatic water, which is easy to lead to the conclusion of a magmatic origin. As a matter of fact, the small-scale subvolcanic magmatism in Yinshan area mainly served as a heat source but not a water source for the large-size mineralization. (Authors' abstract)

HUBUNAYA, S.A. and SOBOLEV, A.V., 1995, Parental magmas for island arc high-alumina basalts: Results of magmatic inclusions study in phenocrysts from high-Mg basalts of Kluchevskoy volcano, Kamchatka (abst.): Eos, v. 76, no. 17, p. S270. Firsts author at Inst. Volcanology RAS, Petropavlovsk-Kamchatsky, Russia.

Kluchevskoy volcano (Kamchatka peninsula) represents the most active present day island arc volcano. The major type of volcanic material corresponds to high-alumina basalts (HAB) typical for island arc magmatism. These basalts closely associate with high Mg basalts (HMB) and picrites enriched in high-Mg olivine (≤Fo92) and clinopyroxene (≤Mg# 92) phenocrysts. Major and trace elements study together with isotopy of Nd and Sr and petrography all suggest close genetic link between HMB and HAB (Kersting and Arculus, J. Petrol., 35, 1994, and our unpublished data). In this paper we report detail study of M and FI trapped in olivine and clinopyroxene phenocrysts from HMB.

P MI in minerals were studied in high-T optical heating stage (Sobolev et al., Proc. 11th LPSC, 1980) and then after quenching by electron and ion microprobes. Major element composition of MI reconstructed to meet equilibrium with host olivine varied from picrite (MgO = 14-15 wt.%.) to basalt intermediate between HMB and HAB (MgO = 7 wt %). Trace elements concentrations show typical affinity of island arc related tholeiites: flat REE pattern, significant relative enrichment in LILE (Ba, K, Sr) and depletion in HFSE (Nb, Zr, Ti, Y). Primitive MI show enrichment in H_2O (2.4-1.3 wt %) and S (0.2-0.3 wt.%) while groundmass glass is completely degassed in both. P FI correspond to high-density CO_2 and suggest that F P during olivine crystallization was >5 kbar.

The obtained data suggest that primary M for both HMB and HAB had picritic composition with MgO ~15 wt.% and was enriched in H_2O (~2 wt.%), S (0.20-0.25 wt %) and CO_2 (>5 kb F P). (Authors' abstract)

HUIZENGA, J.M., 1995, Fluid evolution in shear zones from the late-Archean Harare-Shamva-Bindura greenstone belt (NE Zimbabwe): Thermodynamic calculations of the C-O-H system applied to fluid inclusions: PhD dissertation, Vrije Univ., Amsterdam, The Netherlands, 146 p.

The aim of this study is to investigate the mechanisms of F migration and F focusing in shear zones from Archean greenstone belts. Furthermore, FI studies were performed on shear zones from the late-Archean Harare-Shamva-Bindura greenstone belt in order to investigate the F evolution in these shear zones and in the greenstone belt.

Chapter 2 introduces the computer program *COHFLUID*. F compositions provide information on the P-T conditions and O fugacity (fO_2) of F equilibration. Composition and molar volume of graphite-buffered C-O-H F are entirely determined if the O fugacity, P and T are specified. *COHFLUID* was particularly developed to calculate: (1) F composition and molar volume from P, T, fO_2 and graphite activity; (2) P, T, XH_2O and molar volume from the XCO_2 (XCO_2 + XCH_4) ratio, fO_2 and graphite activity; (3) fO_2 from F compositions; (4) P-T stability field of graphite buffered F; (5) changes in the F composition related to heating or cooling, assuming that F system is closed (i.e., transfer of matter is prohibited). These calculations can be carried out for non-ideal and ideal mixing of the F species. *COHFLUID* is different from other programs since it provides the possibility to calculate P and T from a specified F composition. Calculations for the graphite-buffered C-O-H and graphite-pyrite-pyrrhotite-buffered C-O-H-S system show that the mole ratio $CO_2/(CO_2 + CH_4)$ is largely P independent. This implies that the mole ratio $CO_2/(CO_2 + CH_4)$ can be used as a geothermometer. This geothermometer is independent of the graphite activity if fO_2 equals or is less than the Quartz-Fayalite-Magnetite buffer.

Chapter 3 presents an overview of techniques for FI study used in this study, including microthermometry and Raman microspectrometry. Post-entrapment changes of FI such as water leakage or chemical reactions in the F phase are common features. *COHFLUID* appeared to be very useful in identifying those changes.

Chapter 4 provides a review of shear zone hosted Au deposits in Archean greenstone belts from different parts of the world (Australia, Canada, Southern Africa). I have used these data to develop a physico-chemical model of F migration in shear zones. Archean Au deposits show a wide consistency in: (1) the tectonic setting of the shear zones; (2) P-T conditions of Au mineralization (1-2 kb, 300°-400°C); (3) composition of Au mineralizing F (XH_2O/XCO_2 = 4). Thermodynamic calculations demonstrate that slightly overpressurized F with a XH_2O/XCO_2 ratio of 4 and a $P_{FLUID} > 2$ kb heat up when they move to higher crustal levels. This is largely due to irreversible (isenthalpic-adiabatic) decompression (i.e., Joule-Thompson effect). The T increase of the F becomes greater if XCO_2 increases or if CH_4 or N_2 are present in the F. Therefore, significant amounts of heat may be generated and transported by F in shear zones.

Chapter 5 gives a review of the regional geology of Harare-Shamva-Bindura greenstone belt. Chapters 6 to 8 present the results of FI studies performed on the Umwindsi and Pote Shear Zones. The graphite-bearing H_2O-CO_2-CH_4 FI have a rather constant $XCO_2/(XCO_2 + XCH_4)$ ratio. *COHFLUID* was used to calculate the T of F unmixing and XH_2O of the initial homogeneous F. The presence of graphite at peak metamorphic T constrains fO_2. The calculations demonstrate for $QFM + 0.3 \leq fO_2 \leq QFM - 0.7$ F separation took place at 450°-650°C. Furthermore, XH_2O of the initial homogeneous F was at least 0.8. Trapping of the immiscible F occurred at 3-4 kb and 425°-575°C.

F regimes in both shear zones were dominated by a highly saline (≈30 wt % NaCl) magmatic aqueous and a low-saline aqueous F (H_2O-CO_2, XH_2O = 0.9-0.7). Mixing of both F above the solvus T of the H_2O- CO_2-NaCl system resulted in a highly to moderately saline H_2O-CO_2 F, which became immiscible during cooling. Infiltration of the magmatic and metamorphic F below the solvus T resulted in separate trapping of these F.

Chapter 8 discusses the various possible scenarios of sequential mixing and unmixing along various P-T paths. (From authors' abstract by E.R.)

HURAI, V. and SIMON, K., 1995, Large-scale and local fluid migration during metamorphism: Evidence from H, O, C isotope composition and Na/Ca ratio of the inclusion fluids (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 101. First author at Dionyz Stúr Institute of Geology, 817 04 Bratislava, Slovak Republic.

Chemical and isotopic records obtained from FI indicate two contrasting F regimes during metamorphism of the Veporicum crystalline complexes in the Western Carpathians. The high-T fissures (450-500°C) have probably formed near to or below peak metamorphic conditions during the Hercynian orogeny in a closed system, in which aqueous solutions have been in chemical and isotopic equilibrium with surrounding, mostly granitoid rocks. This is corroborated by narrow ranges of Na/Ca ratios in individual FI, and by uniform δD and $\delta^{18}O$ values (- 59 ± 5‰ and 7-7.5‰ SMOW, respectively).

The extension-related Alpine quartz, precipitating in vertically-dipping veins and mylonitic shear zones at T mostly between 330-380°C, exhibits signatures of the large-scale F migration, resulting in much larger compositional and isotopic variability of the I F.

C isotope composition of the inclusion CO_2 varies between -7.7 to -11.9‰ PDB in both types of metamorphic quartzes. These values have been interpreted to reflect partial influence of the CO_2 liberated by decomposition of organic matter in underlying metasediments. Fixed $\delta^{13}C$ values of the I CO_2 are believed to corroborate the concept of Hercynian granitoid napes in the crystalline basement of the Western Carpathians. (Authors' abstract)

See also FIR, v. 26, p. 74 and next item. (E.R.)

HURAI, V., SIMON, K. and BEZAK, V., 1994, Hercynian age of some Alpine-type fissures in the crystalline complexes of the Veporicum unit (Central Slovakia): Mineralia Slovaca, v. 26, p. 355-361 (in Slovak, extended English abstract). First author at Geol. Surv., Mlynska dolina 1, 817 04 Bratislava, Slovakia.

Two types of Alpine mineral assemblages have been defined in the crystalline complexes of the Veporicum unit (Central Western Carpathians) on the basis of quartz and adularia typology, structural position, and the phase, chemical, and isotopic composition of their I F. It is supposed that earlier high T (450-500°C, 2.8-4.6 kb) [I] may have formed during Hercynian cycle, while later, lower T (330-380°C, 1.5-2.5 kb), NE-SW-trending veins have precipitated during extensive Alpine (Cretaceous) metamorphism. Stable isotope (C, H, O) data from I F place constraints on age of overthrusting as well as the character of Hercynian granitoids, which are hosts for these Alpine-type fissures. (Authors' abstract)

See also previous item. (E.R.)

HURAI, V., SIRANOVA, V., MARKO, F. and SOTAK, J., 1995, Hydrocarbons in fluid inclusions from quartz-calcite veins hosted in Paleogene flysch sediments of the Central Western Carpathians: Mineralia Slovaca, v. 27, p. 383-396 (in Slovak, extended English abstract). First author at Geol. Surv., Mlynska dolina 1, 817 04 Bratislava, Slovakia.

The paper summarizes information gained from hydrocarbon-rich I trapped in quartz-calcite veins, penetrating Paleogene flysch sediments of the Central Western Carpathians. Properties of the I-hosted hydrocarbons, gases and aqueous solutions have been studied by microthermometry, G chromatography, Raman and infrared spectroscopy.

Gaseous phase of the I F is characterized by predominance of CH_4, minor CO_2 and traces of H_2S and C_2H_6. The composition is typical of dry G liberated by thermal degradation of mature hydrocarbons and/or coal. CO_2 has been probably liberated during disintegration of carboxyl groups, whereas H sulphide might have been liberated from oil or volcanic exhalations accompanying Neogene volcanism. Composition of the I G is consistent with those from deep drillings of this region.

Composition of the oil fraction is typical of organic matter in advanced evolution stage. These oils have been leached directly from adjacent country rocks.

Minimum T in the northern part of the basin was at least 130-155°C, which is consistent with mean vitrinite reflectance (1.4). Substantially lower T (60-80°C) in the southern part of the basin are in accord with the mean vitrinite reflectance of 0.6 in this region. P in the northern part fluctuated in a wide range, reaching a maximum at 1.1 kb, very likely as much as 1.5 kb. The overpressures may be attributed to thermal degradation of higher hydrocarbons and liberation of large CH_4 volumes. Minimum P values at ~250 bar might correspond to hydrostatic P. P fluctuations and signatures of a thermal degradation are absent in the southern portion of the flysch basin. Lower degree of thermal alteration is indicated by the presence of light condensate, accompanying CH_4 in FI.

Salinity of aqueous solutions in both localities studied was negligible, corresponding to a common groundwater. The hydrocarbon-containing quartz-calcite veins therefore cannot have originated during subsidence in marine environment. A post-Oligocene age of the veins is therefore envisaged and thermal decomposition of hydrocarbons in the northern part of the flysch basin can be correlated with a heat flow coincidental with local intrusions of Miocene andesites. (Authors' abstract)

HURAIOVA, M., KONECNY, P. and HURAI, V., 1995, Volatiles in mantle-derived magma chambres in the crust: evidence from fluid inclusions in anorthoclasite and trondhjemite xenoliths from late Tertiary alkaline basalts (Western Carpathians) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 102-103. First author at Dept. Mineralogy and Petrology, Comenius Univ., 84215 Bratislava, Slovak Republic.

Mineral composition of these rocks as well as compositional, REE and microthermometry data on intergranular and inclusion silicate melts are documented elsewhere (Konecny et al., this volume). This contribution is focused on FI in the rock-forming quartz and plagioclase, as well as those trapped in the vesicular glass adhering [to] grain boundaries of the rock-forming minerals.

Primary two-phase melt and mostly monophase CO_2-rich I arise in both trondhjemites and anorthoclasites. One trondhjemite sample (KP-30) contains three-phase $CO_2 + H_2O$ I with 0-25 vol % of the aqueous phase, indicating H_2O oversaturated crystallization conditions. H_2O, however, predominates over CO_2 V in isolated vesicles observed in the intergranular melts from trondhjemites. The vesicles in melt pockets of the anorthoclasite xenoliths [have no] discernible aqueous phase.

Aqueous I occur also in quartz and plagioclase hosted, carrousel-resembling I, consisting of rounded core of the host mineral encompassed by a ring of vitreous silicate phase connected by a conduit with the intergranular melt. The vitreous phase occasionally contains several V bubbles, some of them filled with aqueous F. An intimate genetic relationship between the intergranular melts and the carrousel-resembling I is documented by consistent salinities of their aqueous F. The interstitial melt hosted vesicles as well as the carrousel-resembling I are believed to have formed during explosion, when isothermal decompression has led to significant volume expansion of the rock-forming minerals and viscous residual melt. Consequently, the aqueous phase in the vesicles as well as in the carrousel type I possibly represents the equilibrium water initially dissolved in the interstitial melt at higher P and liberated during explosion and concomitant P drop.

Tm CO_2 ranges -57.3 to -58.8; Th CO_2 (L) (minimum) ranges from 5.4 to 27.8°C; Th MI = >1080 to 1280°C; P (kb) = >3.4 + 6.6.

It can be concluded that the anorthoclasite and trondhjemite xenoliths exhibit signatures of cumulate rocks and may thus perhaps represent final products of the fractional crystallization of basaltic magma chambers related to a continental rift zone induced basaltic volcanism. (From authors' abstract by E.R.)

ICHII, Y., FURUNO, M. and TAKAHATA, H., 1995, Alteration and mineralization zones of Nakatoya area, southwestern Hokkaido (abst.): J. Soc. Resource Geol., v. 45, no. 4, p. 266 (in Japanese).

Indexed under FI. (E.R.)

INTASOPA, S. and ATICHAT, W., 1995, Inclusions in Siamese ruby and sapphire: Their application in gemology (abst.): Eos, v. 76, no. 17, p. S157-S158. Authors at Div. Mineral Resources Analysis, Dept. Mineral Resources, Rama VI Rd., Bangkok 10400, Thailand.

The Tertiary gem-bearing basaltic rocks of the Chantabuti and Trat Provinces of eastern Thailand are classified as basanitoid or nephelinite. The rocks are generally high in alkali and titanium and low in silica. The rocks consist of olivine phenocryst and clinopyroxene microphenocryst with megacrysts of ruby, clinopyroxene, spinel, garnet, zircon, and xenocrysts of spinel lherzolite and dunite. Gem-quality corundum including ruby, and blue and green sapphires were found at relatively shallow depths in high weathered basaltic rocks.

Inclusions found in Chantaburi and Trat corundums can be divided into three types based on their formation as Protogenetic, Syngenetic, and Epigenetic. The solid I are bohemite [sic, böhmite?], feldspar, metamict zircon, pyrrhotite, apatite, dolomite, calcite, spinel, sphene, biotite flake, and needle-like rutile. The FI (e.g., partially healed fissures, gas bubble, and two-phase I), are fairly common in the Chantaburi and Trat corundums. (From authors' abstract by E.R.)

IPPACH, P. and SCHMINCKE, H.U., 1995, Petrologic estimation of SO_2 emission during the 1991 eruption of volcan Hudson (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 23.

The petrologic method of estimating the amount of S injected into the stratosphere during explosive eruptions has recently been questioned.

Hudson volcano (Chile) erupted in two main phases in August 1991: phase A, 8/8-10 and phase b, 8/12-15 (B-1, 8/12-13 and B-2, 8/14-15). About 1.5 km (DRE) were erupted in the basaltic phase A (51-52 wt % SiO_2) and 2.5-3.0 km in the paroxysmal high-K andesitic phase B (61-62 wt % SiO_2). Tephra of Phase A (lithoclasts <1 vol %) is characterized by (a) microlite-rich tachylite (20-60 vol % vesicles) and (b) sideromelane (30-80 vol % vesicles) in approximately equal amounts. The composition of matrix glass is mafic to intermediate (50.5-56 wt % SiO_2). Glass I in pl and ol phenocrysts (<2 vol %) range from 52 to 54 wt % SiO_2 and contain <0.18 wt % S. The S content of degassed pyroclasts of Phase A is <0.03 wt % S. Phase B consists of pyroclasts and lithoclasts (5-60 vol %). The andesitic to dacitic pumice (61-67% SiO_2) contains ≤80 vol % vesicles and (<20 vol %) brown mafic I. The SiO_2 content of glass I in phenocrysts (<5 vol %) ranges from 64-66% in pl, 56-64% in ol, and 62-64% in Feoxides. Whole-rock S contents of degassed pyroclasts increase from phase B-1 (0.04 wt % S) to phase B-2 (0.1 wt % S). Matrix glass shows the same compositional trend. MI in phenocrysts contain <0.15 (B-1) and <0.25 (B-2) wt % S. S for 1.95 Mt SO_2 (B-1), and 3.35 Mt SO_2 (B-2) was available.

During phase A ~0.8 Mt S were emitted to the atmosphere; no TOMS data are available. The pre-eruptive S content of phase B magma is estimated to have been 2.7 Mt judging from glass I. The total amount of S in the degassed pyroclasts indicates release of 1.8 Mt to the atmosphere, only 0.9 Mt S was measured by TOMS. Thus during the entire 7 day eruption ca 2.6 Mt S must have been released into the atmosphere. (From authors' abstract by E.R.)

IRIANTO, B. and CLARK, G.H., 1995, The Batu Hijai porphyry copper-gold deposit, Sumbawa Island, Indonesia: PACRIM '95, p. 299-304. First author at Newmont Nusa Tenggara, NTB, Indonesia.

The deposit is associated with a calc-alkaline intrusive complex that was emplaced in a thick sequence of andesitic pyroclastic rocks. Hydrothermal alteration is zoned from a core of pervasive potassic alteration grading to an outer propylitic halo. At depth a propylitic assemblage is developed in the low grade core in the Old Tonalite. Phyllic alteration, late stage and mainly fracture controlled, overprints both potassic and inner propylytic zones. Intermediate argillic alteration overprinting is widespread. (From authors' abstract by E.R.)

FI data, on quartz(?): Th 250-520°C; sal. 30-55 wt % NaCl eq., with dm halite, sylvite, hematite, magnetite and chalcopyrite. (S. Simmons)

IRWIN, J.J. and REYNOLDS, J.H., 1995, Multiple stages of fluid trapping in the Stripa granite indicated by laser microprobe analysis of Cl, Br, I, K, U, and nucleogenic plus radiogenic Ar, Kr, and Xe in fluid inclusions: Geochim. Cosmochim. Acta, v. 59, p. 355-369. Authors at Dept. Physics, Univ. California, Berkeley, CA 94720.

Ar, Kr, and Xe were extracted from FI in the Stripa granite by laser microprobe decrepitation of quartz and feldspar and measured in a low blank, high sensitivity, ion-counting mass spectrometer. Large variations in Br/Cl and I/Cl occur in FI within a single specimen of Stripa drill core. Two "endmember" FI compositions are represented: (1) I/Cl >0.0012 and Br/Cl ~0.006 (atom ratios), a distinctive halogen signature previously measured in brines associated with some oil-fields and fine-grained sediments and (2) I/Cl $<1 \times 10^{-4}$ and Br/Cl ~0.0015, which resembles many F and FI, including high-T "magmatic" FI in some granitic rocks. Most measurements of halogen ratios are intermediate between these two extremes, with uncorrelated variations in I/Cl and Br/Cl indicating at least one additional F.

Abundances of $^{40}Ar_e$ and fissiogenic Xe in FI are typically an order of magnitude greater than production from *in situ* decay of K and U, similar to estimates of average production per unit volume within Stripa in ~2 Ga. It is inferred that a significant fraction of these isotopes were generated within Stripa and then locally transported in a F during episodes of recrystallization/metamorphism. Concentrations of nucleogenic $^{80*}Kr$, $^{82*}Kr$, and $^{128*}Xe$ are several orders of magnitude greater than average production from Br and I within Stripa, evidence that these isotopes were produced in an I- and Br-rich source rock outside of Stripa. (From authors' abstract by E.R.)

IRWIN, J.J. and ROEDDER, E., 1995, Diverse origins of fluid in magmatic inclusions at Bingham (Utah, USA), Butte (Montana, USA), St. Austell (Cornwall, UK), Ascension Island (mid-Atlantic, UK), indicated by laser microprobe analysis of Cl, K, Br, I, Ba + Te, U, Ar, Kr and Xe: Geochim. Cosmochim. Acta, v. 59, p. 295-312.

Full paper for abstract in FIR, v. 27, p. 58, 1994. (E.R.)

ISHIBASHI, J., SANO, Y., WAKITA, H., GAMO, T., TSUTSUMI, M. and SAKAI, H., 1995, Helium and carbon geochemistry of hydrothermal fluids from the Mid-Okinawa Trough Back Arc Basin, southwest of Japan: Chem. Geol., v. 123, p. 1-15. First author at Faculty of Science, Univ. Tokyo, Hongo, Bunkyo-ku, Tokyo 113, Japan.

Chemical and isotopic compositions of the JADE [site] F are considered to indicate that both CO_2 and He are derived from a magmatic source beneath the hydrothermal system without significant contamination. The CLAM [site] F show G geochemistry much more affected by F-sediment interaction. Magmatic activity is the main contributor of G species to the hydrothermal F in both the JADE and CLAM sites, although F-sediment interaction modifies their composition. The relatively high abundance of CO_2 in the Mid-Okinawa Trough hydrothermal systems reflects the geochemical nature of island arc magma. (From authors' abstract by E.R.)

ISHIKAWA, N., ISHIYAMA, D., MIZUTA, T. and ISHIKAWA, Y., 1995, Geochemical study of gold mineralization process in the Nibetsu area, northern Akita City (abst.): J. Soc. Resource Geol., v. 45, no. 4, p. 270-271 (in Japanese).

Indexed under FI. (E.R.)

ISTRATE, G. and ALTHAUS, E., 1995, Fluid-absent and carbonic fluid granulite metamorphism in Grenville Province, Adirondack and Ontario (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 104-105. Authors at Mineralogisches Inst., Univ. Karlsruhe, FRG.

This study has been undertaken to document the occurrence of primary, high-density FI to determine the nature of F and to constrain the P and T for a variety of granulitic rocks from Ontario and Adirondack, Grenville Province.

Detailed examination of the FI in garnet, quartz, plagioclase, pyroxenes, cordierite, sillimanite and apatite confirmed the existence of primary, high-density I, CO_2-rich, pure or with only small amounts (<5 mol %) of other gases such as CH_4, H_2S and N_2; no immiscible aqueous solutions like a syngenetic F have been detected.

The selected garnet occurs as granoblasts in migmatitic metapelitic gneisses, felsic granulites and charnockites and contain different types of I, as follows:

(a) CO_2-rich, FI, high density;

(b) mineral I: Qtz, Bi, Sill, Cc, Kfs, Plg, Spinel, Ap, Ru, Ilm, Mon, Py, commonly concentrated in the core along with a few, rare FI, difficult to distinguish optically;

(c) silicate-MI, glassy or partially recrystallized, with dxls + G.

The high-densities of the FI, typically 1.0 to 1.06 g/cm^3, exceptionally 1.07 to 1.16 g/cm^3, as well as the textural evidences suggest that CO_2-F was trapped at or close to peak-metamorphism (750-800°C and 6.5 to 8.0 kb). The isochores intersect the peak P-T region derived from mineral thermobarometry.

The subsequent evolution of the rocks, documented by up to five FI generations containing high- to low-density CO_2, (and a very rare, late, pure H_2O-F), started with a nearly isothermal decompression, followed by a regionally isobaric cooling which is more obvious in Adirondack. The observation that some rock types contain variable amounts of carbonic F, others are practicably F absent at the peak of metamorphism, support the idea that F-absent and F-present processes may operate in close proximity and are controlled lithologically and by magmatic intrusion and partial melting processes. (From authors' abstract by E.R.)

IVANOVA, G.F., KOLESOV, G.M. and CHERKASOVA, E.V., 1995, REE in granites, topazes, and fluorites of tungsten-ore Mongolian regions: Geokhimiya, no. 8, p. 1157-1177 (in Russian, English abstract).

REE distribution in granites of different types as well as in fluorine minerals of accompanied W deposits of W-ore Mongolian regions has been considered. Evolution of REE distribution in the series M - solution is traced on the basis of REE distribution in the series granites - magmatic topazes and fluorites in granites - hydrothermal topazes and fluorites of ore hydrothermal assemblages. (Authors' abstract)

IWATA, S.A., da SILVEIRA BELLO, R.M. and de MADUREIRA F., J.B., 1995, Estudos microtermométricos em inclusões fluidas do pegmatito da Pedreira Remina (Socorro - SP): Rev. Esc. de Minas, Ouro Preto, v. 49, no. 2, p. 136-141 (in Portuguese, English abstract). First author at Inst. Geociências USP, Rua do Lago, 562 - Cidade Univ., São Paulo, SP, Caixa Postal 20.899 CEP.

FI studies were developed aiming the determination of the crystallization conditions for some pegmatitic occurrences from the Zona Pegmatítica de Socorro (NE region of São Paulo State and southern region of Minas Gerais State).

In spite of the primary aspect of the analysed I, only scattered data were obtained, this fact being attributable to changes in the original characteristics of the trapped F by effect of deformation.

Solid I, possibly MI, suggest high Tt, >575°C.

Very low Tt were yielded from aqueous and CO_2-bearing FI disposed in linear arrays (150-160°C), which were probably formed during late hydrothermal processes. (Authors' abstract)

IYER, S.S., BARBOSA, J.S.F., CHOUDHURI, A. and KROUSE, H.R., 1995, Possible sources of CO_2 in granulites: Carbon isotope evidence from the Jequié complex, Brazil: Petrologiya, v. 3, no. 3, p. 255-266 (in Russian, translated in Petrology, v. 3, no. 3, p. 226-237). First author at Dept. Physics and Astronomy, Univ. Calgary, Calgary, AB 72N 1N4, Canada.

The C isotope composition of FI CO_2 in different lithological types of granulite rocks from the Archean granulite terrain of Jequié are measured. The data show distinctly different ranges of $\delta^{13}C$ values for the plutonic (-7 to -14‰) and the supracrustal granulites (-26 to -10‰). The isotope data may be interpreted in terms of the granulite genesis model involving the movement of magmas through the lower crust. The magmas provided the heat for metamorphism and brought volatiles, which are preserved in the plutonic granulites. In the supracrustal granulites, there appears to be two distinct groups of CO_2. One group ($\delta^{13}C < -20‰$) has CO_2 that was probably derived from the oxidation of Archean metasedimentary organic matter. The FI in the other group (-14 to -10‰) may represent F modified by the process of anatexis. (Authors' abstract)

JAMBON, Albert, DÉRUELLE, Bernard, DREIBUS, Gerlind and PINEAU, Françoise, 1995, Chlorine and bromine abundance in MORB: The contrasting behaviour of the Mid-Atlantic Ridge and East Pacific Rise and implications for chlorine geodynamic cycle: Chem. Geol., v. 126, p. 101-117.

JAMES, R.H., ELDERFIELD, H. and PALMER, M.R., 1995, The chemistry of hydrothermal fluids from the Broken Spur site, 29°N Mid-Atlantic Ridge: Geochim. Cosmochim. Acta, v. 59, p. 651-659.

JANNAS, R.R.R., 1995, Reduced and oxidized high sulfidation deposits of the El Indio District, Chile: Unpub. PhD thesis, Harvard Univ., Cambridge, Massachusetts, 421 p.

Indexed under FI. (E.R.)

JARMOLOWICZ-SZULC, K., 1995a, Fluid inclusions in diagenesis of the Cambrian rocks in Poland (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1. Note: Two-page, late(?) abstract, unpaginated and not bound in Abstracts volume, but in same format. Author at State Geol. Inst., Warsaw, Poland.

Quartz overgrowths and fracture filling cement are common components of the Cambrian sandstones drilled at the coast of the Baltic Sea/N Poland. To place diagenesis in the context of petroleum migration it is important to understand the formation of the siliceous cements relative to the thermal and F migration. The objective of the study is to determine the T and diagenetic environment of quartz cementation.

The Zarnowiec IG-1 borehole is situated in the northern part of the Leba Elevation/the Peribaltic Syneclize, a part of the Precambrian East-European Platform. The Cambrian sediments occur there within the Old-Paleozoic structural complex in the depth interval of ~2722-3237 m being underlain by the Precambrian rocks. Bitumens appear in sandstones in two positive horizons separated by mud- and claystones. Bottom hole T are ~75°C and 82°C at the depth of 2795 m and 3100 m, respectively.

Sampling was done in the lower reservoir horizon and beneath, i.e., within the second and third levels of the increased effective porosity.

As it results from the cathodoluminescence and fluorescence studies diagenetically important [but small -1-3 μm] two-phase FI are trapped along the detrital grain-overgrowth boundary, often within a "dust rim," They are interpreted to be the earliest assemblage of PI (Q1) and have Th = ~105°C. Neogenic quartz rims are best seen and more common in the part of the borehole below the reservoir horizon. Sometimes it is possible to observe even the second assemblage of very small (<1 μm) FI between two stages of the cement there (Q2). These are too small for Th measure.

Another I generation may be observed in fractures that are filled by quartz cement (Q3). Th L oil 87-90°C; Th L H_2O 107°C. Tm ice, though difficult, was -10 to -14°C. Th values seem to be consistent within individual assemblages. They exceed the bottom hole T. They indicate that quartz was precipitated at rather stable T of minimum ~100°C. The salinity of the F was ~8 wt % NaCl. Oil appeared in the basin prior to the fracture cementation and reveals minimum T of ~90°C, which is comparative to the vitrinite reflectance in the borehole discussed. (From authors' abstract by E.R.)

JARMOLOWICZ-SZULC, K., 1995b, Fluid inclusions in the sedimentary rocks from the Polish Lowlands, western Poland (abst.): Mitt. Österr. Miner. Ges., v. 140, p. 408-409 (in English). Author at Polish Geological Inst., ul. Rakowiecka 4, 00-975 Warsaw, Poland.

Cements of the Permian sedimentary rocks (Rotliegendes) from the boreholes in the gas field Paproc have been recently studied by means of the FI method. The purpose was to reconstruct the thermal diagenetic conditions and to trace hydrocarbon migration in the cements, which consist of calcite, anhydrite or quartz.

Water I are very small (≤5 μm) and are mostly of medium salinity and average Th, ≈ the present borehole values. Quartz overgrowth Th are higher. Raman and vitrinite reflectance studies are still in progress. (From author's abstract by E.R.)

JAVAUX, C., SWENNEN, R. and HASSAN, T.H., 1995, Reservoir characterisation of the (M/T) Thamama structure (offshore Abu Dhabi) based on petrography and geochemical analysis (abst.): AAPG Bull., v. 79, no. 8, p. 1223.

Indexed under FI. (E.R.)

JI, Junfeng, LIU, Yingjun, SUN, Chengyuan, QIU, Detong and ZHENG, Qing, 1995, Geochemical characteristics of two types of ores from Jinshan shear zone-hosted gold deposit, Jiangxi, with a discussion on the mechanism of two-stage mineralization: Chinese J. Geochem., v. 14, no. 4, p. 353-360 (in English). Authors at Dept. Earth Sciences, Nanjing Univ., Nanjing 210093, PRC.

Two types of Au ores, siliceous mylonite and quartz vein, formed at the first and second stages of mineralization, respectively, can be clearly recognized in the shear zone-hosted Au deposit at Jinshan, Jiangxi. Similarity in REE and trace elements between the siliceous mylonite and the country rocks indicates that the ore metals were supplied by the surrounding strata during the first stage of mineralization. On the other hand, as indicated by FI data, the ore-forming F at the second stage was of meteoric origin and the precipitation of Au was caused by phase separation. (Authors' abstract)

Includes two analyses (method unstated), for FI in Au-bearing and barren quartz, for K, Na, Ca, Mg, F, Cl, HCO_3, and ΣS (all in mol/L), and for CH_4, CO_2 and H_2O (mol/100 g). The FI in the Au-bearing veins differ from those in the barren veins in that they have lower Th (140-230°C vs. 240-280°C) and are much higher in Ca and Mg, and in S and HCO_3 than the barren. See also abstract in FIR, v. 27, p. 59. (E.R.)

JIANG, Yaohui, CHEN, Henian and CHEN, Sanyuan, 1995, Study on ore-forming geochemistry of gold-tin-polymetal deposits in

Chong' An-Ninhua area, Fujian: Volcanology and Mineral Resources, Bull. Nanjing Inst. Geology and Mineral Resources, Chinese Acad. Geological Sciences, v. 16, no. 3, p. 44-54. Authors at IGMR, Nanjing 210016, PRC.

A systematic study has been made of the ore-forming geochemical characteristics of the metallogenic elements, REE, and Pb, S, H and O isotopes, and also FI. The sources of the ore-forming materials and solutions are also discussed here. The results indicate that the deposits in different genetic types show a great difference on their ore-forming material and solution sources. [Th and FI chemistry are given. H.E.B.] (Authors' abstract)

JOCHUM, J., FRIEDRICH, G., LEYTHAEUSER, D., LITTKE, R. and ROPERTZ, B., 1995, Hydrocarbon-bearing fluid inclusions in calcite-filled horizontal fractures from mature Posidonia Shale (Hils Syncline, NW Germany): Ore Geol. Rev., v. 9, p. 363-370. First author at Inst. Mineralogy and Economic Geology, Aachen Univ. Technology (RWTH), Wüllnerstrasse 2, D-52056 Aachen, Germany.

Hydrocarbon-bearing FI in calcite-filled horizontal fractures from mature Posidonia Shale (0.88% R_o) were investigated by microscopic, microthermometric and chemical methods. The FI predominantly contain both a L hydrocarbon phase, which shows bright UV-fluorescence colours (yellow, brownish light blue), and a non-fluorescent hydrocarbon G phase. The different UV-fluorescence colours probably reflect the different gross chemical compositions of the trapped L hydrocarbons. The saturated hydrocarbon fraction of the FI (most SI) predominantly consists of low-molecular-weight n-alkanes (C_9-C_{12}), while C_{12}-C_{22}-n-alkanes are more abundant in the adjacent rock matrix. The molecular composition of the FI appears to reflect a mobile hydrocarbon phase, which was entrapped within the calcitic fill of the horizontal fractures. P-corrected Tt were estimated for P FI (123°-162°C). This T range is in agreement with the results from numerical simulation studies, which indicate a maximum T of 148°C coinciding with the period of fracture formation, calcite filling, and entrapment of P FI. (Authors' abstract)

JOHNSON, E.L. and HOLLISTER, L.S., 1995, Syndeformational fluid trapping in quartz: Determining the pressure-temperature conditions of deformation from fluid inclusions and the formation of pure CO_2 fluid inclusions during grain-boundary migration: J. Meta. Geol., v. 13, p. 239-249. First author at Geology Dept., Central Michigan Univ., Mt. Pleasant, MI 48859.

Observations and microthermometric data on FI from a terrane that underwent deformation following peak metamorphic conditions show that grain-boundary migration recrystallization favours the entrapment of carbonic I whereas microfracturing during brittle deformation favours the infiltration and eventual entrapment of aqueous F. Our results imply that pure CO_2 FI in metamorphic rocks are likely to be the residue of deformation-recrystallization process rather than representing a primary metamorphic F.

Where the T of deformation can be deduced by other means, the densities of FI trapped during recrystallization, which we call recrystallization-P FI, can be used to constrain the ambient pressure during deformation. Using these constraints, the data imply that the post-metamorphic Hercynian exhumation in Sardinia brought rocks at 300°C to within 3 km of the surface. This conclusion is similar to that described for the rapidly uplifted Southern Alps of New Zealand. (Authors' abstract)

JOHNSON, E.L. and MANCKTELOW, N.S., 1995, The relationship between fluid composition, fluid inclusion entrapment and deformation microstructure in the Simplon Fault Zone, central Alps (Italy/Switzerland) (abst.): J. Czech Geol. Soc., v. 40, no. 3, p. A-19. First author at Dept. Geology, Central Michigan Univ., Mt. Pleasant MI 48859.

FI from a suite of deformed quartz vein samples from the Simplon Fault Zone were studied in an effort to determine the effect of deformation on FI formation and preservation and to determine if F type exerts any control on deformation mechanisms active in the host quartz. The samples were taken along the strike of the detachment and represent differing structural levels for initial deformation. FI from all of the samples studied show a close relationship between FI location and deformation microstructures in the host quartz. Many of the FI observed decorate subgrain and grain boundaries, transgranular microfractures, and grain interiors. Carbonic-rich FI are common in all samples and typically decorate grain boundaries or grain triple junction positions. F type changes along the detachment from a miscible H_2O-CO_2-NaCl F (XCO_2 = 0.3-0.5: relative salinity = 5-10 wt %) in samples deformed at the highest T through bimodal distributions of aqueous-rich (XCO_2 = 0.05-0.2: relative sal. = 8-12%)) and carbonic-rich (XCO_2 = 0.7-1.0) I in samples deformed at lower initial T. This change in F type observed represents the unmixing of a H_2O-CO_2-NaCl F with declining T during host deformation. The dominant intracrystalline deformation mechanisms, as far as these are reflected in the developed crystallographic preferred orientation, do not appear to be markedly affected by variations in the amount and composition of the FI. The grain shape microstructure, largely reflecting the dominant recrystallization mechanism, may, however, be influenced by F composition. In the southern, more deeply exhumed region of the footwall, the deformation microstructure was largely developed in the presence of a single H_2O-rich F (XCO_2 = 0.3 relative sal. = 5-10 wt %), which promotes solution/deposition of quartz, grain boundary diffusion and grain boundary mobility. As the depth of exhumation decreases to the north in the footwall, there is a transition from mixed to unmixed F, the location of the transition is smeared by the presence of a small but variable component of dissolved NaCl. The presence of isolated CO_2-rich FI on grain boundaries should retard their mobility, such that unmixing promotes subgrain rotation recrystallization relative to grain boundary migration. The correspondence between the observed unmixing of F and the transition in dominant recrystallization mechanism is therefore probably not simply fortuitous but reflects linked processes. (Authors' abstract)

JOHNSON, J.A., NIELSEN, R.L. and FISK, M.R., 1995, Plagioclase-hosted melt inclusions in the Steens Basalt, southeastern Oregon (abst.): Eos, v. 76, no. 17, p. S269. Authors at College of Oceanic and Atmospheric Sciences, Oregon State Univ., Corvallis, OR 97331.

The Steens Basalts are an extensive suite of continental flood basalts erupted -16 my bp in SE Oregon. Their chemistry is similar in many ways to enriched MORB. In contrast to plagioclase-hosted MI found in many MORB lavas, MI in the Steens Basalt are both more evolved than the host, and are homogeneous for major and minor elements. In addition, the MI can be related to the host by small amounts (<10%) of olivine and plagioclase crystallization at low P, together with minor crystal accumulation. Homogeneity of minor element compositions of the basalt I demonstrates that the diversity observed in the I from MORB basalts cannot be simply attributed to post-entrapment reaction with the plagioclase, but is an inherent characteristic of the magmas from which the host crystallized. Our results suggest that the plagioclase phenocrysts grew in a fairly shallow (1-3 kb), well-mixed, evolved magma that could have originated by ≈50% fractionation of plagioclase and olivine from a mantle-derived primary basalt. Although absence of primitive phenocrysts and MI in the Steens Basalt means that we do not have the information necessary to construct a physical model of the lower crust, the homogeneity of the MI and of the erupted lavas suggests the presence of a mid-upper crustal magma chamber.

This project indicates that we can experimentally recreate the composition of plagioclase-hosted trapped M in a weathered and altered continental basalt. The results are potentially useful for determining the original composition of the L as well as for extrapolating the bulk composition of mobile elements, such as Na and K. Identification of I that have been affected by alteration can be accomplished by the use of phase equilibria modeling. (Authors' abstract)

JOHNSON, J.P. and McCULLOCH, M.T., 1995, Sources of mineralising fluids for the Olympic Dam deposit (South Australia): Sm-Nd isotopic constraints: Chem. Geol., v. 121, p. 177-199.

JOHNSON, K.T.M., FISK, M.R. and NASLUND, H.R., 1995a, Geochemical characteristics of refractory silicate melt inclusions from Leg 140 diabases, *in* J. Erzinger, K. Becker, H.J. Dick and L.B. Stokking, eds., Proc. Ocean Drilling Program, Scientific Results, v. 137/140, p. 131-139. First author at Dept. Natural Sciences, Bishop Museum, Honolulu, HI 96817.

Geochemical data from plagioclase-hosted silicate MI from Leg 140, Hole 504B diabase dikes are reported. Hand-picked plagioclase grains were heated to 1260°- 1280°C to remelt the glass I and to infer Tt. The samples were then polished to expose the I, which were analyzed by electron and ion microprobes. Inclusion compositions are mainly in equilibrium with the host plagioclase and are more depleted in incompatible elements than the host rock. Simple crystal-L equilibrium calculations show that the MI could have been in equilibrium with depleted abyssal peridotite diopsides, whereas whole-rock basalt compositions generally could not have been. The MI are significantly more depleted than normal (N-type) mid-ocean-ridge basalt (MORB) and are consistent with being produced by 8%-16% incremental or open-system melting with 2% residual porosity in the peridotite source. These magmas were formed during P-release melting of the mantle over a range of depths between 30 and 15 km. (Authors' abstract)

JOHNSON, K.T.M., FISK, M.R. and NASLUND, H.R., 1995b, Silicate melt inclusions from ODP Leg 140 diabases: Petrogenetic implications (abst.): Eos, v. 76, no. 17, p. S267. First author at Dept. Natural Sciences, Bishop Museum, Honolulu, HI 96817.

Geochemical data from plagioclase-hosted silicate MI from Leg 140, Hole 504B diabase dikes are reported. Hand-picked plagioclase grains were heated to 1260°-1280°C to remelt the glass I and to infer Tt. The samples were then polished to expose the I, and the I were analyzed by electron and ion microprobes. Inclusion compositions are mainly in equilibrium with the host plagioclase and are more depleted in incompatible elements than the host rock. Simple crystal-L equilibrium calculations show that the MI could have been in equilibrium with depleted abyssal peridotite diopsides, whereas whole-rock basalt compositions generally could not have been. The MI are significantly more depleted than N-type MORB and are consistent with being produced by 8%-16% incremental or open-system melting with 2% residual porosity in the peridotite source. These magmas were formed during P-release melting of the mantle over a range of depths between 30 and 15 km. (Authors' abstract)

JOHNSON, K.T.M., NIELSEN, R.E. and VICKERS, E., 1995, The diversity of olivine-hosted melt inclusions in individual Hawaiian lavas (abst.): Eos, v. 76, no. 17, p. S269. First author at Dept. Natural Sciences, Bishop Museum, Honolulu, HI 96817.

One of the more controversial issues related to the Kilauea and Mauna Loa magma systems is the degree to which they may be connected, This issue has traditionally been addressed by bulk analysis of lavas sampled from each edifice. Lavas exposed on the surface, however, represent only a very small percentage of the magmas erupted from either center and have seen extensive fractionation and mixing, processes that can mask the differences between the magma types.

We present the early results of a study to: 1) develop a technique for recovering the composition of liquids trapped in primitive olivines, and 2) to understand the chemical variability of primitive melts of Kilauea over time. Primary melt inclusions represent liquids trapped during growth of their host crystals. For rocks that represent liquids, the range of melt inclusion compositions should be narrow and should be related to one another by fractionation of the phases in equilibrium with the host liquid. However, for cumulates, the origin and relationship of the melt inclusions to the host and to one another is less clear. We argue that the most primitive phenocrysts may represent crystals formed in the conduit system of the volcanic center, and may be the products of crystallization of many different magmas over a significant time period.

For the first part of the study, we worked on lavas containing cumulate olivine from Kilauea and Mauna Loa. The inclusions were re-homogenized using a 1 atm furnace. Entrapment temperatures were constrained by the T-MgO experimental relationships of Helz and Johnston. Our results indicate the inclusions from the Mauna Loa sample all fall within the range of Mauna Loa lavas, whereas a few of the inclusions from the Kilauea lava fall within the range of Mauna Loa lavas. In each case inclusion compositions were diverse, but in the range expected for that volcanic center, confirming our hypothesis that they are products of a variety of liquids.

For the second part of the study, we analyzed eight melt inclusions from four samples in a ~2000 m drill core from Kilauea's lower East Rift Zone. The sample depth range was 270-1764 m in the core. In general, inclusion compositions are similar to lava compositions, but in detail REE and trace element ratios in inclusions from the lower core are similar to Mauna Loa, those from the upper core resemble Kilauea, and those from intermediate depths are in between. (Authors' abstract)

JOHNSON, S.E. and VERNON, R.H., Inferring the timing of porphyroblast growth in the absence of continuity between inclusion trails and matrix foliations: Can it be reliably done?: J. Struct. Geol., v. 17, p. 1203-1206. Authors at School of Earth Sciences, Macquarie Univ., Sydney, NSW 2109, Australia.

The timing of porphyroblast inclusion trails can be confidently interpreted relative to surrounding external foliations only where there is continuity between the two. Where this continuity is broken, timing is ambiguous. Where single or multiple growths of two or more different porphyroblastic minerals have occurred during a relatively complex deformation history, the risk of misinterpreting the relative timing of porphyroblast growth is high, and can lead to wrong inferences about P-T-time-deformation (P-T-t-d) paths. Misinterpreting porphyroblast timing can also have considerable consequences for determining rates of fabric evolution relative to changes in metamorphic conditions. The effects of porphyroblast rotation vs. nonrotation (relative to an externally fixed reference frame) on inferred P-T-t-d paths are poorly understood. However, the 'd' part of the path can differ considerably, depending on whether or not porphyroblasts are inferred to have rotated. The effect on the P-T-t part of the path depends on what effect inferences about porphyroblast rotation have on the inferred sequence of porphyroblast growth. (Authors' abstract)

JONES, B.F. and ANDERHOLM, S.K., 1995, Geochemical evaluation of brine compositions from the Salado Formation and underlying strata, SE New Mexico (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 291.

Indexed under FI. (E.R.)

JONES, J.H., WALKER, David, PICKETT, D.A., MURRELL, M.T. and BEATTIE, Paul, 1995, Experimental investigations of the partitioning of Nb, Mo, Ba, Ce, Pb, Ra, Th, Pa, and U between immiscible carbonate and silicate liquids: Geochim. Cosmochim. Acta, v. 59, p. 1307-1320.

JRAD, Lazar, GILHAUMOU, Nicole, PERTHUISOT, Vincent and TOURAY, J.-C., 1994, Reconstitution by fluid inclusion analyses of the fluids resulting in Pb-Zn-Ba mineralization in carbonates: An example from the J. Ajred and Hamra deposits in central Tunisia (abst.): 15th Reunion Sci. de la Terre, p. 74 (in French). First author at ESEM, Univ. d'Orleans, Rue Leonard de Vinci, 45072 Orleans, Cedex 02, France.

The J. Ajred and Hamra deposits formed in an anticlinal NE-SW axis at the heart of aptian reefal carbonates, recut by a large E-W fault (the Kasserine fault). At their intersection, a Trias evaporite diapir has flowed. The core of the fold contains traces of erosion resulting from the simultaneous exposure of the Kasserine Fault and the diapir since the Cretaceous [?].

The quartz FI formed in the Trias are classically hypersaline, with homogenization by dissolution of the halite between 275°C and 295°C, at an approximate P of 1.5 kb. In the Aptian, the quartz associated with the mineralisation yields less saline I, in the Na-Ca-Cl system, compatible with P-T conditions of 0.5 kb and ~150°C.

The hypothesis of synchronous trapping of these two types of I permits reconstruction of a geometry "late pre-extrusion" with an Aptian calcareous sediment [chalk or limestone] anticline at the core of Trias salts [?] associated with the Kasserine Fault. This control was responsible for an important local thermal anomaly. The presence of hydrocarbons (C6-C9) with CO_2 (infrared analyses) in the quartz originating from the Aptian of the same sections shows a connection with neighboring source rocks, probably more recent (from the Alian or Upper Cretaceous). All these observations are compatible with an origin of the mineralizing brines in the basin. (Authors' abstract; translation courtesy of Dr. A.P. Gize)

JRAD, Lazhar and PERTHUISOT, V., 1995, Diapirism, orogeny and Pb-Zn mineralization in North Africa: Examples of the J. Ajred and J. Hamra deposits in central Tunisia: Comptes Rendus de l'Academie des Sciences, Serie II. Sciences de la Terre des Planetes, v. 320, no. 8, p. 721-728 (in French).

Indexed under FI. (E.R.)

JURKOVIC, I., PALINKAS, L., SLOVENEC, D., SIFTAR, D. and PZEDIC, J., 1995, Paragenesis geochemistry and crystallochemistry of the barite deposits in the Mid-Bosnian Schist Mountains (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 331.

FI study (fluorite, quartz, barite): Th from +190°C to +310°C; Tfm from -50°C to -32°C (NaCl-$CaCl_2$ ± $MgCl_2$ F system); Tm from -22°C to +4°C; salinity from 24.2 to 26.3 wt % NaCl eq. (From authors' abstract by E.R.)

KAINDL, R. and HOINKES, G., 1995a, Fluid inclusions in the high-grade metamorphic western Oetztal-Stubai-Complex (abst.): Mitt. Österr. Miner. Ges., v. 140, p. 406 (in German).

The Oetztal-Stubai-Complex is a polymetamorphic nappe complex above the Tauern- and Engadiner window and has seen at least three metamorphic events: a Caledonian high-T event associated with migmatization, a Variscan eclogite- to amphibolite-facies, and an Alpine prehnite-pumpellyite metamorphism characterized by steep P-T gradients. FI are hosted by various minerals in any lithology. They occur in garnet and quartz of metasediments; in apatite, clinopyroxene and quartz of metabasites; in garnet and quartz of aplitic gangues.

Four populations are distinguished based on microthermometry and Raman spectroscopy: one type belongs to the CO_2 system, three others are composed of H_2O-NaCl ± $CaCl_2$ ± $MgCl_2$ ± $FeCl_2$ ± LiCl. They are attributed to different metamorphic events: hydrous I (partly coated on the inner walls with graphite) and CO_2 I are correlated with the peak Variscan metamorphism; hydrous I with low degrees of fill were trapped during Variscan uplift; high-density hydrous I with steep isochores are correlated with the P-dominated Alpine metamorphism. Using the graphite crystallinity determined by Raman spectroscopy, the Tt of the graphite-coated I was determined to be 520-600°C, yielding a trapping P of 5-6 kb. We interpret FI as a good indicator for the early metamorphic history of polymetamorphic rocks given that (I) the I are hosted by garnet, (ii) they have a low degree of fill or belong to the CO_2 system, and (iii) the last metamorphic event was low-T/high-P dominated. (From the authors' abstract, translation courtesy Dr. Bernhard Buehn)

KAINDL, R. and HOINKES, G., 1995b, The preservation of fluid inclusions associated to different metamorphic events in the Eastern Alps (Austroalpine Oetztal basement) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 312.

The Austroalpine Oetztal basement consists of a suite of different lithologies and was affected by at least three metamorphic events. A Caledonian high T event leading to anatexis of paragneisses was followed by a Variscan metamorphic evolution along a P-T loop from eclogite to amphibolite facies conditions. The last early alpine greenschist facial overprint is characterized by a steep P-T gradient. In every lithology a number of host minerals contain FI which exhibit information about nature and composition of the F related to different metamorphic episodes.

FI are hosted in garnet and quartz from metapelites, in apatite, clinopyroxene and quartz from metabasites and in garnet and quartz from aplitic dikes crosscutting orthogneisses. Four types of FI populations are distinguished using microthermometry and Raman spectroscopy: (1) primary H_2O-NaCl- ± $CaCl_2$ ± LiCl I in garnet and quartz with Th > 160°C; (2) primary CO_2 I in quartz; (3) primary, G-rich H_2O-NaCl ± $CaCl_2$ I with a low degree of fill in garnet and quartz; (4) secondary H_2O-NaCl ± $CaCl_2$ ± LiCl ± $MgCl_2$ ± $FeCl_2$ in quartz and apatite (not in garnet) with Th <160°C.

Type I and 2 I were trapped at shortly after the peak of the Variscan metamorphic event which reached 600°-650°C and 6-8 kb. Type 3 I belong to the Variscan cooling path and were most probably trapped at T <500°C. Type 4 I deliver isochores of significantly steeper slopes and are therefore consistent with entrapment of F during the alpine metamorphic overprint at maximum P-T conditions of 300°-400°C and 5-6 kb.

From these results it is concluded that FI may be important indicators of earlier stages of metamorphism in poly-metamorphic terranes. Early I are particularly well preserved if they are rich in CO_2- and H_2O-gas, hosted in garnet and if the last metamorphic overprint is rather low grade and P dominated. (Authors' abstract.)

KALINICHEV, A.G. and HEINZINGER, K., 1995, Molecular dynamics of supercritical water: A computer simulation of vibrational spectra with the flexible BJH potential: Geochim. Cosmochim. Acta, v. 59, p. 641-650.

KALITA, M.A. and FAYNGERSH, L.A., 1994, Water solubility of H_2S in equilibrium multicomponent gas mixtures at high P and T: Geokhimiya, no. 11, p. 1651-1659 (in Russian; translated in Geochem. Int'l, v. 32, no. 7, p. 77-85, 1995).

Abstract in FIR, v. 27, p. 61.

KAMASHIMA, Tsutomu, 1991, Analysis of gases in fluid inclusions by thermal decrepitation-mass spectrometry: An application to pegmatitic quartz: unpub. Masters thesis, Shinshu Univ., 140 p.

A computerized mass spectrometric technique, which has been newly developed for G analysis in FI, is described and applied to natural FI in pegmatitic quartz.

The F from the FI were extracted by thermal decrepitation in vacuum. The methods are much superior to the crushing process in the following respect: (1) since the extraction is done under a high vacuum condition (<10^{-7} Torr), the effects of residual atmosphere in negligible. (2) F once released by decrepitation are not adsorbed on the sample surfaces [sic]. (3) The amount of sample needed for the experiment is small (<50 mg).

The sample is crushed to #20-30 mesh and washed carefully. The 50 mg sample is introduced into a furnace made of Pyrex glass tube and is heated to 130°C in a high vacuum for 6 hr to eliminate adsorbed volatiles, then heated to 650°C at a constant increasing rate of 17°C/min. The gases liberated by the thermal decrepitation is introduced instantaneously into a quadrupole mass spectrometer. The measured m/e members are 2, 15, 18, 28, 32, 34, 36, 40, 44 and 64. The area bounded by a G release curve and the background level for each m/e number is obtained by an integration. The G compositions of FI can be calculated from that value.

The accuracy of the measurement is ±0.8%, ±14.4%, ±7.8%, ±29.3%, ±24.0%, ±15.8% for H_2, CO_2, CH_4, N_2, Ar and H_2S, respectively. The pegmatite samples are from Tanohata, Goyosan, Ishikawa, Myoken-zan, Yamanoo, Shirakawa and Naegi districts.

FI from Tanohata, Yamanoo, Shirakawa and Naegi are simple two-phase and lack dms except for Shirakawa. Those from Gooyosan, Ishikawa and Myoken-zan are mostly P or S CO_2-bearing.

The thermal decrepitation of the FI occurs between 150°C and 600°C, with a prominent G release at the α-ß of quartz (573°C). The G species in order of abundance are as follows: $H_2O >> CO_2 > N_2 = CH_4 >> Ar >> H_2S$. The CO_2 contents range from 2 to 24 mol %; the other type shows H_2O contents >99 mol %. The $\delta^{13}C$ values of CO_2 in the FI from Ishikawa and Goyosan range from -9.0 to -4.8‰, suggesting magmatic origin of CO_2, and CO_2 and H_2S are positively correlated, as well as N_2 and Ar. The Ar content is two to six times that of atmosphere.

Tanohata and Naegi show similar analyses even though one belongs to the ilmenite series and the other to the magnetite series. G release curves for quartz from both pegmatite and host granite were similar; this may indicate that the pegmatite inherited the F from the host granitic magma. (From author's abstract by E.R.)

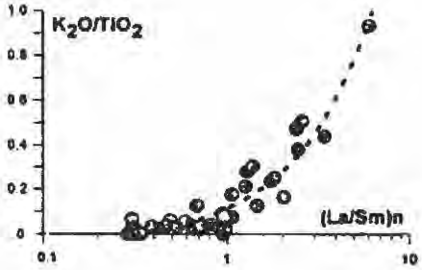
KAMENETSKY, V.S., 1995, New method for determining primitive melts: Example of melt inclusions in spinel from tholeiites of the FAMOUS area, Mid-Atlantic Ridge: Petrologiya, v. 3, no. 5, p. 522-526 (in Russian, translated in Petrology, v. 3, no. 5, p. 473-477). Author at Vernadsky Inst. Geochemistry and Analytical Chemistry, Russian Acad. Sci., ul. Losygina 19, 117975 Russia.

A new petrological method for determining primitive M involves the examination of MI in spinel using microthermometric experiments and microprobe analysis. Studies of quench glasses, phenocrysts, and MI in spinel of tholeiites from the FAMOUS area, Mid-Atlantic Ridge, enable the compositions of the primitive liquidus association and the crystallization T of the M to be determined. It is concluded that M compositions can be determined using the chemistries of the equilibrium olivine and spinel. It is demonstrated that the primary M of the rocks are not picritic, and they show variable contents of the most incompatible elements. (Author's abstract)

KAMENETSKY, V.S. and SOBOLEV, A.V., 1995, Geochemical variability of FAMOUS parental melts: A snapshot from spinel-hosted melt inclusions (abst.): Eos, v. 76, no. 17, p. S270. Authors at Vernadsky Inst. Geochemistry, Kosigin St. 19, Moscow 117975, Russia.

It has been shown that the geochemical composition of MOR rocks and glasses is controlled by the mixing of various M produced by the continuous (critical) melting of mantle beneath ocean ridges (Sobolev and Shimizu, Mineral. Mag., 58A, 1994). Two main end-members are capable of building the line of mixing: One is so-called ultra-depleted M (Sobolev and Shimizu, Nature, 363, 1993), which were found to be ubiquitous in many samples, the other—ultra-enriched M—is not well established, although enriched melts were reported from MAR (Shimizu, Mineral. Mag., 58A, 1994) and Iceland (Gurenko and Chaussidon, Geochim. Cosmochim. Acta, in press).

MI trapped in spinel from picrites from the FAMOUS area, MAR were homogenized at 1240-1320°C and analyzed by electron and ion probes. Host spinel (Mg# 72-76) coexists with high-Mg olivine (Fo90-90.5). All studied MI have very primitive major element composition (CaO/Al_2O_3 0.8-0.9, MgO 9-12.5 wt %, Mg# 69-76). The notable diversity in K_2O (0-0.5 wt %) and P_2O_5 (0-0.2 wt %) has no reflection in other major elements. The most incompatible elements in MI vary significantly (e.g., (in ppm) La 0.45-10.5; Ba 2-200; Sr 30-240; Zr 16-52; Hf 0.5-1.7; (La/Yb)n 0.2-6.5) and form a continuous trend, whereas abundances of elements more compatible than Gd are typical of those of MORBs. The extent of enrichment in highly incompatible elements is much higher than previously reported for the M from the same area ((La/Sm)n 0.3-1.8), Shimizu and Hassler, Eos, 74, 1993). The contrasting compositions are recorded even within a single spinel grain. Such a coexistence of depleted and enriched M provide an extended base to further constrain the composition and genesis of MOR parental melts. (Authors' abstract)



KANEOKA, Ichiro, 1994, The effect of water on noble gas signatures of volcanic materials, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 205-215. Author at Earthquake Research Inst., Univ. Tokyo, Bunkyo-ku, Tokyo 113, Japan.

Noble G signatures of volcanic materials are often affected by secondary components during the ascent of a magma to the surface from a magma source. Among them, the effect of water is significant and should be evaluated properly in order to infer the original signatures of magmatic components.

Similar effects are also observed in phenocrysts of OIB and MORB, where variable $^{40}Ar/^{36}Ar$ ratios with relatively uniform $^{3}He/^{4}He$ ratios are observed due to possible incorporation of the atmospheric noble G through the water. Thus, noble G signatures of volcanic materials are controlled by the environmental conditions of the volcanic conduit and the sites to be extruded. (From author's abstract by E.R.)

KELLEY, D.S. and FRUEH-GREEN, G., 1995, Methane concentrations and isotopic compositions in layer 3 of the oceanic crust (abst.): Eos, v. 76, no. 46, p. F675.

Analyses of F entrapped in plutonic rocks from the Southwest Indian Ridge provide the *first* direct determination of the compositions and isotopic signatures of CO_2- CH_4-H_2O-H_2 F in layer 3 of the oceanic crust. These data demonstrate that CH_4-rich F are present in significant concentrations throughout plutonic rock at this site and show that CH_4 generation is affected by at least two phases of hydrothermal activity. The first phase, documented by mass spectrometric analyses of volatiles released from individual $CO_2 + CH_4 + H_2O$ I at 900°C in olivine and plagioclase mineral separates, is characterized by F that contain ≤30-50 mol % CO_2 and ≤33 mol % CH_4 (±2%). Phase equilibria suggest that the F compositions may reflect respeciation of magmatic CO_2 attendant with graphite precipitation at ~500-700°C, and fO_2 ~ -3 log units below, to close to QFM conditions. Isotopic compositions of these F are generally consistent with a magmatic origin for the CO_2 and H_2O (e.g., $\delta^{13}C$ CO_2 = -1.9 to -5.5‰ and δD H_2O = -33 to -65‰). Isotopic data on the consanguineous CH_4 ($\delta^{13}CCH_4$ = -18.8 to -27.4‰ and δDCH_4 = -128 to -244‰) show no evidence of a biogenetic origin, nor strong evidence for a thermogenic origin, but are consistent with formation by F-rock reactions at high-T. The second phase of CH_4 production is characterized by CH_4-H_2O ± H_2O ± C-fluids, which contain 10-40 mol % CH_4. Phase equilibria indicate that the CH_4-H_2O F were trapped under equilibrium conditions at very near to QFM conditions. The C and H isotope ratios of CH_4 released from these F at 400°C are similar to vent F from 13° and 21°N on the EPR and to F from the Southern Juan de Fuca Ridge. The $CH_4 + H_2O \pm H_2$ F are believed to be a product of seawater alteration of mafic minerals within the plutonic sequence, or of serpentinization of underlying ultramafic material at >400°C. This interpretation is consistent with the fact that the I contain CH_4 concentrations ≤40 times those of vent F from sediment-starved environments and of occluded gases in basalts, and by the isotopic analyses which do not strongly support either a biogenetic or thermogenic origin. These data suggest that the gabbro-hosted F may represent a previously unrecognized source for these volatile species in some hydrothermal systems venting on the seafloor and that they likely play an important role in the transfer of C from the lithosphere to the hydrosphere. (Authors' abstract)

KELLEY, D.S., VANKO, D.A. and GU, Chifeng, 1995, Fluid evolution in oceanic crustal layer 2: Fluid inclusion evidence from the sheeted dike complex, Hole 504B, Costa Rica rift, *in* J. Erzinger, K. Becker, H.J. Dick and L.B. Stokking, eds., Proc. Ocean Drilling Program, Scientific Results, v. 137/140, p. 191-198.

FI in variably altered diabase recovered from Ocean Drilling Program Legs 137 and 140 at Hole 504B, Costa Rica Rift, exhibit F salinities ≤3.7 times that of seawater values (11.7 wt % NaCl eq.) and exhibit uncorrected Th of 125°C to 202°C. The L-dominated I commonly are entrapped in zones of secondary plagioclase and may be primary in origin. F salinities are similar to compositions of F venting on the seafloor (0.4-7.0 wt % NaCl) and overlap with those measured in metabasalt samples recovered from near the Kane Fracture Zone on the Mid-Atlantic Ridge and from the Troodos ophiolite, Cyprus. The salinity variations may reflect hydration reactions involving formation of secondary mineral assemblages under rock-dominated conditions, which modify the ionic strength of hydrothermal F by consuming or liberating water and chloride ion. Rare CO_2-CH_4-bearing I, subjacent to zones where talc after olivine becomes an important secondary mineral phase (1700 mbsf), may have formed due to local interaction of seawater and olivine at low water to rock ratios. Corrected average FI Th exhibit a gradient from 159°C at a depth of 1370 mbsf to 183°C at a depth of 1992 mbsf and are in apparent equilibrium with the present conductive downhole T. These data indicate that FI may be used to estimate downhole T if logging data are unavailable. The compositional and thermal evolution of the diabase-hosted F may reflect late-stage, off-axis circulation and conductive heating of compositionally modified seawater in the sheeted dike complex at Hole 504B. (Authors' abstract)

KENNEY, J.F., 1995, Comment on "Mantle hydrocarbons: Abiotic or biotic?" by R. Sugisaki and K. Mimura: Geochim. Cosmochim. Acta, v. 59, p. 3857-3858.

A comment on Sugisaki and Mimura, 1994, FIR, v. 27, p. 143.

KERKHOF, A.M. van den and GRANTHAM, G.H., 1995, The charnockitization at Nicholson's Point, Natal metamorphic province, South Africa: The role of fluids (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 254-255. First author at

Inst. Geology and Dynamics of the Lithosphere, Univ. Göttingen, Germany.

In the Port Edward area, charnockitic aureoles ≤~4 m in width are developed adjacent to contacts with the Port Edward enderbite which intruded the Nicholson's Point granite. Two-pyroxene thermometry on the Port Edward enderbite suggests that it intruded ~1000-1100°C. It is characterized by dense CO_2 and CO_2-N_2 I and N_2 I with minor CH_4 (V = 46-53 cm^3/mol with a maximum at 46-48 cm^3/mol). The restriction of these I to the enderbite and their absence from the country rock (low salinity water, low density N_2) suggests that they may be primary in composition. CO_2 was probably introduced during emplacement of the enderbitic magma at granulite-facies conditions. The FI morphology suggests that the I are secondary or they have decrepitated (imploded) during isobaric cooling path recognized in Natal (Grantham et al., in press). The garnet-bearing country rock (Nicholson's Point Granite) is characterized dominantly by aqueous saline I showing secondary or decrepitated I morphologies. Te (~-35°C) and SEM analysis indicate the predominance of sulphate solutions. The charnockitic aureole is dominated by low salinity aqueous I showing secondary or strong decrepitated morphologies. SEM-CL observations of samples in the charnockitic aureoles (LB2 Leisure Bay) show some CL textures which can be related with fluid-rock interaction processes.

The charnockitization adjacent to the Port Edward enderbite appears to have been thermally driven. The lack of CO_2 in the aureole is surprising. A possible reason for the low salinity H_2O-rich I in the charnockite is that H_2O, released during thermally induced dehydration of biotite + quartz (opx + Kfsp + H_2O), was trapped during the intrusion of the enderbite. The few N_2 I in the charnockite could similarly have been derived from intrusion of the enderbite. Subsequent cooling along an isobaric cooling path would result in decrepitation of the I causing secondary morphologies. Assuming cooling towards a stable geothermal gradient of 30°C/km, the crustal thickness at 500-600 Ma would have been ~8-9 km or pressures of 2-3 kb, consistent with the entrapment/decrepitation conditions suggested for the higher and lower salinity aqueous I in the garnetiferous and charnockitic granites, respectively. Whereas the genesis of charnockite in other localities has been attributed to high CO_2 F in the Nicholson's Point Granite, charnockitization adjacent to the Port Edward enderbite appears to have been largely controlled by T. (From authors' abstract by E.R.)

KESLER, S.E., APPOLD, M.S., MARTINI, A.M., WALTER, L.M., HUSTON, T.J. and KYLE, J.R., 1995, Na-Cl-Br systematics of mineralizing brines in Mississippi Valley-type deposits: Geology, v. 23, no. 7, p. 641-644.

New and published analyses of FI leachates from MVT deposits can be divided into two groups on the basis of Na/Br and Cl/Br ratios. MVT leachates from the Illinois-Kentucky and Cincinnati arch districts and from cubic galena in the Viburnum Trend have Na/Br and Cl/Br ratios that extend to values significantly above that of seawater, which are characteristic of evaporite-dissolution brines. MVT leachates from Polaris and octahedral galena in the Viburnum Trend have Na/Br and Cl/Br ratios that plot below seawater and along the compositional trend formed by evaporation. Solubility-volume constraints require that brines formed by seawater evaporation had high dissolved metal contents. Preliminary correlation of leachate compositions allows delineation of two brine provinces in the mid-continent U.S.: (1) an early, high-Br province found only in SE Missouri, and (2) a later, low-Br province of probable Permian age that extended from the Cincinnati arch to the Tri-State district. These observations, alone, with Na-Cl-Br data for modern brines from the Illinois basin, argue against models for single-stage mid-continent MVT brine flow based on recharge from late Paleozoic (Arkoma) foreland basins to the south. (Authors' abstract)

KESLER, S.E., WALTER, L.M., MARTINI, A., HUSTON, T., VENNEMANN, T.W., FREDERICSON, C. and VAZQUEZ, R., 1995, Cl-Br-Na and δ^{18} and δD systematics of Appalachian MVT fluid inclusions: implications for brine flow in Eastern North America (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-117.

Cl/Br and Na/Br ratios of most FI-hosted brines from Appalachian MVT sphalerite and fluorite fall into one of two compositionally distinct clusters, one for the Lower Cambrian paleoaquifer and another for the Lower Ordovician paleoaquifer. These clusters have Na/Br and Cl/Br ratios that are lower than seawater and they plot just above the compositional trend formed by evaporation of seawater. They are thought to represent residual brines that migrated downward during formation of evaporites with carbonate shelf deposits, which host most Appalachian MVT mineralization. A third brine compositional cluster, which has the lowest Cl/Br and Na/Br ratios of three, is made up of leachates from MVT barite deposits. Na-Cl-Br compositions of MVT FI in most Lower Ordovician-hosted Zn and F deposits are similar to formation waters in Cambrian and Silurian strata, and I in Lower Cambrian-hosted MVT deposits are somewhat similar to brines in Pennsylvanian rocks, but I in Lower Silurian-hosted deposits and in all Ba deposits differ from all Appalachian formation waters. δ^{18}O and δD compositions of FI from many of these MVT deposits confirm the distinction indicated by the Na-Cl-Br systematics. Inclusion F from deposits in the Lower Cambrian paleoaquifer have distinctly lower δD (-85‰) values and slightly lower δ^{18}O values (+4‰) than those in the Lower Ordovician paleoaquifer (-40‰, +8‰). These Appalachian MVT FI Na-Cl—Br and δD-δ^{18}O compositions differ significantly from those in deposits in the Cincinnati arch-mid-continent region, suggesting that these two MVT provinces formed from different brines and were not part of a single brine province. (Authors' abstract)

KHARAKA, Y.K. and CHUDAEV, O.V., editors, 1995, Water-Rock Interaction: Proc. 8th Int'l Symp. Water-Rock Interaction, Vladivostok, Russia, 15-19 August 1995.

Individual pertinent abstracts entered in this volume. (E.R.)

KHIN, Zaw, 1995, Geology and fluid inclusion microthermometry of granitic pegmatites in Myanmar: Relationships with W-Sn vein mineralisation (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 272-273. Author at Geology Dept., Univ. Tasmania, GPO Box 252C, Hobart, Tasmania, 7001 Australia. [Editor's note: Although alphabetized in the original volume under "Z," as "Zaw, K.," Dr. Khin Zaw prefers to be listed under "K" in all alphabetical listings.]

Pegmatites commonly occur in a 1500-km N-S trending, W-Sn bearing granitoid belt in Myanmar (Khin Zaw, 1990). Pegmatites are emplaced as veins and dykes that cut granitoid, migmatite, granitoid gneiss, gneiss and schist.

Numerous FI have been found in quartz, topaz and beryl. All inclusions are aqueous, two-phase (L and V) inclusions with no dms, and a variable degree of L filling. Th of 173 fluid inclusions were measured in this study. Quartz and topaz from the Sakangyi pegmatite have Th of 290°-320°C. Quartz from the Sakangyi pegmatite gave Th of 315°-318°C, whereas topaz from the same pegmatite yielded 300°-315°C [sic]. Quartz from the Gu Taung pegmatite gave Th of 241°-389°C with a bimodal distribution and modes at 250°C and 370°C. Similar bimodal distribution with modes at 270°C and 410°C was also recorded for the quartz and beryl from the Taunggwa pegmatite. Fluid inclusions in beryl from the Taunggwa pegmatite gave Th of 266° to 410°C, whereas those inclusions in quartz from the same pegmatite yielded Th of 231°-360°C [sic]. Th of quartz from the Sinmakhwa pegmatite range from 273° to 307°C with a mode of 290°C.

Sal. ranged from 1.0 to 10.8 NaCl eq. wt %. The Na/K ratio of the FI in two topaz samples from Sakangyi were 3.0 to 4.9, and that of two quartz samples were 2.9 to 10.5, suggesting an involvement of K in the pegmatite-forming F. Evidence for phase separation of the pegmatite-forming F was not observed.

W-Sn ore veins in Myanmar formed under a Th range of 140°-360°C and sal. of ~1-10 NaCl eq. wt %. No unequivocal FI evidence for boiling was recorded for the W-Sn deposits in Myanmar. Present FI characteristics and geothermometry suggest that pegmatite emplacement occurred under post-magmatic conditions at 200°-400°C and sal. of ~1-10 NaCl eq. wt %, and that extensive vein-type W-Sn mineralization along the same central granitoid belt occurred at lower T (150°-350°C) but with similar sal. and under non-boiling conditions. The post-magmatic, hydrothermal F responsible for the both pegmatites and W-Sn ore veins was probably from the cooling "S"-type granitoids that they are spatially associated with. (From authors' abstract by E.R.)

KHIN, Zaw, GEMMELL, J.B., HUNNS, S.R., MERNAGH, T.P., RYAN, C.G., LARGE, R.R. and BOTH, R.A., 1995, Composition of fluid inclusions from the Hellyer and Mt. Chalmers VHMS deposits, Australia: Implications for source of ore-forming fluids: PACRIM '95, p. 663-668.

The Hellyer and Mt. Chalmers deposits are mound-style volcanic-hosted massive sulphide (VHMS) deposits in Australia. Textural, petrographic and microthermometric investigations of FI in the Hellyer stringer system indicate that Type I, primary, L-V inclusions are 10-15 µm in size, and yield Th of 170-220°C in early 2A veins, 165-322°C in main-stage 2B veins and 190-256°C in late-stage 2C veins. These data suggest a waxing and waning thermal history. However, the average salinity remained between 8-11 NaCl eq. wt % in all Stage 2 veins. At Mt. Chalmers, Type I inclusions ≤ 20 µm are found in quartz from the mineralised zone, and these I yielded Th of 160-268°C and salinities of 5-8 NaCl eq. wt %. Laser Raman spectroscopic (LRS) analysis indicates the presence of CO_2 (<l mole %) in the Hellyer and Mt. Chalmers VHMS systems. Semiquantitative SEM/WDS microprobe analyses of FI decrepitates indicate that the Hellyer and Mt. Chalmers ore F were enriched in K and Ca but depleted in Mg relative to seawater. PIXE microanalysis of FI in quartz also indicates a significant base metal concentration in these F. Cation composition and higher salinities relative to seawater suggest that recycled seawater alone cannot be the sole source of the ore F. High base metal content and the presence of CO_2 in the FI imply that magmatic input of ore metals during seawater leaching of the footwall volcanic pile is a distinct possibility. (Authors' abstract)

KHIN, Zaw, HUSTON, D.L., LARGE, R.R., MERNAGH, T. and RYAN, C.G., 1994, Geothermometry and compositional variation of fluid inclusions from the Tennant Creek gold-copper deposits, Northern Territory: Implications for exploration of auriferous ironstones: The AusIMM Annual Conf., Darwin, 5-9 Aug. 1994, p. 185-188.

See same authors, FIR, v. 27, p. 65. (E.R.)

KIEPER, Jens and BROCKAMP, Olaf, 1995, Tertiary hydrothermal dolomitization of massive limestones at the triple junction of the Rhine Graben: Z. Dt. Geol. Ges., v. 146, p. 386-398 (in German, English abstract). First author at Dept. Geology, Fachbereich Geowissenschaften Univ., Postfach 330-440, D-28334 Bremen, Germany.

Directly north of the triple junction of the Central European Rhine rift system dolomitized Devonian limestones are frequent in the area between Limburg and Giessen. FI in dolostones have salinities of ~20 wt % NaCl eq. From Th data minimum Tf of ~97°C are deduced. The highly saline, low T F can be assigned to ascending basinal brines. Their Mg contents obviously were low as Mg-rich chlorites existing in limestones were dissolved during dolomitization. This process was accompanied by a decrease in the As and Sr concentrations, whereas the Cl, Fe, and Mn contents increased. Thus the MnO- and Fe_2O_3-contents of the dolostones amount to ~0.3 and 0.7 wt %, respectively, which are about a factor of 10 higher than in limestones. Both elements are preferably incorporated into the lattice of dolomites in a divalent state, while oxides and hydroxides with Fe^{3+} and Mn^{4+} are of subordinate importance. Dark brown coloured reaction zones in the transition from dolostones to limestones are a few centimeters wide and fairly sharp, indicating infiltration metasomatism involving reactions between limestones and inflowing F.

An extended survey in the area shows that the Fe and Mn contents of dolostones remain nearly constant from W (Steeden) to E (Wetzlar). In the same direction $\delta^{18}O$-values (PDB) of dolostones increase from -7.7 to -5.4‰; the higher value is also observed in limestones. $\delta^{13}C$ (PDB) in dolostones and limestones varies without an apparent trend between 3.1 and 0.8‰. FI at Wetzlar have similar characteristics to those at Steeden. From the above data it can be derived that the dolomitizing F mobilized during Tertiary lithospheric uplift and taphrogenesis, ascending along young faults, had a homogeneous compositions and a crustal origin.

The investigations provide new information on Tertiary F systems hardly considered up to now within a complex tectonic configuration of Central Europe. (From authors' abstract by H.E.B.)

KIHIEN, Alfredo, 1995, Geology, genesis of mineralization and alteration, and evolution of hydrothermal fluids at the Quellaveco porphyry copper deposit: Geol. Soc. Peru, Alberto Benavides Vol., Oct. 1995, p. 159-178 (in Spanish)

The Quellaveco deposit is a cordillera type continental margin Cu porphyry deposit located in southern Peru. Its probable reserves using a cutoff value of 0.45% Cu are 395 million m.t., with an average value of 0.83% Cu and 0.018% Mo. Most of the exploitable Cu is contained in a zone of secondary sulfides.

The deposit is related genetically and spatially to a biotite granodiorite stock with porphyritic facies (zones), which forms part of a calc-alkaline intrusive complex of batholitic dimensions, emplaced in the Eocene into a package of continental rhyolites and andesites. Emplacement of the host stock for the Quellaveco deposit was guided by a NE trending fault.

Economic alteration-mineralization is contained totally within the granodiorite stock, principally in the porphyritic facies (zones), and is controlled by fractures. Hydrothermal alteration consists of a small nucleus of non-outcropping potassic alteration, an extensive centrally altered zone of quartz-sericite, and a large halo of propylitic alteration. Major fracturing (of the stock) consists of faults and minor fracture systems of probable hydraulic origin consisting of various systems of stockwork type fractures. Regions of most intense fracturing correspond to the zones of major alteration-mineralization.

The hypogene mineralization consists essentially of pyrite, chalcopyrite, and molybdenite. The supergene mineralization is principally chalcocite with accessory covellite, digenite, and bornite present. The major part of economic mineralization is contained in the zone of quartz-sericite alteration.

FI studies indicate that various generations of heated hydrothermal F circulated through the same system of fractures within the stock. One generation of hottest circulating F, with T >600°C, produced the potassic alteration. A generation of F that evolved between 590°C and 500°C produced part of the chalcopyrite deposition along with quartz and muscovite, as a consequence of boiling at 560°C caused by a rapid drop in F P from 800 to 400 bars. A third generation F that is present everywhere and whose FI are the most abundant in all samples studied, evolved between 500°C and 340°C producing the major part of the quartz-sericite alteration, and major chalcopyrite precipitation between 240°C and 380°C, with episodes of boiling during drops in P between 350 and 150 bars. The fourth generation F evolved between 340°C and 200°C, dissolving some of the chalcopyrite and precipitating quartz and pyrite in fractures. The final generation of F appear to have been present only in the peripheral areas of alteration and evolved between 180°C and 100°C at very low F P. (Authors' abstract; translation courtesy G.P. Landis)

KIHLE, J., 1995, Adaptation of fluorescence excitation-emission micro-spectroscopy for characterization of single hydrocarbon fluid inclusions: Organic Geochem., v. 23, p. 1029-1042.

KILIAS, S.P., VERANIS, N.S. and KONNERUP-MADSEN, J., 1995, The nature of the fluids associated with scheelite (± gold) mineralization, Metaggitsi-Pravita Area, Central Chalkidiki Peninsula, N. Greece, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 877-880.

FI, and O- and C-isotope studies have provided evidence on the nature of the F associated with Alpine scheelite (± Au) mineralization, Metaggitsi and Pravita Areas, central Chalkidiki peninsula, N. Greece. The most abundant I in quartz (and scheelite in Metaggitsi) contain a low salinity aqueous F (~2 to 6 eq. wt % NaCl), variable volume percentages of a CO_2 phase, and minor CH_4. Inclusions containing an aqueous brine also occur, especially at Pravita. Scheelite (± Au) was deposited either from heterogeneous (Metaggitsi Area), or homogeneous (Pravita Am), CO_2-rich F, at P-T conditions of 1-2.5 kb and 250°-310°C, and minimum P-T conditions of 1.9-3.0 kb and 250°-380°C, respectively. F densities and P-T characteristics, coupled by $\delta^{18}O_{fluid}$ values of 3-6‰ (SMOW) and $\delta^{13}C$ CO_2-fluid values of -1.2 to +4.3‰ (PDB) for Metaggitsi, and geologic data, suggest generation of mineralizing F by metamorphic devolatilization reactions. (Authors' abstract)

KIM, K.H., MIZUTANI, Yoshihiko and MOON, H.S., 1995, Oxygen and sulfur isotopic compositions of quartz, barite and sulfide minerals from the Sambo Pb-Zn-barite ore deposits, South Korea: Geochem. J., v. 29, p. 277-286. First author at Dept. Science Education, Ewha Womans Univ., Seoul 120-750, Korea.

O and S isotopic compositions of sulfate, quartz and sulfide minerals from the veins of the Sambo Pb-Zn-barite ore deposits have been measured to study their depositional conditions and evolution of ore F.

The results are as follows: (1) The $\delta^{34}S$ values of sulfides vary from -3.9 to -13.5‰ and those of sulfates from +15.7 to +17.2‰. Isotopic T from barite-sphalerite and barite-galena pairs were 210-290°C, in fairly good agreement with the Th of FI in the stage II quartz. At relatively low T (210-290°C), isotopic equilibria were attained between sulfate and sulfide minerals in the Sambo ore deposits. (2) Barites have homogeneous $\delta^{34}S$ and $\delta^{18}O$ values of +15.7 to +17.2‰ and +2.4 to +3.9‰, respectively.

Calculated $\delta^{18}O$ values of ore F in equilibrium with barite and quartz vary from -2.1 to +0.9‰ and -4.2 to -1.3‰, respectively, suggesting a contribution of ^{18}O depleted meteoric water to ore F of the Sambo deposits. (Authors' abstract)

KIMATA, Mitsuyoshi, SHIMIZU, Masahiro, SAITO, Shizuo and ARAKAWA, Yoji, 1995, Plagioclase megacrysts including native coppers and hydrocarbons: Implication for freezing of optimum magma mixing. Part 2. Hydrocarbon-bearing plagioclase megacrysts and their geochemical significance: J. Mineral. Soc. Japan, v. 24, p. 3-16 (in Japanese, English abstract). First author at Inst. Geosciences, Univ. Tsukuba, Ibaraki 305, Japan.

Hydrocarbons, verified by high-T micro-FTIR, are found to be included by the same anorthite and laboradorite megacrysts containing native Cu, as described in Part 1, in basaltic rocks, from Japanese island arc and in the western continental margin of North America, respectively. A finding of Muntz metal ($Cu_{60}Zn_{40}$) within the anorthite megacryst offered the establishment of Hume-Rothery's rule in nature. Concerning the genesis of native Cu coexistent with the hydrocarbon, the exsolution model fortified by their purity and oriented distribution has been suggested and can account for crystal growth of native Cu based on the theory of Ostwald ripening.

Review must be highly speculative because of the paucity of experimental and natural evidence on the megacrysts and their I, [but] reconstruction must elicit the far-reaching effect of mixing the basaltic magma with the seawater and slab-sediments rich in metals. (From authors' abstract by E.R.)

KINGSLEY, R.H. and SCHILLING, J.-G., 1995, Carbon in Mid-Atlantic Ridge basalt glasses from 28°N to 63°N: Evidence for a carbon-enriched Azores mantle plume: Earth Planet. Sci. Lett., v. 129, p. 31-53.

KIRSCHNER, D.L., SHARP, Z.D. and MASSON, Henri, 1995, Oxygen isotope thermometry of quartz-calcite veins: Unraveling the thermal-tectonic history of the subgreenschist facies Morcles Nappe (Swiss Alps): Geol. Soc. Am. Bull., v. 107, p. 1145-1156.

Combined structural analysis and O isotope thermometry of syntectonic quartz-calcite fibrous veins can be used to correlate the thermal history of deformed rocks with specific structural and tectonic events. Results are presented for the Morcles nappe in the western Helvetic Alps, Switzerland, where mineral parageneses, illite "crystallinity," and FI chemistry record an apparent peak metamorphic T gradient that increased across the Morcles nappe from anchizonal conditions in the foreland to epizonal conditions in its hinterland root zone. Twenty-seven quartz-calcite veins were analyzed in this study in order to determine the T of veining during formation and deformation of the nappe. Peak metamorphic T ranged from nearly equal 260 to 290°C in the shallower, foreland localities and to nearly equal 330 to 350°C in the deeper, more hinterland localities at the end of S1-foliation formation, related to large-scale folding. T gradually decreased throughout the nappe during subsequent development of the S2 foliation and S3 crenulation cleavage. Uplift and erosion of the overlying nappe pile resulted in slow cooling of the Morcles nappe during the waning stages of the Alpine Orogeny. The dominant foliation-forming deformation of the Morcles nappe occurred at elevated T over the course of 10 to 15 Ma. Combined structure-O isotope analyses of quartz-calcite veins yield better T and temporal constraints on the thermal histories of subgreenschist vein-bearing tectonites than do other geothermometers. (Authors' abstract)

KITTO, Paul, 1994, Structural and geochemical controls on metal zonation at the Renison tin mine, western Tasmania (abst.), *in* D.R. Cooke and P.A. Kitto, eds., Contentious Issues in Tasmanian Geology: A Symposium: Geol. Soc. Australia, Tasmania Div., Abstracts, no. 39, p. 95-96. Author at CODES Key Centre, Univ. Tasmania, GPO Box 252C, Hobart 7001, Australia.

FI results from the oxide-silicate stage, in association with thermodynamic modeling, provide the following estimates for initial magmatic-hydrothermal F at Renison: ~250 bars F P, ~350°C T, sal. ~12 eq. wt % NaCl, pH 3.8 to 5.4, $\Sigma S \approx 0.05$ molal, log fO_2 between -32.0 and -33.8, log fH_2S between -0.5 and -2.5, aH_3AsO_3 between 10^{-5} and 10-1, aNa+ ≈ 0.1742, aK+ ≈ 0.085, mMg^{2+} between 1.6×10^{-5} and 6.2×10^{-2}, mCa^{2+} between 7.96×10^{-3} and 12.61 mF- between 1.05×10^{-5} and 4.16×10^{-4}, and Sn solubility ≈20 ppm. Numerical simulations for this Renison-type oxide-silicate stage F predict that boiling, cooling, and mixing with pure water (25°C) are inefficient depositional mechanisms for precipitating cassiterite. In contrast, F-rock interaction appears to be crucial for cassiterite deposition. Based on numerous simulations of F-rock interaction, reaction with dolomite provides the closest approximation of the actual oxide-silicate, sulphide stage and carbonate replacement mineral assemblages. Sn transport in the Renison-type F was dominated by $SnCl^{3-}$ and $Sn(OH)_2Cl_2$ complexes at 350°C and log $fO_2 = 33.5$, allowing the hydrothermal F to carry ≈20 ppm Sn. At lower T, $Sn(OH)_2Cl_2$ complexes became dominant. The most effective mechanism for cassiterite deposition, as predicted by numerical modeling, was by redox and pH changes induced by arsenopyrite deposition and carbonate dissolution, respectively. (From authors' abstract by H.E.B.)

KIYOSU, Yasuhiro and ASADA, Noriko, 1995, Light hydrocarbons in volcanic gases from the Japanese island arc: Geochem. J., v. 29, p. 231-242.

KLEMD, Reiner, BRÖCKER, Michael and SCHRAMM, Jürgen, 1995, Characterisation of amphibolite-facies fluids of Variscan eclogites from the Orlica-Snieznik dome (Sudetes, SW Poland): Chem. Geol., v. 119, p. 101-113. First author at Fachbereich Geowissenschaften, Univ. Bremen, PO Box 330440, D-28334 Bremen, Germany.

Eclogites from the Orlica-Snieznik dome (Sudetes, SW Poland) exhibit evidence for Variscan high-P metamorphism and a subsequent amphibolite-facies overprint. Three main types of FI were observed in quartz of partially retrogressed eclogites. Type 1: aqueous I, mostly two-phase I (L + V). Type 2: (a) $CO_2 \pm N_2 \pm CH_4$ I, normally one-phase I, some contain graphite as daughter mineral; (b) $N_2 \pm CH_4$ I, one-phase I. Type 3: mixed $H_2O\text{-}CO_2 \pm N_2$ I, normally two-phase I ($LH_2O + LCO_2 \pm VCO_2$) consisting of -70-80 vol % CO_2. The texturally earliest I are the $CO_2 \pm N_2 \pm CH_4$ (type 2a) I, which were followed by $H_2O\text{-}CO_2\text{-}N_2$ (type 3) and H_2O (type 1) I in chronological order. Late aqueous (type 1) and $N_2\text{-}CH_4$ (type 2b) I were the last to be trapped. Isochores for FI are not conformable with peak-metamorphic conditions which are estimated at T between 640° and 790°C and minimum pressures of >14 kb. At least three possible explanations must be considered: (1) no F phase was present during the eclogite-facies metamorphism; (2) all FI which were trapped during the high-P event decrepitated during retrogression; (3) only under medium-P conditions FI were trapped. We did not succeed to identify FI which clearly are related to the eclogite-facies metamorphism. However, the isochores derived from microthermometric measurements can be used to constrain the retrograde P-T path. The highest-density isochore of the early $CO_2 \pm N_2 \pm CH_4$ I indicates a pressure of 8 kbar at 600°C. The isochores of the $H_2O\text{-}CO_2 \pm N_2$, the H_2O I and the re-equilibrated $CO_2 \pm N_2 \pm CH_4$ I suggest an almost isothermal decompressional uplift to ~2 kb at 600°C, which was followed by isobaric cooling to ~200°C. Therefore, the rate of uplift was low relative to the rate of cooling, indicating a relatively long period of tectonic inactivity. (Authors' abstract)

KLING, M., 1995, The ankerite-siderite-sulphide-barite deposit of Kamsdorf (Thuringia, Germany), *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 275-276. Author at Inst. Allgemeine und Angewandte Geologie, München, Germany.

At Kamsdorf/Thuringia a metasomatic ankerite-siderite-sulfide mineralization hosted in carbonates is exposed. It is intersected by barite veins. The mineralization is regionally bound to the faults at the southern border of the Thuringian basin. The preliminary data point to the activity of two different F during mineralization, one derived from the basement, the other from the basin. (Author's abstract)

The carbonates and barites contain mostly very small FI. All I show Te ~-55°C. The very rare FI of ankerite show two phases and a high degree of filling. Their salinity is ~25 wt % NaCl eq. And the Th ranges from 160 to 100°C. The I of siderite also exhibit two phases and high degrees of filling, but the salinity of the F is lower, 20 to 25 wt % NaCl eq., and they exhibit Th between 110 and 80°C. In contrary barite exhibits single phase aqueous I with significant lower salinities compared with ankerite and siderite. Calcite intergrown with barite contains I with two phases, but similar salinity. These FI exhibit Th between 60 and 90°C. The F exhibit a cooling trend during ankerite formation and subsequent mixing of two F of different T and salinities. (From author's text by E.R.)

KNIPE, R.J. and McCAIG, A.M., 1994, Microstructural and microchemical consequences of fluid flow in deforming rocks, *in* J. Parnell, ed., Geofluids: Origin, Migration and Evolution of Fluids in Sedimentary Basins: Geol. Soc. (London) Spec. Publ. No. 78, p. 99-111. Authors at Dept. Earth Sciences, The Univ., Leeds LS2 9JT, UK>

A brief review of the processes which interact to control F flow during deformation in sedimentary basins, crystalline basement under low to moderate grade metamorphism and during prograde metamorphism at moderate to high grades. (From authors' abstract by E.R.)

KODERA, P., 1995, Fluid evolution at the Vyhne-Klokoc iron skarn deposit (Western Carpathians, Slovakia) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 106-107. Author at Dionyz Stúr Inst. Geology, Mlynská dolina 1, 817 04 Bratislava, Slovakia

The magnetite exoskarn deposit Vyhne-Klokoc is the largest and the best known skarn locality in the Western Carpathians, with 2.6 mil tones proved magnetite ore. Three basic evolution stages are recognized: isochemical magmatic, metasomatic and retrograde stage. The isochemical stage had the character of thermal contact metamorphism.

The metasomatic stage began by gradual increase of tectonic activity and penetrating Fe-enriched metasomatic F. Characteristic is the occurrence of epidote, tremolite and also the development of several garnet generations, especially andradite. Important is the origin of magnetite, replacing carbonate rocks and older skarn assemblages.

The retrograde stage is characteristic by non-equilibrium crystallisation under varying redox conditions. Zoned garnet, major hematite and minor magnetite (both accompanied by extensive mutual overprinting) were formed here, also together with lesser amounts of epidote, amphibole and chlorite (picnochlorite and pennine).

The FI indicate decreasing salinity and T towards the later stages. Inclusions in earliest garnets and interstitial quartz contain dms, implying probably a magmatic origin of these F. Variable L-to-V ratios observed in selected garnet-hosted I trails indicate local boiling of the mineral-forming F. Most intensive boiling, however, was observed in the hematite-quartz-calcite assemblage, what might account for non-equilibrium crystallisation in the retrograde stage. The retrograde stage must have been affected by the progressively increasing involvement of meteoric waters, which caused continual cooling and dilution of mineral-forming F. Th from the latest garnet occurred at 320°C and salinity was ~10 wt % NaCl eq. Th of FI trapped in interstitial calcite were 250-310°C and salinity ~2 wt % NaCl eq. No signs of boiling were found in later hydrothermal substages. Therefore, the mineral precipitation in these substages was controlled by decreasing T driven by circulating meteoric F. FI measurements from hydrothermal calcite-pyrite mineralization showed pure water with Th ~230°C.

Th from FI in interstitial calcite, which originated together with picnochlorite, showed values of 225-275°C. (From author's abstract by E.R.)

KOEBERL, Christian, REIMOLD, W.U. and BRANDT, Dion, 1995, The Newporte impact structure, North Dakota: Shock metamorphism in breccias: Lunar and Planet. Sci. Conf., v. 26, part 2, p. 773-774.

Indexed under FI. (E.R.)

KOGARKO, L.N., HENDERSON, C.M.B. and PACHECO, H., 1995, Primary Ca-rich carbonatite magma and carbonate-silicate-sulphide liquid immiscibility in the upper mantle: Contrib. Mineral. Petrol., v. 121, p. 267-274. First author at Vernadsky Inst. Geochemistry, Moscow 117975, CIS.

A primary carbonate phase with Ca/(Ca + Mg) in the range 0.85-0.95 has been identified in a metasomatized, depleted harzburgite nodule from Montana Clara Island, Canary Islands; textural relations show that this carbonate represents a quenched liquid. (From authors' abstract by E.R.)

KOLKOVSKI, B., TODOROV, T. and NIKOVSKI, V., 1993, Mineralogy, geochemistry and genetic features of gold polymetallic mineralizations in the Bakadjik ore field, East Srednogorgie: Annuaire de l'Univ. Sofia St. Kliment Ohridski, Fac. Geologie at Geographie, v. 85, p. 99-152 (in Bulgarian, English abstract).

The mineral composition and succession of mineral formation of hypogene ores in Bakadjik ore field have been determined. The trace elements in the main ore minerals were studied. Conclusions about endogene zonality and genesis of ore mineralizations have been made.

Th data are as follows:

(1) quartz-specularite stage: 100-320°C (with max. frequencies at 100-120°C and 200-220°C);

(2) quartz-chalcopyrite stage: 160-360°C (with max. frequency at 300-320°C, no differences between various levels of the mine);

(3) quartz-sphalerite-galena-chalcopyrite stage: 200-300°C (max. frequency at 260-280°C) and 260-320°C (max. frequency at 300-320°C);

(4) late-stage dolomite and calcite: 100-120°C (dolomite) and 80-110°C (calcite). (Authors' abstract extended by F. Molnar)

KOLONIN, G.R., PAL'YANOVA, G.A., SHIRONOSOVA, G.P. and MORGUNOV, K.G., 1994, A thermodynamic model for possible gold levels in a hot chloride H_2O-CO_2 fluid: Geokhimiya, no. 12, p. 1725-1734 (in Russian; translated in Geochem. Int'l, v. 32, no. 8, p. 1-10, 1995).

Abstract in FIR, v. 27, p. 68.

KOMATSU, M., 1970, Chemical composition of glass inclusions in olivine: MAGMA, no. 21/22, p. 10-13 (in Japanese).

Chemical compositions of glass I in olivine and quartz from volcanic rocks were analyzed by EPMA. Glass I from alkaline olivine basalt series rocks are poor in FeO, compared to tholeiite series rocks. Compositions of glass I probably give a clue to consider origin of igneous rocks. (Abstract courtesy T. Sawaki)

KOMATSU, R., MURAMATSU, Y., SAWAKI, T. and SASAKI, M., 1995, Distribution of salinity of fluid inclusions in the Mori geothermal field, Hokkaido—Determination after correction for CO_2 content (abst.): Abstracts (FIR) of 1995 Annual Mtg., Geothermal Research Soc. Japan (in Japanese).

Mori geothermal is located in the Nigorikawa Caldera, SW of Hokkaido. Geothermal power plant of 50 MWe has been generating since 1982. The F produced from deep reservoir is chemically considered CO_2 rich. Measurement of Tm(ice) of FI depends on dissolved amount of salts and G such as CO_2. Then, estimation of true salinity of FI need the evaluation of contribution from dissolved G. G analyses was conducted by quadrupole mass spectrometer with capacitance manometer [developed] in GSJ, and true salinity was calculated with correction for the effect of dissolved CO_2. Anhydrite and quartz in cuttings were collected from some depths of wells that were drilled before operation and used in this study. The compositions of FI were 97.9 to 99.2 mol % for H_2O, 0.73 to 1.92 mol % for CO_2, <0.24 mol % for N_2, <0.032 mol % for CH_4, and <0.0012 mol % for Ar. The concentrations of CO_2 G in FI are higher than those in produced F which is flashing in the reservoir, indicating that FI trapped the F before degassing. Taking into account the effect of dissolved CO_2 to Tm(ice), the true salinity of FI ranges <2 wt % with the exception of two samples in which polyphase I were observed. The salinity of the produced F range from 0.7 to 1.0 wt %, and falls in the salinity range of FI.

(Authors' abstract, translated courtesy M. Sasaki)

KOMNINOU, A. and SVERJENSKY, D.A., 1995, Hydrothermal alteration and the chemistry of ore-forming fluids in an unconformity-type uranium deposit: Geochim. Cosmochim. Acta, v. 59, p. 2709-2723. First author at Dept. Earth Sciences, Univ. Leeds, Leeds LS2 9JT, UK.

White mica compositions were used to calculate the activity ratios for the hydrothermal F associated with deposition of uraninite. Hydrothermal apatite analyses in conjunction with salinities suggested from FI studies were used to calculate the pH of the F during the pre-ore alteration. (From authors' abstract by E.R.)

KONECNY, P., KONECNY, V., LEXA, J. and HURAIOVA, M., 1995, Mantle xenoliths in alkali basalts of Southern Slovakia: Acta Vulcanologica, v. 7, p. 241-247. First author at Geol. Surv., Mlynska dolina 1, 817 04 Bratislava, Slovakia.

CO_2 and silicate MI are abundant in olivine and Cr-diopside from spinel lherzolite xenoliths entrained by Late Tertiary-to-Quaternary alkaline basalts. Important are relatively high densities (≤ 0.99 g·cm^{-3}) of the CO_2 phase. Additional G species are indicated by depression of Tm values below that for triple point of pure CO_2. Raman spectra of two I trapped in lherzolite and olivine megacryst revealed minor quantities of CO and N_2. F P recalculated from the densest CO_2 I must have attained 7.7-8.3 kb at 1000-1100°C, possible equilibration T for the host olivine and Cr-diopside. O fugacities recalculated from F composition overlap those obtained from the equilibrium among coexisting olivine, orthopyroxene and spinel, ranging -1.6 to +1.2 log units around QFM experimental buffer, with an average to -0.15. (Authors' abstract)

KONECNY, P., SIMON, K., HURAIOVA, M. and HURAI, V., 1995, Silicate melts in anorthoclasitic melts and trondhjemitic xenoliths hosted by Late Tertiary alkali basalts (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 108-109. First author at Dionyz Stúr Inst. Geology, 81704 Bratislava, Slovak Republic.

Xenoliths with modal composition corresponding to anorthoclasite and trondhjemite-tonalite series have been found in the explosive equivalents of the Upper Tertiary basaltic volcanism.

Two types of M have been observed in the anorthoclasites: microscale PI trapped in anorthoclases and irregular pockets of intergranular M that may constitute ≤3 vol % of rock. The interstitial M crystallizes Fe-Ti oxides whereas Fe-Al spinels have been found as dms directly precipitated from zircon-hosted MI.

Trondhjemite xenoliths are composed of three main phases: plagioclase, quartz and interstitial M that may form ≤35 vol % of rock.

REE-patterns of the anorthoclasites and trondhjemites are characteristic of strong LREE-enrichment (≤400 times relative to chondrite), negative Eu-anomaly in the interstitial M and high positive Eu-anomaly in the rock-forming plagioclases, what is suggestive of cumulate origin of the rock-forming minerals.

M composition does not significantly vary within samples and even between rock types. The M is enriched in Si, Fe, Ti, Mn as compared with feldspar. The Na/K ratio is approximately constant for the M, although variable in feldspars. Increased Zr contents in M may be attributed to dissolved zircon. The M is also enriched in Cl (≤1 wt %).

P MI have been observed in all rock-forming minerals, as well as in apatite, zircon and monazite. The inclusions are closely associated with primary CO_2 I (Huraiová et al., this volume). Melting and Th of the M could be measured only in rock-forming quartz and anorthoclase. Onset of the melting (solidus) has been observed within the T interval between 850-870°C in the anorthoclasite, and between 905-930°C in the trondhjemite. The final melting (liquidus) occurred ~1070-1080°C in the anorthoclasite. The Th Es [sic] for two trondhjemites were 1140-1190°C and between 1260-1280°C, respectively. The Th in MI hosted by plagioclases could not be determined, because the I always decrepitated prior to homogenization. Solidus T of the I M are roughly consistent with the solidi in the water-absent and water-deficient haplogranitic M. It cannot be ruled out that the Th are overestimated owing to high M viscosity and by failing the CO_2-V to dissolve in the molten silicate phase.

Evidences for immiscibility of two silicate M have been obtained from the FI hosted by trondhjemitic xenoliths. Homogenization of these two coexisting M has been reached at 1090°C.

Several lines of evidence (close association with gabbroic xenoliths, typical REE-patterns, high Fe-Ti contents of the interstitial and I M, high Th) suggest that the salic alkaline and sub-alkaline xenoliths might have been formed by fractional crystallization within chambers of basaltic magma. The host alkali basalts are the most reasonable candidates for the parental rocks. Densities of the coexisting CO_2-rich I indicate that quartz and plagioclases must have crystallized at mid- (~11-13 km) and deep-crustal levels (~22 km). (From authors' abstract by E.R.)

KONONKOVA, N.N., 1994, Composition of inclusions in minerals and the crystallization conditions for the Homrat Akarem rare-metal granites, Egypt: Geokhimiya, no. 7, p. 956-967 (in Russian; translated in Geochem. Int'l, v. 32, no. 2, p. 43-55, 1995). Author at Inst. Ore-Deposit Geology, Petrography, Mineralogy, and Geochemistry, Russian Acad. Sci., and Vernadskiy Inst. Geochemistry and Analytical Chemistry, Russian Acad. Sci., Moscow, Russia.

M, solid, and FI have been examined in quartz from these rare-metal granites. The P and T have been determined for the most important times in the evolution of the granite magma, which contained ≤0.5 wt. % F and 9-10 wt. % H_2O: (1) quartz crystallization at 640°C and 8 kb; (2) complete solidification at 500-550°C; (3) partial loss of F by the MI at 550°C and 6 kb; (4) segregation of the late magmatic F at 500-550°C and 4-5 kb; and (5) crystallization of micro-schlieren in the granite at 300°C and 0.1 kb. Evidence is obtained for a magmatic origin of the topaz and fluorite. (Authors' abstract)

KONSTANTINOV, M.M., KALININ, A.I., NATALENKO, V.E., STRUZHKOV, S.F. and DVURECHENSKAYA, S.S., 1995, The Dukat gold-silver deposit, Russia: Geol. Rudnykh Mestorozhdenii, v. 37, no. 4, p. 317-334 (in Russian; translated in Geology of Ore Deposits, v. 37, no. 4, p. 274-290, 1995).

The mineralization belongs to a shallow (0.5-1 km) type, but it is characterized by relatively dilute, high T (320-450°C) solutions [literature data] and a rejuvenation of the ore process. (From authors' abstract by E.R.)

KONTAK, D.J., 1994, Geological and geochemical studies of alteration processes in a fluorine-rich environment: The East Kemptville Sn-(Zn-Cu-Ag) deposit, Yarmouth County, Nova Scotia, Canada, *in* D.R. Lentz, ed., Alteration and Alteration Processes associated with Ore-forming Systems: Geol. Assoc. Canada, Short Course Notes, v. 11, p. 261-314. Author at Nova Scotia Dept. Mines and Energy, PO Box 1087, Halifax, Nova Scotia B3J 2X1, Canada.

Preliminary petrographic studies and thermometric measurements of FI were made on quartz, cassiterite, topaz, triplite, carbonate and fluorite. These studies indicate that the greisens and veins formed from similar F in terms of salinity, T and gaseous species. The salinity fluctuated between low to moderate (<20 wt % eq. NaCl) and highly saline (to 38 wt % eq. NaCl) and P corrected Th (to 100 MPa) indicate Tt of 450-500°C. However, greisen-hosted minerals are distinguished by containing more V-rich and halite-rich I. (From author's abstract by E.R.)

KONTAK, D.J., CHI, G., SAVARD, M. and SANGSTER, D.F., 1995, Fluid inclusion studies of carbonate-hosted mineral deposits in the basal Windsor Group of Nova Scotia: Generation of high-temperature, high-salinity fluids as a consequence of an anomalous geothermal gradient or dewatering of a sedimentary basin (abst.): Atlantic Geoscience Soc., Abstracts, 1995 Colloquium and Annual General Mtg., Antigonish, Nova Scotia, published in Atlantic Geol., v. 31, p. 50. First author at Nova Scotia Dept. Natural Resources, PO Box 698, Halifax, NS B3J 2T9, Canada.

The basal part of the marine Windsor Group of the Maritimes Basin is host to Pb-Zn-Ba-Cu-Ag mineralization which replaces the carbonate rocks or infills primary and secondary porosity. FI have been studied in pre-ore (dolomite, calcite, quartz(?); Gays River and Jubilee), syn-ore (sphalerite, calcite, barite; all deposits) and post-ore (calcite, barite, fluorite; all deposits) phases. Inclusion types include: (1) aqueous L-V ± halite; (2) CH_4; (3) H_2O-CO_2 (Gays River); and (4) petroleum. Aqueous-type I dominate, but petroleum types are abundant at Jubilee (pre-, syn- and post-ore) and Walton (syn- and post-ore). Th of aqueous I for the three deposits range from <100°C to 300°C, with pre-ore phases having Th of <160° at

Gays River and <100°C at Jubilee. Salinities (eq. wt % NaCl) of aqueous I for all deposits range from 10 to 30 wt % with most in the 20 to 25 wt % range; low first-melting T indicate H_2O-NaCl-$CaCl_2$ F composition and ice-hydrohalite melting suggests variable $CaCl_2$/NaCl ratios. At Walton and Gays River, low-salinity I (0-5 wt %) are commonly associated with high-salinity types. Type 2 I (CH_4) homogenize to the V phase at -85° to -74°C. Petroleum I homogenize to the L phase with Th = 90-280°C at Walton and 30-200°C at Jubilee. Analyses (GC) of gases liberated from I hosted by sphalerite and calcite at Gays River confirm the presence of CO_2, CH_4 and hydrocarbons.

The high T of Th for syn-mineralization phases contrast with the relatively low T of pre-ore phases and T generally associated with MVT-style mineralization. Results from examination of clay mineralogy and organic maturation at Gays River also suggest a high-T anomaly compared T the local sub-basin. Thus, collectively the data indicate that the regional, saline brines generated within the basins either mixed with or were flushed out by higher-T F, perhaps focused along structural zones, to produce mineralization. A third F, which postdates mineralization, is suggested by mixing trends in Th-salinity plots and by the presence of low-salinity I. Generation of petroleum is related to local cracking of organic matter (Horton or Windsor group rocks) within the F pathway; rapid transport and trapping of the petroleum is essential to its preservation. (From authors' abstract by H.E.B.)

KONTAK, D.J. and KERRICH, Robert, 1995, Geological and geochemical studies of a metaturbidite-hosted lode gold deposit: The Beaver Dam deposit, Nova Scotia: II. Isotopic studies: Econ. Geol., v. 90, p. 885-901. First author at Nova Scotia Dept. Natural Resources, PO Box 698, Halifax, Nova Scotia B3J 2T9, Canada.

Mineralization formed from a low-salinity, H_2O-CO_2 (XCO_2 = 0.15) F. Isotopic studies (O, C, H, Sr) of mineral phases (quartz, amphibole, feldspar, mica, carbonate, tourmaline) indicate that the ore-forming F were not generated within the Meguma Group. We conclude that the isotopic data for the Beaver Dam deposit are most consistent with a model invoking generation of F from metamorphic devolatilization reactions deep within the crust and structural focusing of such F. In contrast, a magmatic source is incompatible with the isotopic data unless such a F has been highly modified by F-rock interaction. Finally, there is no support for a meteoric component to the ore F. (From authors' abstract by E.R.)

KONTNY, A. and FRIEDRICH, G., 1995, Ore mineralization in metamorphic rocks of the KTB, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 881-884.

Uses literature FI data. (E.R.)

KOTELNIKOVA, Z.A. and CHEPKAY, N.A., 1995, Correlation between fluid inclusions cavities and crystal defects in quartz (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 288.

Methods of selective etching and chemical decoration with application of transmission and scanning electron microscope have established unity of cavities of FI in quartz with line defects of its crystal structure, i.e., edge and screw dislocations. It has been found out that the primary FI of 1-5 m [μm?] of 10 m [μm?] and larger size are characterized by a bunch of dislocations, fan-like, dispersing from the cavity. Many of PI associated with subgrain boundaries in crystals are connected by plane defected, i.e., tilted and screw dislocation boundaries. Practically all the cavities of SI are located in healed fractures linked with rows or screen of dislocations. The large FI have more dislocations than small ones and density of dislocation on the wall of I is higher then in general of crystal. (Authors' abstract.)

KOTELNIKOVA, Z.A. and KOTELNIKOV, A.R., 1995, Parameters of metamorphism of Khanka massif (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 318.

P-T conditions and compositions and composition of F during metamorphism of the Khanka massif were estimated using mineral equilibria and FI study. The trend of the change in the metamorphism conditions was determined in P-T coordinates: retrograde stage occurred at 910 to 450°C and 7.5 to 0.5 kb. F phase enriched in H_2O relative to CO_2 with decreasing of P-T parameters: molar fraction of CO_2 varied from 0.25 (700°C) to 0.1 (500°C). We suggest previously homogeneous F at ~650°C became immiscible, and more mobile CO_2 phase migrated efficiently and was lost partially. At 400°C P-T-X conditions corresponded again to homogeneous state and entrapped H_2O-CO_2 FI. (Authors' abstract.)

KOTOV, E.I., MALOV, V.S. and ZVEZDINSKAYA, L.V., 1995, Yttrium-rare-earth mineralization of the Strel'tsovskii uranium ore district (eastern Zabaikal'e, Russia): Geol. Rudnykh Mestorozhdenii, v. 37, no. 1, p. 67-76 (in Russian; translated in Geology of Ore Deposits, v. 37, no. 1, p. 56-64, 1995). Authors at Inst. Geology of Ore Deposits, Petrography, and Geochemistry, Russian Acad. Sci., 35 Star., Moscow 109017, Russia.

Chlorite metasomatites and veinlets formed by alkaline (pH ~9) hydrothermal solutions with carbonic acid and Cl at P of no less than 0.5 kb, 310 to 330°C [Th 264-287°C], and a redox potential close to -0.7 V. (From authors' abstract by E.R.)

KOTZER, T.G. and KYSER, T.K., 1995, Petrogenesis of the Proterozoic Athabasca Basin, northern Saskatchewan, Canada, and its relation to diagenesis, hydrothermal uranium mineralization and paleohydrogeology: Chem. Geol., v. 120, p. 45-89. Authors at Dept. Geological Sciences, Univ. Saskatchewan, Saskatoon, Sask. S7N 0W0, Canada.

In the Athabasca Basin Proterozoic sandstones unconformably overlie Archean and Aphebian rocks. Multiple F events, involving isotopically- and chemically-distinct F which have migrated laterally for considerable distances and along fault zones, have produced a paragenetically-identifiable assemblage of clay, silicate and oxide minerals in the basin and basement rocks. Altered sandstones and the underlying metasedimentary rocks proximal to fault zones host high-grade U-Ni-Co unconformity-type U ore deposits. FI T in diagenetic quartz, and δD values of 1 M kaolinite, 2M/3T illite, dravite and in FI in the quartz indicate formation from a basinal F that had δD values of -60 ± 10‰ and which underwent salinity, T and ^{18}O increases from 5 to 34 wt % NaCl, 120° to 240°C, and -5 to + 3‰, respectively, as a result of increasing burial depth and sustained water-rock interactions with the basinal sediments over substantial time periods. The evolution of Sr isotopic compositions of F in the basin and basement rocks, as reflected by the $^{87}Sr/^{86}Sr$ ratios of chlorite, illite and dravite, indicates that mixing of two isotopically-distinct F in the vicinity of faults was the process by which U was precipitated, similar to that suggested by O and H isotope systematics in the clays and silicate minerals. ε_{Nd} ratios in the high-T diagenetic and hydrothermal clay and silicate minerals and the cogenetic U ores suggest they all have formed from similar F which have interacted substantially with the basin sediments.

In general, the isotopic, chemical, microthermometric and petrologic data indicate that the Athabasca Basin has had a protracted F history comparable to that documented for more modern sedimentary basins. The data clearly show that the major sandstone aquifers have been affected by widespread lateral flow of diagenetic F over distances of hundreds of kilometers and also that these F migration paths have been modified by cross-formational F flow near active fault zones. (From authors' abstract by E.R.)

KOVALENKER, V.A., LEVIN, K.A., NAUMOV, V.B., SALAZKIN, A.N. and KABO, A.Ye., 1994, Conditions of formation of the rich silver arsenide ores at the Aktepe deposit, central Tian Shan: Geokhimiya, no. 5, p. 718-731 (in Russian; translated in Geochem. Int'l, v. 31, no. 12, p. 114-127, 1995).

Abstract in FIR, v. 27, p. 69.

KOVALENKO, V.I., TSARYEVA, G.M., ANDREEVA, I.A., HERVIG, R.L., NEWMAN, S., NAUMOV, V.B., CUNEY, M. and RAMBAULT, L., 1995, Melt inclusions of rare-metal magmas (granites, pantellerites, carbonatites, apatite rocks) (abst.): Eos, v. 76, no. 17, p. S268. Authors at Inst. Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Staromonetny per. 35, Moscow 109017, Russia.

We have investigated MI in minerals from Russia, Ukraine, Mongolia, USA, France. We have found that magmas of the rare-metal acid rocks (peralkaline-comendites, Zr, Nb, REE-bearing granites, pantellerites; peraluminous Li-F - ongonites, topaz rhyolites, Ta and Sn-bearing Li-F granites and pegmatites) have general composition, trace element contents like those of rocks. Peralkaline rare-metal magmas are enriched especially in Zr, Nb, REE (≤2.6 wt % Zr, 0.58 wt % Nb, 0.4 wt % REE in Mongolian peralkaline rare-metal granites). Concentrations of trace elements in peraluminous Li-F rare-metal magmas are 30-40 ppm Zr, 35-80 ppm Nb, no more than 20 ppm REE. Peralkaline acid magmas are LREE-rich, whereas peraluminous magmas have about the same concentratins of LREE and HREE, but both have negative Eu anomalies. Peraluminous Li-F acid magmas are enriched especially in Li, Ta, Rb, Sn, Be, F. U/Th ratios are 0.2-0.4 in peralkaline magmas, but 0.7-1.1 in peraluminous Li-F rare-metal magmas. We have obtained fairly stable maximum H_2O content in peraluminous Li-F rare-metal acid magmas: 7 wt % in Ukrainian chamber pegmatites, 7.5 wt % in Russian ongonites, 7.8 wt % in USA topaz rhyolites, 7.9 wt % in French Ta and Sn-bearing Li-F granites. Th of these MI is 650-750°C. Maximum H_2O content in peralkaline rare-metal magmas is 5 wt %, Th is 700°C (Mongolian rare-metal comendites). The highest concentrations of F are revealed in peraluminous rare-metal magmas: 5 wt % in Ukrainian pegmatites, 6 wt % in Mongolian ongonites. Maximum F content in peraklaline magmas is 2.5 wt % (Mongolian Zr-Nb-REE-bearing peralkaline granites). The highest concentrations of Cl are found in peralkaline magmas of pantellerites from Pantelleria Island (>1 wt %). The chemical composition of magmas from carbonatite-bearing magmatic association is enriched by P_2O_5 (≤20.5 wt %) and REE. H_2O content is low (<0.5 wt %). Th of such MI is 1155-1220°C.

The results of our investigations prove the existence of natural deeply evolved rare-element rich magmatic melts. (From authors' abstract by E.R.)

KOVALENKO, V.I., TSARYEVA, G.M., GOREGLYAD, A.V., YARMOLYUK, V.V., TROITSKY, V.A., HERVIG, R.L. and FARMER, G.L., 1995, The peralkaline granite-related Khaldzan-Buregtey rare metal (Zr, Nb, REE) deposit, western Mongolia: Econ. Geol., v. 90, p. 530-547. First author at Inst. Geology of Ore Deposits, Petrography, and Geochemistry, Russian Acad. Sci., 35 Star., Moscow 109017, Russia.

The deposit is in peralkaline granitoids. These contain P MI which were homogenized in a bomb under a P of 3 kb, and the glass analyzed by electron and ion microprobe. This enabled direct determination of the composition of the peralkaline rare metal granite magma (F, H_2O in mass %, other elements in ppm): $H_2O = 2.2$, Li = 230, Be = 340, B = 12, F = 2.5, P = 520, Ti = 4210, Rb = 3770, Sr = 5, Y = 2240, Zr = 26,530, Nb = 5750, Sn = 660, and Ce = 1450. The proportion of crystals in the rare metal granite magma, the initial magma composition, and the combined partition coefficients have been evaluated. The initial magmas were rich in rare elements. Calculation partition coefficients indicate that the rare metal magma was generated by differentiation of the most primitive pantellerite magma which we surmise originated from fractional melting of the basaltic crust. (From authors' abstract by E.R.)

KOVALENKO, V.I., TSARYEVA, G.M., HERVIG, R.L. and YARMOLYUK, V.V., 1992, Trace elements and water in melt inclusions (magmas) from rare-metal alkali granites: Dokl. Ross. Akad. Nauk, v. 326, no. 2, p. 349-353 (in Russian; translated in Dokl. Acad. Sci. USSR, v. ___, no. ___, p. 177-181, 1994). First author at Inst. for Ore-Deposit Geology, Petrography, Mineralogy, and Geochemistry, Russian Acad. Sci., Moscow, Russia.

The contents of water and trace elements have been measured in homogenized primary crystallized MI in quartz from the Khaldzan-Buregtey intrusion rare-metal alkali granites from Western Mongolia using the ion probe at Arizona State Univ. in Tempe (Arizona, USA). These I were first examined with an electron microprobe and the overall compositions of the glasses (quenched magmas) were obtained. Most of the details of the ion probe method are given. The hydrogen (water) was measured with the use of standards consisting of experimentally hydrated glasses made by Stolper (Caltech), which were analyzed by IR spectroscopy. The trace-element contents were calibrated by means of NBS 610 standard, which is a glass rich in Na and SiO_2 that has been analyzed at the 500 ppm level for 61 elements. That specimen was compared with our rhyolite glasses, which showed that the elements were determined to within 10% of their nominal concentrations. We used the [5] method to correct of interference from ions of the light and heavy REE. The fluorine analyses employed a combination of the NBS 610 and KN-18 standard specimens (the latter is a comendite glass containing 6400 ppm F). The reproducibility of those standards was ±10% for contents for 200 to 500 ppm, ±10-20% for 50-200 ppm, ±20-30% for 5-50 ppm, and ±50% for a few ppm or less. The lower detection limit for Cs and Mo was 10 ppm. We estimated the error in determining As and W as reaching ±40% because of the low sensitivity.

The I lay in concentric growth zones in the quartz grains in rare-metal granites (snow shower structure) together with crystalline ones (albite, KFS, aegirine, mica, fluorite, and sometimes pyrochlore) and were often accompanied by crystal-FI (C + LW + LCD + G). The latter contained H_2O and L CO_2.

The P MI were oval and irregular in shape and reached 30 to 60 µm in size, being crystalline: extremely fine micrographic or micropoikilitic aggregates of quartz, KFS, aegirine, amphibole, mica, unidentified minerals, and a G phase. The first signs of melting occurred at 480 to 500°C. (Authors' abstract)

KOVALEVICH, V.M. and PERYT, T.M., 1995, Chemistry of fluid inclusions in the Werra (Zechstein, Upper Permian) halite of North Poland (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 110-111. First author at Inst. Geology and Geochemistry of Combustible Minerals, Nat'l Acad. Sci. Ukraine, Naukova 3a, 290053 L'viv, Ukraine.

Study of FI in sedimentary halite crystals may explain the evolution of ocean chemistry in time, and second, they are of use to predict the zones where potassium salts could be deposited.

We studied the Werra (Zechstein) halites occurring in North Poland. During the Zechstein there existed a gulf of the Zechstein Sea in the Peri-Baltic area and peripheral evaporite platform (shelf) developed there, with local thick sulphate platforms surrounded by halite basins which in places contain also potash salts.

We studied halites in two wells: from the shoal (Zdrada IG3), and the slope of the sulphate platform (Zdrada IG6). The inclusions are a fraction of [1] to 300 micrometres long, although exceptionally long (1 mm) I occur. For the chemical analysis, Petrichenko's (1973) method of glass capillaries was applied.

It was found that the Werra brine is of $Na-K-Mg-Cl-SO_4$ type and is similar to recent concentrated ocean water considering ratios between particular ions although it differs in having slightly lower sulphate ion content (Fig. 1). There is some variability of total content of ions examined in the profiles although all results suggest that the degree of concentration corresponds to the beginning and middle stages of halite precipitation. This is also supported by other geochemical data (distribution of bromine).

The relations between K^+, Mg^{2+} and SO_4^{2-} as found during this study are similar to those found during examination of other Permian halites (Kovalevich, 1990, 1992; Horita et al., 1991). Accordingly, these data indicate that Permian marine water was simi-

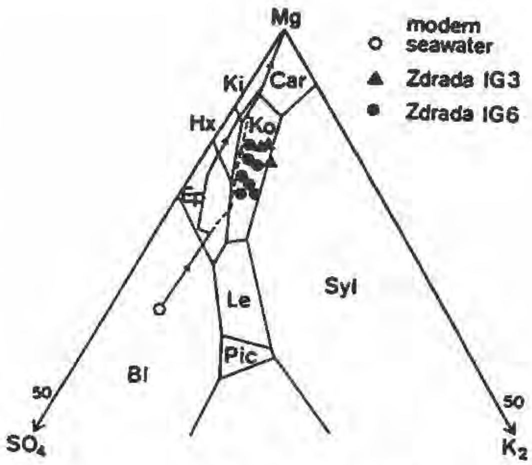


Fig. 1. Brine composition in the inclusions in the Werra halite of the Zdrada area plotted on the Jänecke projection in the quinary system $Na-K-Mg-SO_4-Cl-H_2O$ saturated with respect to halite at 25°C (Eugster et al., 1980).

lar to recent one and differed only in slightly lower content of sulphate ion in the Permian. (From authors' abstract by E.R.)

KOVALEVICH, V.M. and PETRICHENKO, O.Y., 1995, Fluid inclusions in halite from Paratethys Miocene evaporites and the problems of their chemical composition interpretation (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 112-113. Authors at Inst. Geology and Geochemistry of Combustible Minerals, Naukova st., 31, 290053, L'viv, Ukraine.

FI in halite from Miocene marine evaporite deposits from various submontane and intermontane depressions in Ukraine, Poland, Romania, Slovakia, Sicily and Spain were studied.

The results show that seawater was the main source of studied basins supplying. Solutions of these I belong to Na-K-Mg-Cl-SO_4 type and by ratio of major ions are close to modern seawater. All basins have some differences in solutions composition that, in our opinion, may be explained by differences in paleogeographic environment of salt accumulation. The obtained data do not consist [conform?] with views about significant impact of continental runoff or endogenic sources. (From authors' abstract by E.R.)

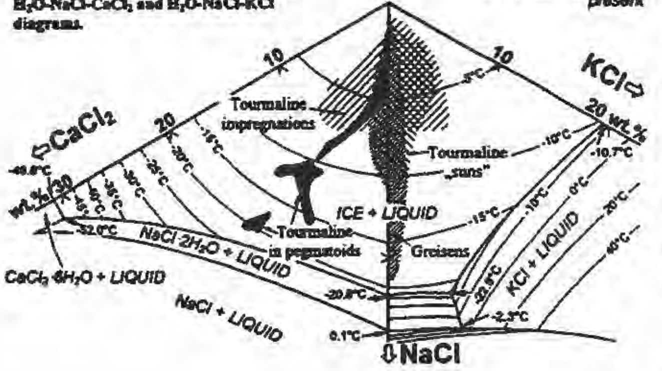
KOZLOWSKI, Andrzej, 1995, Origin of Zn-Pb ores in the Olkusz and Chrzanów districts: A model based on fluid inclusions: Acta Geologica Polonica, v. 45, no. 1-2, p. 83-141 (in English).

FI studies in sphalerite from early-stage Zn-Pb mineralization, hosted by Devonian, Triassic and Jurassic carbonate beds in the Olkusz and Chrzanów ore districts, Silesian-Cracow region (southern Poland), yielded Th from 80 to 158°C with the upper range higher in the south of the region and lower in the north. Vertical thermal gradient of the parent F was 6 to 10°C, and the ore crystallization T ranges varied from <10°C at deep levels to 25°C at shallow levels. The peculiarities of formation of P and S FI from organic-matter-bearing H_2O-dominated medium, position of the I in crystals, features of SI, the I refilling phenomena, the bearing on recrystallization of ores, and Th distribution in single fissure fillings were considered. The ore-forming F were L-hydrocarbon-bearing aqueous solutions of Na-Ca-Cl type with lower Ca contents in the south and higher Ca contents in the north of the region. The ore-forming F had salinities from 0 to c. 23 wt % of NaCl eq. Three types of F were recognized: (1) low-to-moderate salinity [with] high Th, (2) high salinity [with] moderate Th, and (3) low salinity [with] low-to-moderate Th, attributed to ascending F, formation brines, and meteoric descending waters, respectively. The three F mixed during ore precipitation. Mobilization of the F (ascending and partly formation brines) is linked with folding and uplift of the Carpathians to the south of the ore region. A comparison of the Silesian-Cracow deposits with the MVT ones is presented. (Author's abstract)

KOZLOWSKI, A. and METZ, P., 1995, Tourmalinization in Izera Mts., south-western Poland (abst.): Mitt. Österr. Miner. Ges., v. 140, p. 407-408 (in English). First author at Inst. Geochemistry, Mineralogy and Petrography, Warsaw Univ., al. Zwirki I Wigury 93, 02-089 Warszawa, Poland.

Metasomatites in the Izera area developed in pre-Variscan gneisses and consist of albitites (leucogranites), tourmaline-topaz, topaz-quartz- and muscovite greisens with variable amount of fluorite, and quartz metasomatites (Karwowski, 1977; Kozlowski, 1978). The metasomatites are supposed to be connected with the adjacent Karkonosze (Riesengebirge) Variscan granitoid massif. FI were investigated in the main metasomatic minerals, muscovite exclusively[ed?]. Inclusion filling indicated rare activity of pneumatolytic F; metasomatites formed mostly from hydrothermal aqueous solutions, containing <25 vol % CO_2. Salinities of the solutions essentially did not exceed 15 wt % of total salts, except for tourmalines. Freezing determinations, leachate method and electron microprobe analyses yielded mainly an Na-dominated composition with Ca and K. Metasomatites formed at 550-110°C (P-corrected Th) and P of 0.9-0.3 kb, determined from CO_2-bearing I.

Four main kinds of tourmaline (schörl) metasomatites were distinguished, and their FI fall in either the NaCl-$CaCl_2$-H_2O or NaCl-KCl-H_2O systems. (From authors' abstract by E.R.)



Composition of parent fluids of tourmalines from Izera area, plotted on two separate H_2O-NaCl-$CaCl_2$ and H_2O-NaCl-KCl diagrams.

KRASNOZHYMA, Z.V., ZAGNITKO, V.N. and DEMIHOV, Yu.A., 1995, Tin, tin-tungstem [sic], gold-tungsten deposits from different terranes of southern Pamir: Paragenesis, geochemistry and stable isotope systematic: Geol. Soc. Greece, Sp. Publ., No. 4, p.754-756.

FI and FI H isotope data is given. (H.E.B.)

KRAUSKOPF, K.B. and BIRD, D.K., 1995, Introduction to Geochemistry, 3rd ed.: McGraw-Hill, Inc., New York, 647 p.

Devotes five pages to a discussion of the origin and significance of FI to hydrothermal ore deposits. (H.E.B.)

KRAVCHUK, I.F., IVANOVA, G.F., VAREZHKINA, N.S. and MALININ, S.D., 1995, REE fractionation in acid fluid-magma systems: Geokhimiya, no. 3, p. 377-385 (in Russian, English abstract; translated in Geochem. Int'l, v. 32, no. 11, p. 60-68, 1995). Authors at Vernadsky Inst. Geochemistry and Analytical Chemistry, Russian Acad. Sci., Moscow, Russia.

Measurements have been made at 800°C and 2 kb by the capsule method and the use of radioactive tracers on the distributions of the La, Ce, Nd, Tb, Tm, and Lu between aqueous chloride F and M of various types (natural granites and model aluminosilicate M of acid composition). The REE patterns differ and are complicated for the two natural granite specimens, which are similar as regards the main petrogenetic elements but differ in contents of the rare components and volatiles. The differences are particularly large for Th. This shows a positive correlation between the REE partition coefficient and the concentration of NaCl in solution, so there is complexing of Tb with Cl. For model M of Ab-Qz composition, the REE partition coefficients are substantially higher than those in natural granites, they decrease regularly from the light REE to the heavy ones, and they depend on the ratio of sodium to Al in the M. (Authors' abstract)

KREKELER, M.P.S., FRIEHOFF, M., YOST, D.A., HUFF, W.D., YOST, D.A. and CINGOLANI, C., 1995, Alteration and mineralogy of Middle Ordovician volcaniclastic rocks at Del Corral Hill, Argentina (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 2, p. 67. First author at Dept. Geology, Univ. Cincinnati, Cincinnati, OH 45221.

A Middle Ordovician altered pyroclastic bed from the SW section of the Sierras Septantrionales of the Buenos Aires province, Argentina, contains an unusual clay mineral assemblage of kaolinite and berthierine.

Unaltered primary phenocryst minerals of the unit consist dominantly of quartz, and some amphiboles. Quartz grains contain pristine I of glass, primary biotite, and also contain FI. K-feldspar has also been identified; however, it is unclear as to whether the origin of K-feldspar is volcanic, or if it is a product of authigenesis.

The presence of primary quartz, biotite and possible primary K-feldspar, in conjunction with the preserved tuffaceous texture, indicate that the original parent rock was rhyodacitic to rhyolitic. Since the rock consists of ~70% kaolinite, 20% berthierine and 10% primary quartz, large quantities of K, Mg, Fe and Si must have been mobilized from primary glass during alteration. (From authors' abstract by H.E.B.)

KUEHN, C.A. and ROSE, A.W., 1995, Carlin gold deposits, Nevada: Origin in a deep zone of mixing between normally pressured and overpressured fluids: Econ. Geol., v. 90, p. 17-36. First author at IMDEX Inc., PO Box 65538, Tucson, AZ 85717.

Au mineralization at Carlin is clearly younger than hydrocarbon maturation (pre-Cretaceous) and felsic dike intrusion (Cretaceous), and older than deep oxidation (late Tertiary). Within the episode of Au mineralization, the main Au ore (MGO) stage and late Au ore (LGO) stage are distinguished paragenetically, with a variety of vein and mineralization types in each. MGO stage fluids contained 5 to 1 0 mole percent CO_2, appreciable H_2S, and 3 ± 1 wt % NaCl eq. At least portions of MGO stage mineralization were characterized by two-phase boiling (CO_2 exsolution) at 215° ± 30°C and 800 ± 400 bars. In contrast, LGO stage F were G poor with sal. ≤1.5 wt % NaCl eq. and record only nonboiling conditions. MGO stage F had $\delta^{18}O(H_2O)$ values of 5 to 9‰, whereas LGO stage F resembled unevolved meteoric water with $\delta^{18}O(H_2O)$ values ≤-3‰.

From the MGO stage to the LGO stage, calcite $\delta^{18}O$ values shifted from near whole-rock values of 12 ± 3‰ to ~0 ± 1‰ as LGO stage F flooded the system. Jasperoids also record a large range (9-22‰) $\delta^{18}O(H_2O)$ values. These data indicate the involvement of two very different F in ore deposition. Because MGO and LGO stage features are closely associated spatially with each other and with Au, As, Sb, Hg, and other ore elements, both F are believed to have both been present during most stages of ore deposition.

At P of 80 to 85% lithostatic, depths of 3.8 ± 1.9 km are required to accommodate the 800 ± 400 bars of P recorded in MGO stage FI. Carlin, therefore, is not an epithermal or hot spring deposit. CO_2 in G-rich MGO stage F may have originated either directly from buried intrusions or their contact aureoles, or from low-grade regional metamorphism at depth. (From authors' abstract by E.R.)

KUHLEMANN, Joachim and ZEEH, Stefan, 1995, Sphalerite stratigraphy and trace element composition of East Alpine Pb-Zn deposits (Drau range, Austria-Slovenia): Econ. Geol., v. 90, p. 2073-2080. First author at Geological-Palaeontological Inst., Sigwartstrasse 10, 72076 Tübingen, Germany.

The objectives of this paper are to show that if a succession of sphalerites cannot be recognized by their natural color, other optical methods (fluorescence, cathodoluminescence) can give details about the succession of sphalerite. (From authors' abstract by E.R.)

Of pertinence to study of FI in sphalerites. (E.R.)

KUNOV, A., VELINOV, I., YANEV, Y., NAKOV, R. and STEPHANOV, N., 1994, Adularia-sericite type of wall rock alteration of the epithermal Au-Ag mineral occurrence of Obichnik (eastern Rhodopes, Bulgaria): Dokl. na Bulgarskata Akad. na Naukite (Comptes rendus de l'Acad. bulgare de Sci.), v. 47, no. 8, p. 61-64 (in English).

The mineral deposit of this study is located in the northern part of the Zvezdel-Pcheloyad Pb-Zn ore field. Andesites and epiclastic rocks of Oligicene age host the mineralization. Quartz-adularia alteration is connected to the main faults. FI in coarse-grained quartz associated with adularia homogenized between 260-300°C. Fine-grained quartz yielded Th between 230 and 250°C. (Abstract by F. Molnar)

KUPFERSCHMIED, M.P., KLING, M., LOTH, G. and LEWANDOWSKI, K., 1995, The ancient copper deposit of Brenntal (Tauern Window, Austria), *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 283-286. First author at Inst. Allgemeine und Angewandte Geologie, München, Germany.

In the Brenntal area two types of ore mineralisation are present. A first one is a stratiform massive sulfide mineralisation probably of the SEDEX type hosted by the Upper Proterozoic to Lower Paleozoic Habach Group. The second type consists of quartz veins with sulfides bound to Alpine shear zones. This mineralisation was formed during the young uplift of the Tauern Window. (Authors' abstract)

The quartz veinlets contain P aqueous two-phase FI, Th in L. A separate G phase such as CO_2 was not detected. Te = ~-37°C; Tm(ice) = ~-6°C. This points T $FeCl_2$-NaCl dominated F with salinities ~9 wt % NaCl eq. Th is between 150°C and 210°C. This is obviously the minimum Tf of the quartz veinlets and the associated Cu mineralisation. The FI are similar to F from the Habachtal emerald deposit ~7 km to the south of Brenntal, which are correlated with the young uplift of the area. (From authors' text by E.R.)

KÜSTER, M. and STÖCKHERT, B., The thermobarometric potential of fluid inclusions in high pressure metamorphic rocks: Constraints on the exhumation path: Bochumer Geol. U. Geotech. Arb., v. 44, p. 91-98 (English). Authors at Research Group High Pressure Metamorphism, Ruhr Univ., Bochum, Germany.

FI in minerals can be used as geothermal- or geobarometer, if a number of prerequisites are fulfilled. (1) I formation can be related to a specific stage of geologic history; (2) the I has remained a closed system after formation; (3) the volume of the I has not changed after formation; (4) the composition can be properly analyzed; (5) reliable PVT-data are available for this specific composition; (6) one of the two variables, P or T of formation, can be independently estimated.

The principal problems are:

(1) The process involved in formation of the I is derived from microstructural criteria; in many cases some ambiguity remains.

(2) Experimental results suggest that I do not form closed systems at high T, even on laboratory time scales (e.g., Bakker and Jansen, 1991, Sterner et al., 1995). On the other hand, FI with contrasting compositions (not due to immiscibility) are found a few microns apart in natural crystals. Hence, at somewhat lower T a closed system (as a first approximation) is retained over geological times.

(3) Volume changes due to differences between internal and external P (ΔP) are widely reported (e.g., Hollister et al., 1979; Swanenberg, 1980). In many cases they are attributed to decrepitation, which is discernible from microstructural criteria. Diagnostic features are highly irregular shapes (Bodnar et al., 1989; Touret, 1981; Swanenberg, 1980) and healed fractures decorated by small "satellite" I. Volume change by plastic creep ("stretching") of the host mineral has been reported for low strength minerals like fluorite, halite or calcite (e.g., Bodnar and Bethke, 1984; Prezbindowski and Larese, 1987). Microstructural criteria for stretching are not available and the unspecific term "reequilibrated" is generally used to describe I with unexpected densities and lacking criteria for decrepitation.

(4) Microthermometric analysis does not allow the detection of low amounts (<~3 mol %) of volatiles such as CO_2, CH_4 and N_2 in aqueous I. Due to the marked effect on the PVT-relations additional methods to check the composition are essential, e.g., Raman, FTIR or QMS.

(5) Reliable PVT-data are available for simple systems only.

(6) A reliable estimation of one variable, P or T, may be impossible for shallow crustal levels, where P may vary between lithostatic and hydrostatic and focused F flow may create local thermal anomalies. (Authors' abstract)

KUZMIN, D.V., TITOV, A.V. and CHUPIN, V.P., 1995, Temperatures of crystallization and volatiles of A-type magmas (on inclusions in minerals of alkali granites of Bryanskii Massif and their volcanic comagmatites, West Transbaikalia) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 114-115. Authors at Inst. Mineralogy and Petrography, Univ. pr. 3, 630090 Novosibirsk, Russia.

It is supposed that majority of A-type acidic magmas can be formed under the influence of volatiles derived from mantle alkaline basitic magmas. In this study F and Cl in glasses of MI were analyzed by electron microprobe. The composition of G bubbles of M and syngenetic FI was determined by Raman and cryometrical procedure. The T regime of magma crystallization was established by means Th of P MI.

It is shown that liquidus T was ~790-760°C and crystallization finished at 700-680°C. Under these conditions high fluorine (1.5-1.7 wt %) and Cl contents (0.2-0.3 wt %) were determined. L H_2O was visible only in syngenetic FI from the late pegmatoids.

The Bryanskii massif granites can be subdivided into two groups: High T (≤990-960°C) and Cl-rich (≤0.3-0.4 wt %), and low-T (750-700°C) fluorine-rich (1.75 wt %) and probably H_2O-rich. The study of G bubbles of MI showed H_2O along with N_2 in early stages and CO_2 in the late stages.

Trachyandesites of the Tsagan-Khuntey member show high liquidus T (1200-1180°C), low Cl content (≤0.11 wt %) and the absence of fluorine in an initial M. Acidic volcanites of the Tsagan-Khurtey Ridge may be also subdivided into two groups: high-T (1110-1130°C) and low-T (920-735°C). Fluorine content in glasses of these I are relatively high (0.4-0.9 wt %) and approach 1.5 wt % in the low-T I. Cl content in the homogeneous glasses varies from 0.09 to 0.15 wt %.

Inclusions in olivine phenocrysts from basalts homogenize at T = 1320-1280°C. Ti-augite and rhonite were found as dps in these I. Initial M composition refers to subalkaline basalt. Some homogeneous glasses are rich in fluorine (≤0.64 wt %) and poor in Cl. The residual glasses of the unheated I correspond in composition to dacitic M. In these glasses fluorine is absent and Cl content is slightly higher than in initial M.

It is shown that F derived from basalt M on the late stages of olivine crystallization contains mainly CO_2. The F P at this stage was equal to 0.8-1 kb. N_2 predominated in the G bubbles of glassy I in both basalts and acidic rocks.

Data obtained display that basaltic magma could be the source of fluorine during formation of A-type acidic magmas. Formation of high-T, Cl-rich magmas could occur under the influence of trachyandesitic M. (From authors' abstract by E.R.)

KWAK, T.A.P., 1994, Hydrothermal alteration in carbonate-replacement deposits: Ore skarns and distal equivalents, *in* D.R. Lentz, ed., Alteration and Alteration Processes associated with Ore-forming Systems: Geol. Assoc. Canada, Short Course Notes, v. 11, p. 381-402.

Presents a diagram (Fig. 13) showing the generalized variation of sal. and T for various assemblages taken from >30 deposits (literature data). This shows a decrease in both parameters from garnet-pyroxene, amphibole-epidote, biotite, chlorite-muscovite, sulfide, and carbonate facies. (E.R.)

KWONG, M.H., 1995, Salinity and stable isotope constraints for the composition of Devonian seawater: Evidence from marine calcite cement sequences in Upper Devonian reef complexes, Canning Basin, Western Australia: unpub. Masters thesis, Univ. Texas, Austin, Texas, 140 p.

Salinity determinations on P, single-phase FI indicate that (1) the diagenetic F responsible for cement precipitation are consistent with slightly sub-normal to saline seawater; and (2) salinities fluctuated temporally from older to younger cement zones. $\delta^{18}O$ values of correlated cement zones reveal temporal variations in the isotopic composition of the marine cements and are consistent laterally over a distance of 625 m at Dingo Gap, suggesting that the cements may also be recording changes in the isotopic composition of seawater. Salinity-T-$\delta^{18}O$ models suggest that a $\delta^{18}O$-depleted Upper Devonian seawater is necessary to account for the geochemical constraints placed by salinity and stable isotope results. (From author's abstract by E.R.)

KYLE, J.R. and BODNAR, R.J., 1995, Fluid inclusion studies of porphyry-skarn ore formation, Gunung Bijih (Ertsberg) District, Irian Jaya, Indonesia (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-65.

Reconnaissance FI studies have been conducted on various mineralized zones within the Ertsberg District. Because of the variety of mineralized bodies and their considerable three-dimensional extent, plus their complex paragenetic relationships, FI studies have much potential to contribute to the detailed understanding of the hydrothermal evolution of this world-class district. FI investigations consisted of: (1) petrography to characterize their origin, (2) thermal and compositional data, (3) analysis of selected elements using synchrotron x-ray fluorescence. Measurements of Th(V) in multiphase FI in stockwork quartz within the potassic alteration zone of the Grasberg porphyry Cu-Au deposit indicate a range from ~400° to 700+°C with ≤70 wt % total salts and Na/(Na + K) ranging from 0.68 to 0.90. Chalcopyrite, magnetite, and hematite dxls are common in the salt-bearing I; V-rich I co-exist with multiphase I in many samples. SXRF analyses of early "magmatic" FI in the Grasberg quartz stockwork indicate high concentrations of Cu, as well as Zn, Pb, and Mn that appear distal and paragenetically late with respect to the Cu- rich stockwork ore zone. FI in Zn-Pb-Ag-fluorite mineralized zones in carbonate strata peripheral to the Grasberg intrusive complex have Th V from 140 to 270°C and variable salinities. Halite-bearing I are present locally in fluorite, whereas other I have Th V of 190°C with salinities <1 wt %.

FI in prograde calc-silicate minerals, e.g., monticellite and clinopyroxene, from the Dom and Big Gossan skarns near the margins of the Ertsberg pluton contain halite-bearing I that homogenize in the range of 370 to 510°C. Paragenetically late quartz and calcite have Th V from 260 to 330°C and salinities of 6 to 17 wt %. These data suggest complex hydrothermal systems that evolved from metal-rich hypersaline F sourced from magmatic centers that were cooled and diluted by heated meteoric water during the late and distal stages of mineralization. (Authors' abstract)

KYLE, J.R. and SAUNDERS, J.A., 1995, Diverse styles of sediment-hosted mineralization in the Gulf Coast basin (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 2, p. 67-68. First author at Dept. Geological Sciences, Univ. Texas, Austin, TX 78712.

The geologically young Gulf Coast basin contains many components generally regarded as critical elements for the formation of sediment-hosted orebodies, including metal-rich oil field brines, petroleum reservoirs, various H_2S sources, and F migration pathways such as permeable formations and growth faults. Zn-Pb-Ag sulfide concentrations have been identified within salt dome cap rocks and shelf carbonates in the Gulf Coast. These metal deposits have a genetic affinity with MVT deposits that typically occur in older sedimentary terranes, although cap rock deposits have some similarities with SEDEX-style mineralization.

Geologic, stable isotope, and reaction-path geochemical modeling studies support a cap rock mineralization model whereby the "exotic" mineral suite is the result of episodic introduction of deep-sourced, relatively hot, metal-bearing brines into the upper salt dome environment. The S reservoir in the shallow, cool, cap rock environment is controlled by alternating periods of bacterial sulfate reduction and inorganic anhydrite dissolution (or by mixing with seawater). Mixing of brines with abundant H_2S produced by bacterial sulfate reduction leads to rapid precipitation of dissolved metals as metallic sulfide minerals, with residual sulfate fixed as sulfate minerals.

Zn-Pb sulfide occurrences are widespread within the Upper Jurassic Smackover Formation in southern Arkansas, including a particularly well mineralized intercept at a depth of ~2.5 km. Sulfides form complex replacement and pore-filling textures and are locally associated with styolites. FI and S isotope data indicate precipitation from Na-Ca-Cl brines in a range of 100 ± 20°C. Textural evidence indicates that at least some sulfide mineralization postdates maximum burial and compaction. Thus, the Smackover sulfide concentrations not only are presently at depths >2.5 km, but mineralization also took place at these depths. Therefore, Smackover Zn-Pb sulfide concentrations represent one of the youngest and deepest examples of MVT mineralization. (From authors' abstract by H.E.B.)

LAGACHE, M., DUJON, S.-C. and SEBASTIAN, A., 1995, Assemblages of Li-Cs pegmatite minerals in equilibrium with a fluid from their primary crystallization until their hydrothermal alteration: An experimental study: Mineral. and Petrol., v. 55, p. 131-143. Authors at Laboratorie de Géologie, Ecole Normale Supérieure, Paris, France.

Hydrothermal alteration of alkali-rich pegmatites gives rise to secondary minerals: for example spodumene + quartz replace petalite, cesian analcime crystallizes at the expense of pollucite and albite. Earlier experiments were performed at 450° and 600°C to determine the composition of the hydrothermal solution in equilibrium with Na-Li-Cs bearing minerals during their primary crystallization. New experiments performed at 330°C extend the previous results. (From authors' abstract by E.R.)

LAI, Yong, 1995a, Metallogenic conditions and processes of the Wendeng gold deposit, Shandong province—The application of cathodoluminescence to fluid inclusion study: Mineral Deposits (Kuangchuang Dizhi), v. 14, no. 3, p. 281-289 (in Chinese, English abstract). Author at Dept. Geology, Peking Univ., Beijing 100871, PRC.

The Wendeng Au deposit occurs within a shattered alteration zone of a fault. The cathodoluminescence of quartz shows that the alteration might be divided at least into three stages, with mineralization closely related to the first and second stages. Detailed p-t-v-x parameters of ore-bearing F were obtained from FI trapped in the growth zone of minerals. The orebody location mechanism and metallogenic dynamics were determined, suggesting that tectonism heated meteoric water to form ore-bearing F, and the two depressurization and boiling events of open-system F led to Au precipitation. (From author's abstract by E.R.)

See also next item. (E.R.)

LAI, Yong, 1995b, Ore-forming conditions and the process of gold mineralization of Wendeng gold deposit, Shandong: Application of cathodo-luminescence in fluid inclusion studies: Chinese J. Geochem., v. 14, no. 2, p. 179-187 (in English). Author at Dept. Geology, Peking Univ., Beijing 100871, PRC.

The Wendeng Au deposit is located 30 km NW of Wendeng City, Shandong Province, occurring in a brecciated alteration zone in the footwall of the NNE-striking fault (F1). It consists of quartz, pyrite, specularite, potash feldspar, sericite, carbonates and chlorite hosted in Proterozoic biotite-plagioclase gneiss.

Three generations of quartz are recognized based on cathodoluminescence and micro-morphology. Systematic studies of FI provide data to establish P-T-V-X relations for the F evolution in mineralization process. It is concluded that the ore-forming solution was evolved from meteoric water through thermal events during Mesozoic tectonics. The precipitation of Au was related to two boiling events. (Author's abstract)

See previous item and FIR, v. 27, p. 72. (E.R.)

LAL, D., 1994, Helium isotopic information from diamonds: Critical data available and needed, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 245-260. Author at Scripps Inst. Oceanography, Geological Research Div., La Jolla, CA 92093.

Previous studies on He isotopic compositions in diamonds recovered from principal global mining sites have clearly established that individual diamonds usually contain, besides the He incorporated in them at the time of their formation, He (both 3He and 4He) from a number of sources: implantation of 4He after emplacement in the earth's crust, and 3He produced by radiogenic and cosmic-ray induced nuclear reactions within the diamond. The gains/losses due to additions of 3He and/or 4He in the diamond make it difficult to unambiguously use the He isotopic data in diamonds to obtain information on the temporal variation in the isotopic composition of the upper mantle. Besides, effects of diffusion during their sojourn in the mantle may make this task impossible!

In this paper I present results of "model" calculations and "statistical" analyses of the available He data in diamonds, and show that in principle it is possible to filter out most of the noise arising from additions due to various sources of 3He and 4He discussed above, but that alterations due to diffusion in the mantle itself would limit the usefulness of the diamond for delineation of He isotopic composition at accretion. Finally, the various processes considered suggest themselves how we may obtain much improved, relatively noise-free He isotopic data from diamonds. (From author's abstract by E.R.)

LAMB, J.B., 1995, A petrographic and fluid inclusion study of the Purple Vein and Post-Betze orebodies, Carlin, Nevada: Unpub. Masters thesis, Univ. Nevada, Las Vegas, NV.

The Purple Vein (Meikle Mine) and Post/Betze orebodies are two Carlin-type, sediment-hosted, disseminated Au deposits. They display important differences in size, alteration, silicification, pyritization, and Au grade. The paragenesis of each deposit is divided into three stages: (1) The Early Mineralization Stage is primarily comprised of quartz and pyrobitumen ± barite, sphalerite, sulfosalts, quartz and pyrite. Salinities of the early F in both deposits are 11 to 20 wt % NaCl eq. (2) The Gold Ore Stage contains primarily quartz, pyrite, marcasite and Au ± arsenopyrite, stibnite, micas and clays. (3) A Late Gold Ore Stage is represented by calcite, barite, quartz, pyrite, marcasite and stibnite; Gold Ore Stage FI in quartz have salinities of < or =10 wt % NaCl eq.; minimum Tt modes of 200° to 225°C and 150° to 180°C and 200° to 210°C. Dominantly aqueous I containing minor CO_2 show clathrate and CO_2 melting at -56.6°C. Some CO_2-rich FI have Th(L) 19.5° to 25.4°C (Purple Vein) and 10.6° to 20°C (Post/Betze). Thus, there are only slight variations between the two deposits. Phase equilibria constraints indicate minimum P of 750 to 800 bars and minimum depths of 2.8-3.0 km. (From authors' abstract by E.R.)

LAMB, W.M., 1995, The stability of carbonates in granulite facies gneisses: implications for the formation of CO_2-rich fluid inclusions (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-315.

Mineral assemblages that characterize the granulite facies were stabilized at relatively high T and P, and low fugacities of H_2O (fH_2O). Various mechanisms have been proposed to account for low fH_2O in granulites, including: (1) partial melting, (2) infiltration of CO_2, and (3) recrystallization of lithologies that were anhydrous prior to metamorphism. CO_2-rich FI occur within granulite facies terranes throughout the world, and their presence has sometimes been taken as evidence for CO_2-infiltration.

A review of 39 publications that describe granulite facies FI has revealed that 14 of these studies report the presence of carbonate minerals. These carbonates occur in quartzo-feldspathic gneisses (not marbles) which contain Qtz + Pl + Opx ± Grt ± Cpx ± Kfs ± Bt ± Amph (abbreviations after Kretz, 1983, Am. Mineral.). In many, but not all, cases the carbonates are thought to be part of the peak metamorphic assemblage and are intimately associated with CO_2-rich FI. These carbonates occur within FI (dxls), and as solid I within minerals such as Grt, Pl, Qtz and Crd.

The program THERMOCALC (Holland and Powell, 1990) was employed to calculate the stability of the following end-member equilibria: (1) Cal + Qtz + En = Di + CO_2, (2) Cal + Qtz + Fs = Hd + CO_2, (3) Dol + Qtz = Di + CO_2, (4) FeDol + Qtz = Fs + CO_2, (5) Sd + Qtz = Fs + CO_2, and (6) Mgs + Qtz = En + CO_2. These equilibria lie between ~40 and 120°C below granulite facies T (at $XCO_2 = 1$), indicating that carbonates are not stable in granulite facies Ort + Opx-bearing gneisses. However, rigorous evaluation of the stability of carbonates in any given rock requires estimation of the relevant end-member activities. Touret and Hansteen (1988) describe I of Fe-rich Dol in garnets which also contain FI (Doddabetta, S. India), and their published chemical analyses for Grt, Opx, and Pl provide the basis to calculate the stability of the FeDol. The stability of the equilibria Alm + FeDol + Qtz = Fs + An + CO_2 was calculated using their analyses and various activity models. The composition of the Fe-rich Dol is not reported, however, for FeDol activities ranging from 0.2 to 1.0 the equilibria in question lies ~125 to 180°C below peak T at peak P. Thus, the carbonate is not stable under peak conditions, and may be retrograde. The association between carbonates and CO_2-rich I indicates that the FI were modified or formed after the peak of granulite metamorphism. (Authors' abstract)

LAND, L.S., 1995, Na-Ca-Cl saline formation waters, Frio Formation (Oligocene), south Texas, USA: Products of diagenesis: Geochim. Cosmochim. Acta, v. 59, p. 2163-2174.

LAND, L.S., EUSTICE, R.A., MACK, L.E. and HORITA, Juske, 1995, Reactivity of evaporites during burial: An example from the Jurassic of Alabama: Geochim. Cosmochim. Acta, v. 59, p. 3765-3778.

The Jurassic Louann sail was the first significant sedimentary unit to accumulate in the Gulf of Mexico sedimentary basin. Br/Cl and $^{87}Sr/^{86}Sr$ ratios of halite from a single core into the top of the formation record the evaporation of normal seawater to bittern stage. The bittern zone today consists of intergrown halite and sylvite. The Br and Rb contents of the solid phases, along with $^{87}Sr/^{86}Sr$ ratios and Rb/Sr systematics, are inconsistent with precipitation of the existing phases from seawater evaporated in Jurassic time. Rather, petrography and FI and solid phase chemistry from the bittern zone is consistent with postdepositional water/rock interaction which diagenetically modified a marine bittern assemblage to halite + sylvite. The chemistry of the Br- and Rb-rich saline formation waters characteristic of this area today, likewise, may reflect water/evaporite interaction during burial. (Authors' abstract)

Twelve analyses of FI, from chevron halite, for Li, Na, K, Mg, Ca, Cl and Br, are given in millimoles/kg. SO_4 is absent. (E.R.)

LANG, J.R., STANLEY, C.R. and THOMPSON, J.F.H., 1995, Porphyry copper-gold deposits related to alkalic igneous rocks in the Triassic-Jurassic arc terranes of British Columbia, *in* F.W. Pierce and J.G. Bolm, eds., Porphyry Copper Deposits of the American

Cordillera: Arizona Geol. Soc. Digest, v. 20, p. 219-236.

The deposits fall into two groups, associated with silica-saturated or feldspathoid-bearing rocks. The eight differences between both these types and the more common calc-alkalic deposits are listed; the similarities include the characteristics of the FI.

Limited FI studies are quoted from the literature for Galore Creek and Copper Mountain, and unpublished data on Mount Pelley. (E.R.)

LANGE, I.M., KROUSE, H.R. and WOODWARD, L.A., 1995, The Golden Messenger mine, York district, Montana: Geologic and isotopic constraints: Econ. Geol., v. 90, p. 1322-1328. First author at Geology Dept., Univ. Montana, Missoula, MT 59812.

The Golden Messenger deposit is a ladderlike vein system hosted mostly within a Late Proterozoic quartz diorite dike. Th was determined on the four usable PI within three quartz veinlets. These I, 1 to 2 μm in length, had reproducible Th of 210°, 268°, 290°, and 367°C and no dms. (From authors' abstract by E.R.)

LANGMEAD, R.P. and McLEOD, R.L., 1991, Characteristics of the Tolukuma Au-Ag deposit, *in* R. Rogerson, ed., Proc. PNG Geology, Exploration and Mining Conference 1991, Rabaul, p. 77-81: Australasian Inst. Mining and Metallurgy, Melbourne. First author at Newmont Australia Ltd., 339 Coronation Dr., Milton 4064, QLD, Australia.

The Tolukuma Au-Ag prospect has outcrops of epithermal "adularia-sericite" style mineralisation >1200 m within an *en echelon* quartz veined zone 1 to 10 m wide. At a 4 g/t cutoff grade, a geological resource of ~1.47 Mt @ 13.77 g/t Au is indicated.

P FI homogenisation data from quartz indicate a temperature of deposition of 220-260°C in the mineralised zone. Alteration is characterised by a regional propylitisation of the volcanic suite, overprinted by structurally controlled phyllic and argillic alteration.

Au and Ag mineralisation is accompanied by significant, but highly variable amounts of arsenic, antimony and Hg. Adularia is a common accessory associated with vein quartz. (From authors' abstract by H.E.B.)

LARSEN, R.B., BURKE, E.A.J., DOBRZHINETSKAYA, L.F., EIDE, E.A. and STURT, B.A., 1995, N_2-CO_2-CH_4-H_2O metamorphic fluids in microdiamond-bearing lithologies from the Western Gneiss Region in Norway: Norges Geologiske Undersøkolse Bull. 247, p. 41-43. First author at Geol. Surv. Norway, PO Box 3006-Lade, N- 7002 Trondheim, Norway.

Previous studies of volatiles in metamorphic lithologies from the Western Gneiss Region (WGR) in Norway document that eclogite- and granulite-facies metamorphism is associated with mixtures of CO_2, N_2 and H_2O F (e.g., Andersen et al., 1993). Our study of microdiamond-bearing granulites from the island of Fjortoft supports this conclusion but also documents a strongly reducing volatile regime, with CH_4 as a significant constituent, during parts of the metamorphic history. (Authors' abstract)

LARTER, S.R. and 7 others, 1995, Reservoir geochemistry as a reservoir appraisal and management tool: An evaluation (abst): AAPG Bull., v. 79, no. 8, p. 1228.

Indexed under FI. (E.R.)

LAYNE, G.D., CHARLAND, A.P. and STIX, J., 1995, Melt inclusion evidence for small shallow magma chambers and open system volatile loss from modern eruptions of Nevado Del Ruiz, Colombia (abst.): Eos, v. 76, no. 17, p. S268-S269. First author at Inst. Meteoritics, Univ. Nex Mexico, Albuquerque, NM 87131.

The November 13, 1985, eruption of Nevado Del Ruiz ejected ~0.03 km^3 of mixed pumice (EOS, 67(16), 405. 1987). Published models suggest a magmatic system which contained discrete volumes of both andesitic melt and overlying, or marginal, dacitic melt at depth (JVGR, 41, 127-151, 1990).

Ion microprobe analyses of MI in plagioclase and pyroxene phenocrysts show a similar range of H_2O contents (1.3-3.9 wt %) in samples of both dacitic ("high-SiO_2") and andesitic ("low-SiO_2") melt volumes. These same I show evidence of H_2O saturation, implying entrapment depths spanning 0.5-3.5 km. Low-SiO_2 I and matrix glasses have higher S contents (140-365 ppm and 230-570 ppm) than high-SiO_2 I (45-145 ppm) or silicic matrix glass (35-115 ppm). Within the analyzed population of high-SiO_2 I S, F and Cl all show a broad negative correlation with SiO_2 content. MI from the subsequent September 1, 1989, eruption have higher H_2O contents (2.7-5.0 wt %), suggesting a somewhat deeper (2-5 km) origin for this magma.

The volatile contents of MI are consistent with the development of bimodally zoned magmas originating in relatively shallow but vertically extensive (dike-like) chambers. Water, halogens and S were all being lost pre-eruptively by open-system degassing. The presence of an array of such shallow, crystallizing magma chambers could account for the continuing high flux of S from the Ruiz edifice. (Authors' abstract)

LEBRUN, P., BILLIOTTE, J., DEVEUGHELE, M. and LE CLEAC, H.J.M., 1995, Local increase of rock salt porosity by coalescence of fluid inclusions under the effect of a temperature gradient: Comptes Rendus de l'Academie des Sciences, Serie II. Sciences de la Terre des Planetes, v. 321, no. 7, p. 555-561 (in French, English summary).

LEE, Insung and RIPLEY, E.M., 1995, Genesis of Cu-Ni sulfide mineralization in the South Kawishiwi intrusion, Spruce Road area, Duluth Complex, Minnesota: Canadian Mineral., v. 33, p. 723-743. Authors at Dept. Geological Sciences, Indiana Univ., Bloomington, IN 47405.

The proposed model for the genesis of the sulfides involves the mixing of S derived from two sources, accumulation of immiscible sulfide L, and emplacement of sulfide-saturated magmas. (From authors' abstract by E.R.)

LEE, Mingchou, LEWANDOWSKI, Juergen and KINZEL, Martin, 1995, Reservoir heterogeneity due to fault related diagenesis in NW Germany (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 251.

Indexed under FI. (E.R.)

LEE, W.-J. and WYLLIE, P.J., 1995, Experimental data bearing on liquid immiscibility, crystal fractionation, and the origin of calciocarbonatites and natrocarbonatites: Int'l Geol. Rev., v. 36, no. 9, p. 797-xxx.

LEGENDRE, O. and GIRARD, J.P., 1995, Constraints on temperatures of quartz and carbonate cementation in the Middle Jurassic Oseberg reservoir (northern North Sea) derived from fluid inclusions (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 116-117. Authors at BRGM, BP 6009, 45060 Orléans cedex 02, FRANCE.

These coarse to medium-grained and immature sandstones are interpreted as representing proximal, marine-dominated delta fan deposits bracketed by alluvial deposits. The burial history of the reservoir is typical of many Brent reservoirs in the North Sea and characterized by a initial period of slow subsidence or local uplift (late Jurassic to early Cretaceous) followed by a rapid subsidence (22 m/my) up to present day.

The main successive events are as follows: early precipitation of minor siderite and pyrite, and K-feldspar overgrowth; sporadic precipitation of ankerite cement; extensive and pervasive dissolution of detrital and diagenetic feldspars; ubiquitous crystallization of intergranular vermiform kaolinite together with discrete precipitation of quartz overgrowths; development of porosity-occluding, poikilotopic Fe-rich calcite, in areas which appear lens-like; and precipitation of dickite (recrystallization of kaolinite?) restricted to the water-filled part of the formation.

K-feldspar, quartz and carbonate cements were systematically investigated for FI. However, two-phase I suitable for microthermometric measurements were found in ankerite, quartz and calcite only. Observations under UV fluorescence microscope indicate that hydrocarbon-bearing I are present in quartz and calcite in association with aqueous (non fluorescent) I. Th were measured for both types of I and yielded similar results for a given sample.

One sample of ankerite showed Th of 66 to 76°C (av. 72°C).

Most FI in quartz occur at the boundary between the detrital grain and the diagenetic rim. In a few instances I were also found within the overgrowth but yielded identical Th; these results suggest that a positive T trend may have existed from South to North at the time the quartz cement formed. Alternatively, diagenetic quartz may have formed at slightly different times, i.e., different depths. Three measured freezing T indicate salinities ~3-4 wt % eq. NaCl.

FI in diagenetic calcite occur either as isolated, scattered inclusions or in small clusters. Th values range from 88 to 100°C (avg. = 92°C), 91 to 107°C (avg. = 97°C) and 101 to 112°C (avg. = 106°C), successively from North to South, a trend opposite to that observed for quartz. Similarly, it may relate to different ages of calcite formation as well. Freezing T indicate salinities on the order of 2 to 4 wt % eq. NaCl.

Because Raman spectroscopy indicates unambiguously the presence of CH_4 in the V phase of a few aqueous I and because the reservoir contains a gas cap, it is likely that the aqueous solution in the I is CH_4-rich. As a consequence, Th values may be approximated as close representatives of TT.

The results therefore indicate that ankerite formed at lower T than quartz and calcite, i.e., earlier in the diagenetic sequence. This is in agreement with petrographic observations. Quartz formed at T lower than calcite on average. Both quartz and calcite formed at T either slightly lower or similar to present reservoir T, in agreement with a late diagenetic precipitation. Combining FI T with the modeled burial-thermal history for the Oseberg reservoir indicates that ankerite most likely formed during early Tertiary times, while quartz and calcite did not formed before mid-Tertiary times. (From authors' abstract by E.R.)

LEITCH, C.H.B., ROSS, K.V., FLEMING, J.A. and DAWSON, K.M., 1995, Preliminary studies of hydrothermal alteration events at the Island Copper deposit, northern Vancouver Island, British Columbia, *in* Current Research 1995-A: Geological Survey of Canada, p. 51-59.

Three main stages of intrusion, are suggested (early, intermediate, late), defined by differences in alteration intensity. Chalcopyrite was introduced in several stages: minor with Mg-biotite, followed by main-stage disseminations/fracture fills accompanying quartz veins, some with biotite envelopes, and finally with epidote-chlorite and pyrite-chalcopyrite filled fractures. FI in quartz-magnetite veins are highly saline (multiple daughter products); in quartz-chalcopyrite veins saline (halite only); in reopenings associated with epidote less saline (L/V only). (Authors' abstract)

LEITCH, C.H.B., TURNER, R.J.W. and SHAW, D.R., 1995, Fluid evolution of the Vent complex, Sullivan stratiform sedimentary Zn-Pb-Ag deposit, B.C. (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-58. First author at Geol. Surv. Canada, 100 W. Pender St., Vancouver, B.C., Canada.

Ore formation at Sullivan has been modeled from evidence in the vent zone, were F responsible for mineralization are recorded by alteration assemblages and FI. F evolution included several hydrothermal stages: (1) main stage ore formation (footwall tourmalinite alteration and pyrrhotite network, seafloor sulphide body, metasomatic pyrrhotite body); (2) late main stage (trace-metal rich network, chlorite or muscovite alteration); and (3) post-ore albite-chlorite-pyrite-calcite alteration associated with shallow level gabbro emplacement.

Alteration and FI studies suggest that main stage ore deposition was from saline brines, 15-30 wt % NaCl + $CaCl_2$ + ?$MgCl_2$ at 300-350°C, that were able to transport Pb and Zn in significant quantities as chloride complexes. These F were in equilibrium with tourmaline and probably deposited tourmaline below, and to a lesser degree at, the seafloor. Ongoing hydrothermal upflow locally replaced the Pb-Zn sulphides of the orebody with massive pyrrhotite. Late main stage hydrothermal upflow resulted in local trace metal enrichment of the footwall and sulphide body, and altered tourmalinite to chlorite-pyrrhotite and muscovite. Post-ore F of lower salinity and T (10-15 wt % NaCl+?KCl, 250°C) resulted in albite-chlorite-pyrite-calcite alteration in the footwall, ore zone and hangingwall, coincident with the emplacement of gabbro dykes and sills. Fracture controlled chlorite-pyrite overprints hangingwall albite alteration and is interpreted to represent collapse of the Na-brine plume and ingress of Mg bearing seawater into the hydrothermal system.

The vent zone is surrounded by a Mn enrichment halo in garnet, carbonate, and chlorite. Calcic minerals such as plagioclase, tremolite and diopside are anomalous in the ore layers. The finely laminated nature of the major portion of the bedded ores, in which details of stratigraphy can be followed for up to 2 km, could reflect either brine pool precipitation or plume fallout; however, high salinities in the FI are like those of the Red Sea brine pools (13.5-25.6%) and underlying anhydrite veins. At Sullivan, the presence of scapolite with a composition near dipyre (Cl-rich, Na > Ca), garnet coticule-bearing rocks and hypogene Fe-oxide-hydroxide minerals such as goethite and magnetite, all suggest a brine pool setting. Evaporites provide an attractive source for the high salinities of the FI and the Cl content of the scapolite. Although the base evaporites would be expected at the base of the section in a rift basin. (From authors' abstract by H.E.B)

LENTZ, D.R., editor, 1994, Alteration and alteration processes associated with ore-forming systems: Geol. Assoc. Canada Short Course Notes, v. 11, 467 p.

Pertinent to many FI studies. (E.R.)

LEOST, I., RAMBOZ, C., BRIL, H., FERNANDEZ, A. and MARTIN, P., 1995, Fluid-rock interactions in the Ardeche margin: Results from the Morte Merie borehole (deep geology of France program) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 201.

Fracture-fillings are so far related to four phases: (1) At the burial stage, barite crystallization at level -200 predates the major movement of the Uzer border fault, of presumed Hettanginan age. FI in diagenetic anhydrite (-342 m) trap a cold (Th<60°C), diluted F (1 to 15 wt % eq NaCl), with a probable meteoric component [1]. The outer rims of diagenetic dolomite crystals (-295 m) trap hotter (63°<Th<102°C) and salt-enriched F (8.5 to 22 wt % eq. NaCl), compatible with F mixing at the maximum burial accepted for the pile (burial 2000 ± 500 m; thermal gradient of 35°/km [2]). (2) Moreover, some replacement minerals and fracture-fillings are considered to correspond to hydrothermal events contemporaneous with the extension period of the margin, by analogy with available datings in the Cévenole margin. At -342m, quartz, which replaces diagenetic anhydrite, yields variable salinities (14 to 23 wt % eq. NaCl), consistent with F mixing, and 83°<Th<127°C in excess of the maximum admitted diagenetic T. Small vertical dolomitic veins at -191 and -130m trap pulsating F with constant composition (mainly 11 and 16 wt % eq. NaCl) and variable T (103<Th<173°C), in thermal disequilibrium with the wall-rock. (3) Fibrous gypsum in cm-wide horizontal veins crosscutting the Anisian-Carnian formations crystallized from cold pressurized F, in a stress field with $\sigma 1$ horizontal. These fractures, which necessarily formed after the erosion of the top of the sedimentary pile, are tentatively related to a Cenozoic compressive episode (pyrenean?). (4) Some late anhydrite (-279; -369 m) and barite (-69 m), which clearly postdate fibrous gypsum, could represent remobilizations of earlier-formed sulfates.
[1] Renac C., Thèse Université de Poitiers, 1994, 205 p.
[2] Disnar J.R., Terra Abstracts, 1993, 5, no. 1, p.649.
(From authors' abstract by E.R.)

LEOST, I., RAMBOZ, C., MOSSMANN, J.R. and BRIL, H., 1995, Fluid palaeocirculations in a passive margin of the southeast basin of France. Preliminary results of fluid inclusions and stable isotopes in the Morte Merie-1 borehole (Ardeche) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 118-120.

Th and Tm ice on FI in anhydrite, dolomite and quartz from veins (and stratabound) were used to reveal circulation patterns, depths of trapping, and F origins. Isotopic (C, O, S) data on host minerals were also obtained. The data have been complicated by FI leakage and host recrystallization. (E.R.)

LEPEZIN, G.G. and OSORGIN, N.Yu., 1994, Natural cordierite outgassing kinetics: Determination of H_2O diffusion coefficients under isothermal conditions: Dokl. Ross. Akad. Nauk, v. 339, no. 5, p. 658-661 (in Russian). Authors at Inst. Mineralogy and Petrography, Siberian Div., Russian Acad. Sci., Novosibirsk, Russia.

The coefficients of diffusion of water D in four natural specimens differing in composition, distortion parameters and formation conditions were determined. (E.R.)

LEPEZIN, G.G., OSORGIN, N.Yu. and SHVEDENKOV, G.Yu., 1995, Natural cordierite outgassing kinetics: Determination of CO_2 diffusion coefficient under isothermal conditions: Dokl. Ross. Akad. Nauk, v. 342, no. 1, p. 92-94 (in Russian).

LESPINASSE, M. and CATHELINEAU, M., 1995, Paleostress magnitudes determination by using fault slip and fluid inclusions planes data: J. Geophys. Res., v. 100, no. 3, p. 3895-3904. Author at CREGU, Centre de Reserches sur la Geologie des Matieres Premieres et Energetiques, Vandoeuvre les Nancy, France.

Paleostress magnitudes can be estimated by using fault slip data, rupture and friction laws (Angelier, 1989) for dry conditions. However, their estimation is difficult if F are present during deformation, the lithostatic load and the F P being generally unknown. This paper shows that the quantitative estimation of the lithostatic load and the F P during a tectonic event can be derived from paleofluid analysis in FIP. As FIP are healed mode I cracks oriented in a consistent manner relative to regional or local structures, stress and F features may be obtained for a given deformation event. This approach has been applied to a fault system affecting an Hercynian granite of the NW French Massif Central. (From authors' abstract by E.R.)

LEUNG, I.S., LI, Y.L. and HAN, Z.G., 1995, A comparative study of SiC crystals from Kiberley and Fuxian (abst.): Eos, v. 76, no. 17, p. S155. First author at Dept. Geology and Geography, Lehman College, CUNY, Bronx, NY 10468.

We crushed 1 kg of kimberlite from Kiberley, South Africa, and recovered 17 α-SiC (6H polytype) crystals. One crystal contains two linear F (M) I tubes, and graphic intergrowths of rutile exhibiting a decussate texture. Both phenomena indicate a melt-grown origin. Our study indicates that SiC may form in environments ranging from highly to mildly reducing. In experimental studies, plastic deformation was observed in SiC and diamond at T of at least 1400° and 1600°C, respectively. On the basis of these results, natural SiC might have come from a depth of >400 km, located in the transition zone of the mantle. (From authors' abstract by E.R.)

LEUNG, I.S., TSAO, C.S. and HAN, Zhuguo, 1995, Inclusions of immiscible melts and quartz trapped in diamonds from Fuxian, China (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-365.

In a study of diamonds from Fuxian, China we found several I (20-200 µm in size) whose chemical composition in silica (SiO2). Their colors range from colorless , pale yellow to gray. Two of the I contain numerous brown and colorless globules of melt (glass). By means of SEM/EDS, X-ray diffraction and electron microprobe techniques, we confirmed that three of the I are crystals of quartz. A turbid, gray I showed only smeared-out rings of X-ray diffraction intensity. Such an X-ray pattern may be derived from a devitrified glass, or, from a high-P silica phase which, being very unstable at ambient T and P, have suffered lattice disruption and changes akin to metamictization. Trapped in this gray I are brown, Ca-Fe-rich glass spherules 10-15 µm in diameter, and many minute, colorless ones. In another diamond, we also found two types of melts trapped in an I of quartz in which the brown glass is enriched in Ca-Fe-Mn, while the colorless glass is composed of SiO_2.

In the diamond containing the turbid, gray I described above, we also found a crystal of clinopyroxene intergrown with a quartz-biotite-rutile assemblage. From another diamond, a plate yellow I of silica shows an X-ray pattern of quartz displaying a mosaic structure. As it is often difficult to quench coesite completely in experiments, this mosaic crystal seems to be an inverted coesite originally captured by the diamond host at high P in the mantle of the earth. Our results may be important to studies of L immiscibility in the mantle and kimberlite genesis. (Authors' abstract)

LEWCHUK M.T. and SYMONS, D.T.A., 1995, Age and duration of Mississippi Valley-type ore-mineralizing events: Geology, v. 23, no. 3, p. 233-236. First author at Dept. Earth Sciences, Univ. Western Ontario, London, Ontario N6A 5B8, Canada.

Statistics of a combined paleomagnetic data set from six studies of MVT deposits and their surrounding host rocks show that the characteristic remnant magnetization of the host rocks predates the magnetization of the mineralization, providing a positive contact test confirming that the ore magnetization is primary. Either multiple F or dramatic changes to a single F through time are required to account for the separate magnetization ages observed in the host rocks and ores. The dispersion of the characteristic remnant magnetization directions provides an estimator for the duration of the mineralizing process, suggesting a mineralizing event of about 4 m.y. duration. (Authors' abstract)

LI, Baohua and CAI, Jianming, 1995, Physicochemical conditions of mineralization and the transportation and deposition of Au in Planyanzi gold deposit: J. Chengdu Inst. Tech., v. 22, no. 2, p. 89-95 (in Chinese).

LI, Chusi, BARNES, S.J. and FLEET, M.E., 1995, Fractional crystallization of anhydrous sulfide liquid in the system Fe-Ni-Cu-S, with application to magmatic sulfide deposits: Discussion and reply: Geochim. Cosmochim. Acta, v. 59, p. 3863-3870.

Pertinent to FI of immiscible sulfide melt. (E.R.)

LI, Shengrong, CHEN, Guangyuan, SHAO, Wei and SUN, Daisheng, 1995, A study on the relative optical densities of CO_2 and H_2O in quartz from Rushan gold mine, Jiaodong: Acta Mineralogica Sinica (Kuangwu Xuebao), v. 15, no. 1, p. 97-103 (in Chinese, English abstract).

The relative optical densities [sic] of CO_2 and H_2O in quartz have been studied, revealing that DH_2O forms two decreasing cycles and DCO_2 forms two low-high-low evolution cycles in the whole ore-forming process. This provides strong evidence for the division of two metallogenic periods. The negative correlation between DH_2O and Th of FI in quartz is worked out. The significance of DCO_2 and DH_2O as prospecting criteria for Au is also discussed, and a new idea is put forward on rich ore prospecting in a poorly mineralized region. (Authors' abstract)

LI, Yingqing and CHEN, Dianfen, 1995, A study of fluid inclusions and ore-forming process of the Xiaoxinancha gold-copper deposit, Jilin province: Mineral Deposits (Kuangchuang Dizhi), v. 14, no. 2, p. 151-173 (in Chinese, English abstract).

This is the same as in FIR, v. 27, p. 77, incorrectly dated "1994" there. (E.R.)

LI, Zhaolin, QIU, Zhili, QIN, Shecai, PANG, Xuebin, LIANG, Dehua, TENG, Yunye and LI, Yang, 1994, A study on the forming conditions of basalts in seamounts of the South China Sea: Chinese J. Geochem., v. 13, no. 2, p. 107-117 (in English).

Volcanic rocks in seamounts of the South China Sea consist mainly of alkali basalt, tholeiitic basalt, trachyandesitic pumice, dacite, etc. Inclusions in the minerals of the volcanic rocks are mainly amorphous MI, which reflects that the volcanic rocks are characterized by submarine eruption and rapid cooling on the seafloor. Furthermore, F-MI have been discovered for the first time in alkali basalts and mantle-derived xenoliths, indicating a process of differentiation between magma and F in the course of mantle partial melting. Alkali basalts and I may have been formed in this nonhomogeneous system.

Rock-forming T of four seamounts were estimated as follows: the Zhongnan seamount alkali basalt 1155-1185°C; the Xianbei seamount alkali basalt 960-1200°C; tholeiitic basalt 1040-1230°C; the Daimao seamount tholeiitic basalt 1245-1280°C; and the Jianfeng seamount trachyandesitic pumice 880-1140°C. Equilibrium P of alkali basalts in the Zhongnan and Xianbei seamounts are 13.57 and 8.8×10^8 Pa, respectively. Pyroxene equilibrium T of mantle xenoliths from the Xianbei seamount were estimated at 1073-1121°C, and P at $(15.58\text{-}22.47) \times 10^8$ Pa, suggesting a deep-source (e.g., the asthenosphere) for the alkali basalts. (Authors' abstract)

Fourteen types of FI in pyroxene, olivine and feldspar are diagrammed and their changes sketched at various T on the way to Th (Fig. 2). (E.R.)

LI, Zhaolin and YANG, Zhongfang, 1995, A study of rock-forming and ore-forming temperatures of the Lianhuashan tungsten deposit, Guandong province: Mineral Deposits (Kuangchuang Dizhi), v. 14, no. 3, p. 252-260 (in Chinese, English abstract). First author at Dept. Geology, Zhongshan Univ., Guangzhou 510275, PRC.

The Lianhuashan W deposit occurs at the endo- and exocontact zone between quartz porphyry and metasandstone. Th of MI in zircon and quartz are 1100°C and 1050°C for rhyolite, 1000°C and 860°C for quartz porphyry, and 950-1000°C and 820°C for granite, respectively, suggesting that rock-forming T dropped successively from eruptive rocks to intrusive rocks, and that Th of MI in zircon are 50-180°C higher than those in quartz. Th of G-L I in quartz are 520-230°C (the most being 230-270°C) for quartz porphyry, 450-200°C (the most being 200-360°C) for ore-bearing quartz veins, 150-210°C for granite, and 170-200°C for its vein quartz. (From authors' abstract by E.R.)

LIANG, Xiangji, 1995, Water-rock interaction as a mechanism for the formation of Dexing porphyry copper deposit, Jiangxi, China, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 647-650. Author at Inst. Geology, Chinese Acad. Geological Sciences, Beijing, PRC.

To simulate the geologic characteristics of the porphyry Cu deposit in Dexing, Jiangxi, China, the author performed experiments reacting aqueous solutions of Na, K, chloride (fluoride) with the metamorphic wallrocks of this deposit. The experiments were conducted at T of 250-400°C and at P of 200×10^5 Pa - 500×10^5 Pa. Results indicate that the metamorphic rocks of the pro-Sinian System are the source rocks for the porphyry Cu deposit. (Author's abstract)

According to a study of the mineral I [FI] and the hydrochemistry of the Dexing porphyry Cu deposit, the results showed: main ore-forming T were 255-470°C, and ore-forming P were 90×10^5 - 1850×10^5 Pa. NaCl was 26-39% and KCl was 16-20% in total dissolved solids. The pH values of the ore-forming hydrothermal solution were 2.0-5.0‰. (From author's text by E.R.)

LIEBEN, F., MORITZ, R., FONTBOTÉ, L. and FONTIGNIE, D., 1995, Sr and S isotopic composition of barites from Ba ± Pb ± Zn occurrences in the Chañarcillo Group, northern Chile, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 291-294. First author at Dept. Minéralogie, Univ. Genève, Switzerland.

The Sr and S isotopic composition of barites bas been analyzed to constrain the genesis of Ba and Ba-Pb-Zn ore occurrences in the Lower Cretaceous back-arc basin of the Atacama Region, northern Chile. The data support an origin by interaction of metal-bearing F having leached underlying volcanic rocks with the host carbonate (and evaporitic) rocks. A broad correlation between the Sr and S isotopic composition and the typology of the barites suggest different degrees of interaction between the metal-bearing F and the host rocks. (Authors' abstract)

Preliminary data on FI in quartz and barite from this deposit have also been obtained and indicate that the mineralizing F were warm (Th:100-140°C) and highly saline Na-Ca-Cl brines. (From authors' text by E.R.)

LIETH, F.G. and CROWE, D.E., 1995, Oxygen isotope study of the Dalnegorsk borosilicate skarn, Far East Russia (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 377-378.

Indexed under FI. (E.R.)

LIKHOYDOV, G.G. and NEKRASOV, I.Ya., 1995, The solubility of gold in the Na-Fe-S-Cl-H_2O-O_2 system at 300 to 500°C and P_{tot} = 1 kbar in the presence of the pyrite-magnetite-pyrrhotite buffer assemblage: Dokl. Ross. Akad. Nauk, v. 341, no. 6, p. 804-806 (in Russian).

LIN, Guichang and NUNN, J.A., 1995, Thermal insulation by low conductivity coal: an important mechanism for formation of Mississippi Valley-type ore deposits (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-426.

Coal and carbonaceous mudstone were once common in many sedimentary basins in the mid-continent of North America the Late Paleozoic. Carbonaceous rocks are characterized by thermal conductivities in the range of 0.25 to 1.0 $W/m^{-1}K^{-1}$, lower by a factor of 5 to 10 than other common rocks. Thus, carbonaceous rocks act as a thermal blanket retaining heat energy within basin sediments. A two-dimensional finite element model of F flow and heat transport has been used to study the insulating effect of a coal layer on an uplifted foreland basin. Our model section cuts through the Arkoma Basin to Ozark Dome and terminates near the Missouri River, west of St. Louis. A few hundred meters of carbonaceous rock are placed on the top of the model basin. Topographically-driven recharge is assumed to be the major driving force for regional groundwater flow. Our model results show that thermal gradient in the coal layer can ≤0.14°C/m, much higher than that in normal sediments. High T in underlying sediments are caused by the thermal insulation and high rates of advective heat transport associated with basin-scale F flow along basal aquifers (Darcy velocities of ≤5 m/yr.). Our model results show high T (~150°C) in the groundwater discharge region at shallow depths (<1.5 km), even with typical continent basal heat flow of 60 mW/m^2. High T (100-150°C) at shallow depths (<1.5 km) are inferred from homogenization and freezing T obtained from FI associated with MVT ore deposits in the mid-continent of North America (Sverjensky, 1986). Thus, thermal insulation by an overlying coal layer can explain the T regime believed to be required for MVT ore deposits without imposing unrealistic thermal constraints, such as high basal heat flow (90 to 100 mW/m2). After the coal layer is removed by subsequent uplift and erosion and F flow stops or slows down, the model basin slowly returns to a normal geothermal gradient of ~0.028°C/m. (Authors' abstract)

LIN, Jingqian, TAN, Dongjuan, YU, Xuefeng, XU, Wenliang, LI, Bingren and LI, Ying, 1995, Genesis and metallogenic model of Guilaizhuang gold deposit: J. Changchun Univ. Earth Sciences (Changchun Dizhi Xueyuan Xuebao), v. 25, no. 3, p. 286-293. First author at Changchun Univ. Earth Sciences, Changchun 130026, PRC.

Several types of Au mineralization formed in and around the Tonshi subvolcanic complex characterized by K-rich alkali affinity. In the framework of a mineralization model, the Guilaizhuang Au deposit is related to intrusion-cryptoexplosion breccia. Breccia-type and porphyry-type of Au mineralization were distributed in the deeper layers. The telescoped mineralization of Au was formed in the Fe-ore bearing skarn belt. The types of layer-like and vein-like Au mineralization were generated at the intersection of the Mantou group and the monzonite porphyry sill. The ratio of Ag/Au is 1.3 in average. There is a tendency for Au enrichment at a shallow level of the ore body with low T. The Au deposits in Guilaizhuang belong to a type of alkalic-related, precious-metal rich, quartz-fluorite-adularia, hypabyssal and low-to-moderate T hydrothermal deposit. Th data from quartz and fluorite hosts are given. (From authors' abstract by H.E.B.)

LINKLATER, M.A.L.F., 1995, The exploration for, and possible genesis of, some Archean granite/gneiss-hosted gold deposits in the Pietersburg granite-greenstone terrane (abst.): Exploration and Mining Geol., v. 4, no. 1, p. 88.

Indexed under FI. (E.R.)

LINNEN, R.L., KEPPLER, H. and STERNER, S.M., 1995, High temperature FTIR measurements of synthetic H_2O-CO_2 fluid inclusions in the one-phase field (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 121-122. First author at Bayerisches Geoinst., Univ. Bayreuth, 95440 Bayreuth, Germany.

A major problem in the analysis of aqueous-carbonic FI is the determination of their bulk composition and density. Normally, the molar volumes of the aqueous and carbonic phases at room T, together with the volume percentage of each phase are used to calculate these bulk parameters. Because FI are three-dimensional objects, commonly with irregular shapes, large errors can be associated with estimating volume proportions, resulting in incorrect compositions, molar volumes and isochore extrapolation. In this study we present preliminary Fourier transform infrared spectroscopic results for aqueous-carbonic I with different compositions and molar volumes, determined at P-T conditions in the one phase field. The ultimate goal is to establish the effects of P-T-V-X on the H_2O and CO_2 extinction coefficients, which could provide the means for routine analysis of the composition of natural aqueous-carbonic FI.

Details of the instrumentation and equipment modifications are given, permitting FTIR studies of synthetic FI of known composition at 300°C. The results are encouraging for the development of a calibration curve for extinction coefficients in the system H_2O-CO_2 at high T, but a wide range of compositions and densities need to be examined. (From authors' abstract by E.R.)

LINNEN, R.L. and WILLIAMS-JONES, A.E., 1995, Genesis of a magmatic metamorphic hydrothermal system: The Sn-W polymetallic deposits at Pilok, Thailand: Econ. Geol., v. 90, p. 1148-

1166. First author at Bayerisches Geoinst., Univ. Bayreuth, 95440 Bayreuth, Germany.

Cassiterite, wolframite, and base metal mineralization in the Pilok area are hosted by veins and stockworks in the apical portion of leucocratic granite stocks, close to their contacts with pelitic metasedimentary rocks. A minimum P of emplacement of ~1500 bars is indicated.

The earliest mineralization is late magmatic to early postmagmatic wolframite ± cassiterite intergrown with Li- and F-rich muscovite in pegmatite pods. The bulk of the wolframite mineralization was subsequently deposited in veins with potassic alteration which could have originated either by orthomagmatic or remobilization processes. Finally, cassiterite and sulfides (chalcopyrite-sphalerite) were deposited in association with greisen alteration and formed as a result of the remobilization of Sn from the host granite.

FI and stable isotope data indicate the involvement of at least four F types: a moderately saline F of presumed magmatic original, aqueous-carbonic metamorphic F, low-T and low-salinity meteoric F and high-salinity formational or metamorphic F. The isotopic compositions of waters calculated from δO^{18} analyses of quartz, muscovite, and cassiterite and δD analyses of muscovite range from 1.4 to 9.4 and -63 to -118‰, respectively; these are consistent with the mixing of magmatic and organic-rich metamorphic F. O isotope thermometry indicates T of 350° to 500°C for cassiterite mineralization. The oldest preserved FI are primary aqueous-carbonic I from wolframite and cassiterite mineralization. Both the homogenization of the carbonic phase and the bulk homogenization are to L, V, and critical, signifying a large compositional and density variation. Molar volume relationships of these I indicate that F mixing controlled the ratio of $CO_2 + CH_4$ to H_2O and, using the T from O isotope thermometry, aqueous-carbonic isochores indicate that F were trapped under fluctuating P conditions, with a maximum variation of 500 to 2500 bars. Aqueous-carbonic I from cassiterite mineralization are enriched in CH_4 relative to those from the preceding wolframite event, suggesting a redox control for Sn mineralization. Moderately saline aqueous F are interpreted to have mixed with the aqueous-carbonic F and subsequently with later low-T-low salinity aqueous F of meteoric origin. A predominance of early aqueous-carbonic metamorphic F is also common in many other deposits that are associated with moderately deep granites. This contrasts with subvolcanic magmatic-meteoric hydrothermal systems which are characterized by high-T hypersaline F. (From authors' abstract by E.R.)

LINNEN, R.L., PICHAVANT, Michel, HOLTZ, François and BURGESS, Simon, 1995, The effect of fO_2 on the solubility, diffusion, and speciation of tin in haplogranitic melt at 850°C and 2 kbar: Geochim. Cosmochim. Acta, v. 59, p. 1579-1588.

LIRA, R., MARTÍNEZ, E. and GOMEZ, G.M., 1995, Fluid inclusion studies on skarn helvites from Cordoba Province, central Argentina (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 123-124. First author at CONICET, Inst. Geología Aplicada, Secretaría de Minería de la Prov. de Córdoba, Celso Barrios s/n°, (5000) Córdoba, Argentina.

Helvite from the Chingolo scheelite mine is found in a garnet-epidote skarn formed on both sides of a marble unit in contact with a granite pegmatite. Superb crystals, sometimes larger than 15 cm edge, occur partially included in garnet, lining cavities later filled with calcite, or sometimes with fluorite or quartz. They contain three distinctive types of FI: Type I P and PSI represent boiling F. Inclusions are primarily aqueous V-rich and V-poor polyphase dxl-rich with small amounts of CO_2. Th ranges from 345 ≤ 403°C and Tm ice ranges either from -4.5 to -5.5°C or from -15.2 to -23.8°C. Solids identified by a combination of optical microscopy and SEM-ED analysis include the recurrent presence of an opaque mineral (Zn,Fe)S (sphalerite), a highly birefringent carbonate $(Mn,Fe,Zn)CO_3$, possibly rhodochrosite, and a pure Si-mineral (quartz?).

Type II are S V-rich (V/L range: 0.6 to ≈1.0) CO_2-rich FI grouped in healed fractures. Clathrate melting T are ~+6.6°C. Homogenization mode is to the V phase between 340 and 350°C. CO_2 Th mean value is +30.2°C, and CO_2 melting T are close to that of pure CO_2. This low salinity type of F introduced in already crystallized helvite is thought to be related to the deposition of later-stage spathic coarse crystals of vug-filling calcite.

Type III are two-phase or polyphase L-rich S aqueous I. Necking-down features characterize this group. Th are lower than Types I and II, ranging from 245 ≤ 325°C. Tm ice are low, within the range -2.0 to -5.5°C.

The data suggest that helvite was formed during late stages of garnet-epidote skarn evolution, after the reaction between hydrothermal F (pegmatite related?) and dolomite-bearing host marbles. F were boiling at the moment of trapping P and PS I, hence Th within the range 345-403°C are Tt. Eutectic point values suggest that components such as H_2O-$MgCl_2$-$NaCl$-$FeCl_x$ could be present in a mixed F. Sphalerite, as a dp, suggests reducing conditions during helvite crystallization stage. Dps also indicate that Mn, Fe, Zn and Si were important components of the F.

As already stated by Holser (Am. Mineral., 38, 1953), the role played by wallrock composition was decisive to precipitate helvite instead of beryl by the removal of excess Al_2O_3 from the F as garnet + epidote creating subaluminous conditions for helvite precipitation. (From authors' abstract by E.R.)

LISK, Mark and EADINGTON, Peter, 1994, Oil migration in the Cartier Trough, Vulcan Sub-basin, *in* P.G. and R.R. Purcell, eds., The Sedimentary Basins of Western Australia: Proc. Petroleum Exploration Soc. Australia Symp., Perth, 1994, p. 302-312.

In currently water wet sandstones of the Plover Formation from Octavius-2, the high percentage of quartz grains containing oil-bearing I is comparable to oil zone samples from Jabiru-1A. This evidence for high palaeo-oil saturation in samples from a continuous 60 m sandstone interval in Octavius-2 is consistent with this interval having been oil saturated. The percentage of grains containing oil I in Octavius-2 is two orders of magnitude higher than observed in samples taken from the water wet Plover Formation in Douglas-1, Augustus-1, and Hadrian-1, which contain only limited hydrocarbon indications.

Oil-filled FI in the AC/P-11 wells exhibit variable fluorescence colours and correspond to oil of different maturity. FI containing high maturity oil are most numerous and represent the principal oil charge. These are restricted to the Plover Formation and confirm the potential of this reservoir as a regional migration pathway for oil. This high maturity oil in I exhibits blue and white fluorescence colours which are identical to the fluorescence colours of the majority of oil I seen in Jabiru-1A.

FI containing yellow and orange fluorescing oil, and interpreted to be of low maturity, occur in both Plover Formation and Swan Group sandstones. The absence of mature oil in FI from Tithonian sandstones of the Swan Group suggests a lack of lateral continuity for migration paths at this level, probably reflecting the localised distribution of these fan deposits. Kinetic simulations of oil generation suggest that interbedded shales of the Vulcan Formation near these wells have expelled low maturity oil which is consistent with the occurrence of yellow and orange fluorescing oil I.

The abundance of oil I within diagenetic quartz overgrowths at Jabiru-1A and Octavius-2 suggests oil columns were present at the time of trapping of oil I by crystallization of quartz overgrowths. FI palaeotemperatures indicate this occurred from Miocene time. (Authors' abstract)

LIU, Bin and SHEN, Kun, 1995, Formulae for calculating oxygen fugacities of fluid inclusions and their applications: Acta Mineralogica Sinica, v. 15, no. 3, p. 291-302 (in Chinese, English abstract). First author at Dept. Geotechnic Engineering, Tongji Univ., Shanghai, 200092, PR China.

At present several formulae for calculating O fugacities on the basis of FI data and corresponding diagrams and tables have been proposed by some researchers. Because these diagrams and tables are low in precision and accuracy, they could not be used for detailed study and comparison. Moreover, the formulae derived are used in step-by-step calculations and there are no straightforward formulae available, which would bring about much inconvenience in practice.

On the basis of the chemical reaction with O_2 involved and the thermodynamic principles, we have derived the specific formulae for calculating O fugacities with only three parameters, i.e., T, p and x.

By substituting the mole fraction of each component in FI and the Tf and P of the I by chemical analysis and other approaches respectively into the formulae, the O fugacities of FI can be directly calculated. The results obtained in this way are more accurate than those obtained by diagrams. The approach is more convenient than other step-by-step calculating methods. (Authors' abstract)

LIU, Changshi, SHEN, Weizhou and WANG, Dezi, 1995, The characteristics and genetic mechanism of igneous topazites in South China: Acta Geol. Sinica (Dizhi Xuebao), v. 69, no. 3, p. 221-231 (in Chinese, English abstract). Authors at Dept. Earth Sciences, Nanjing Univ., Nanjing, Jiangsu, PRC.

Igneous topazites found recently in South China are closely associated with F-rich granites in time and space. They have a typical igneous porphyritic texture. The phenocrysts are quartz and topaz, while the groundmass consists mainly of acicular or prismatic topaz microlites and anhedral quartz. Hydroxylated silicate MI, consisting of some grains of quartz and aqueous F, have been found in the quartz phenocrysts. The entrapment T of these I is ~520°C. (From authors' abstract by H.E.B.)

LIU, Dehan, 1995, Fluid inclusion studies—An effective means for basin fluid investigation: Earth Sci. Frontiers (Dixue Qianyuan), v. 2, no. 4, p. 149-154 (in Chinese, English abstract).

Describes the use of FI studies in sedimentary basin research. (H.E.B.)

LIU, J., HAY, R.L., SHELTON, K.L., DEINO, A. and KYSER, T.K., 1995, Hot saline fluids are responsible for K-metasomatism in the uppermost Precambrian rocks of west-central Wisconsin (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-248.

K metamorphism is widespread in an alteration profile developed on uppermost Precambrian rock of the North American Midcontinent. Near Neillsville, in west-central Wisconsin, authigenic K-feldspar is in many places the most abundant mineral in an alteration profile 2-3 m thick that underlies the Cambrian Mt. Simon sandstone. K-feldspar occurs as a coarse-grained replacement of kaolinite in one quarry and as small rhombic crystals and overgrowths on microcline in the upper part of the profile in another quarry.

The K-feldspar may have been formed in two episodes, as based on $^{40}Ar/^{39}Ar$ single-grain step-heat spectra using a laser as the energy source. A late Ordovician and/or Silurian episode is suggested by plateau dates of 434 and 444 Ma and integrated ages of 426-438 Ma from two samples from the part of the profile. A Devonian-Mississippian episode is suggested by spectra from a sample from the upper part of the profile , in which steps rise from 335 to 370 Ma and are concentrated at ~360 Ma.

K-feldspar giving the younger dates formed from hot, moderately saline F, as based on measurements of FI in K-feldspar overgrowths. Th are 94-123°C, averaging 106°C (n = 16). Freezing-point depression measurement (n = 5) range from -5.5° to -7.5°C, corresponding to 8.5-11.1% NaCl equivalent. A $\delta^{18}O$ value of 19.8‰ for K-feldspar from the upper part of the profile gives a $\delta^{18}O$ H_2O value of +3‰ at 106°C. Values are 21.3 and 21.9‰ for samples of K-feldspar giving the older dates, implying lower T or F with higher $\delta^{18}O$ $\delta^{18}O$ values. (Authors' abstract)

LIU, J.-H., LI, X.-L., SHI, W.-J. and SUN, Z.-X., 1995, Origin of water in the Xiazhuang fossil hydrothermal system, China, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 379-382. Authors at East China Geological Inst., Fuzhou, Jiangxi, PRC.

This paper investigates the origin of water in the Xiazhuang fossil hydrothermal system on the basis of the H and O isotopic compositions and the principles of water-rock interaction. H and O isotopic studies indicate that the $\delta^{18}O$ values of FI water vary from 6.21‰ to -4.56‰ (SMOW), and the δD values are in the range of -23.2‰ to -81.0‰ (SMOW) in the Xiazhuang uranium orefield. Calculations indicate that the original $\delta^{18}O$ values of the oreform[ing] hydrothermal F are between -4‰ and -11‰ (SMOW). As a result of water-rock isotopic exchange, the ^{18}O values of altered granite and unaltered granite are 7.0 - 7.8‰ and 8.7 - 12.4‰, respectively, showing that the $\delta^{18}O$ value of altered rocks are decreased. These data suggest that ore-forming hydrothermal solution was derived from meteoric water. Calculations of W/R ratios calculating for this system support this conclusion. (Authors' abstract)

Includes 12 analyses of O and H from FI in quartz, fluorite and calcite. (E.R.)

LIU, Shuwen, 1995, Study on fluid inclusions from high grade metamorphic rocks in East Hebei province: Acta Petrologica Sinica, v. 11, no. 4, p. 375-385 (in Chinese, English abstract). Authors at Peking Univ., Beijing 100871, PR China.

FI from high-grade metamorphosed garnet plagioclase gneisses, garnet-bring-free [sic] hornblende two pyroxene gneisses, charnockite, amphibolite and trondhjemites in East Hebei province can be divided into four types by order of trapping. The first type is H_2O and CO_2 two L phase I, in which CO_2 partial Th is -12°C, density 1.04 g/cm^3 and H_2O content ~21%-39% (mol %). The second type is CO_2 L phase I with freezing T of -56°C to -61°C, Th of -7.4°C to -35.1°C, CO_2 density ~1.05 g/cm^3 and CO_2 content 82.1-98.4% (mol), having a little of CH_4, N_2 and H_2. The third type is H_2O and CO_2 multiple phases I in which CO_2 partial Th is ~7°C-28°C and CO_2 density 0.64-0.93 g/cm^3. In this type of FI, CO_2, CH_4 and CO are major components in G phase and H_2O and CO_2 in L phase. The last type is multiple generation brine I in which freezing T is -0.5°C to -20°C, salinity 0.87%-22.8% (wt %) and brine density 0.7-1.05 g/cm^3. Their Th shows two peaks at 150°C-200°C and ~300°C. FI in different generations record isodensity decreasing T P-T paths. $H_2O/H_2O + CO_2$ (mol) ratio reduces from peak metamorphism to earlier decreasing T metamorphic processes, but this ratio increases in late retrograde metamorphism and uplifting processes. (Author's abstract)

LOKHOV, K.I. and LEVSKY, L.K., 1995, Carbon and heavy noble gas isotopes in the metamorphic fluids: Geokhimiya, no. 6, p. 829-842 (in Russian, English abstract).

Based on the data on the correlation of C and non-radiogenic noble G isotopes in the mantle reservoirs, a new genetic criterion for the metamorphic F is presented. Modeling calculations indicate that the $C/^{36}Ar$ ratio of the metamorphic F in the continental crust must be $<10^{10}$, the latter known as a mantle value. The causes and results of C and noble G isotopic fractionation in the F phase in the process of volatile capture from natural waters and within the subsequent diagenesis is studied. (From authors' abstract by E.R.)

LOWENSTEIN, T.K., LI, Jianren, SPENCER, R.J., ROBERTS, S.M., YANG, Wenbo, KU, T.-L., LUO, Shangde and FORESTER, R.M., 1995, Death Valley salt core: 200,000 year paleoclimate record from mineralogy, fluid inclusions, sedimentary structures and ostracodes (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-321. First author at Dept. Geological Sciences, Binghamton Univ., Binghamton, NY 13902.

The 186 m core from Badwater salt pan, Death Valley, CA, contains a 200,000 year paleoclimate record. Mudflat and saline pan environments, similar to the modern, existed in Death Valley 10-0 ka (thousand years before present), 120-35 ka, and 192-186 ka. Long-lived perennial lakes, formed under relatively wet climates, occurred 35-10 ka and 186-120 ka (marine O isotope stages 2 and 6). Perennial lake muds contain ostracode species *Limnocythere staplini*, *L. sappaensis*, and *L. Ceriotuberosa*. The occurrence of shoreline carbonate tufas indicates lake depths of at least 300 m. The paleotemperature component of the climate record is provided by Th_{max} of FI in subaqueous halites, which give maximum brine T during salt crystallization. Notwithstanding possible differences in brine depth and seasons of halite possible differences in brine depth and season of halite precipitation, maximum FI Th are lowest during the last glacial period, ~35-12 ka (Th_{max} = 19-26°C) compared to ~12-10 ka (Th = 26-30°C). Similarly colder conditions are recorded in FI for the 186-120 ka perennial lake. Mineralogy of the Death Valley core provides constraints on water inflow sources over the past 200 ka. During wet lacustrine periods (186-120 ka and 35-10 ka), HCO_3-rich, Ca-poor inflow (spillover from the Owens-Searles-Panamint lake system or major Amargosa River input) produced a $CaSO_4$-poor mineral assemblage. Ca was removed as calcite during the early stages of brine evolution. During dry periods (120-60 ka and 10-0 ka) Ca-rich, basin-margin spring inflow from southern Death Valley contributed enough solutes to produce brines with Ca > HCO_3. Gypsum and glauberite

($CaSO_4.Na_2SO_4$) are therefore common phases in mudflat/saline pan sediments. (Authors' abstract)

LOWENSTERN, J.B., 1995, Applications of silicate-melt inclusions to the study of magmatic volatiles: Mineral. Assoc. Canada Short Course, v. 23, p. 71-99.

An extensive and thorough review, with excellent photographs and a table of 40 analyses of MI in silicic magmas for H_2O, F, Cl, S and CO_2. (E.R.)

LOWENSTERN, J.B. and HERVIG, R.L., 1995, Volatile and trace-element compositions of melt inclusions from the Pine Grove Mo porphyry system, SW Utah, USA (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-2 [62]. First author at U.S. Geological Survey, M.S. 910, Menlo Park, CA 94025.

We analyzed 29 glassy silicate MI in quartz from Plinian fallout of the tuff of Pine Grove for their major-element, Cl, F, S, H_2O, CO_2 and trace-element concentrations. The fallout is indistinguishable in composition and age from associated pyroclastic flows and extrusive domes as well as nearby intrusive porphyries, one of which contains ore-grade mineralization (Keith et al., Econ. Geol., v. 81, p. 553). As such, the fallout serves as a proxy for the unaltered porphyry magma.

Electron microprobe analyses demonstrate that the MI are homogeneous high-silica rhyolite with a composition very similar to the 2-kb-H_2O-P minimum in the haplogranite system. Their mean volatile concentrations in ppm are F (3340), Cl (580) and S (<60). IR spectroscopic analyses showed that the MI contain 6-8 wt % dissolved H_2O and 60 to 970 ppm CO_2. Speciation of H_2O and OH^-, and K/Na ratios confirm that the I retain magmatic volatiles and were not hydrated by groundwater. Magma mixing, V-undersaturated degassing and isobaric crystallization cannot explain the variation of H_2O with CO_2. Instead the volatile concentrations are consistent with open-system decompression degassing of the magma from a depth of 16 km (4.3 kb) to ~9 km (2.5 kb), where I ceased to be trapped and the record ends (Lowenstern, Geology, v. 22, p. 893). Although volcanic ejecta reached the surface, the porphyries stalled at several km depth, were they crystallized and degassed.

Ion microprobe analyses (see table) also indicate that the Pine Grove melt phase was homogeneous. The MI contain similar trace-element concentrations as whole rocks from Pine Grove, given that the whole rocks contain ~30% phenocrysts and are slightly altered. The low Sr, Mg, Ti and Ba concentrations in the MI imply that they are extreme crystal fractionates from a less-evolved parent magma. The moderate F, and low Mo, W, and Sn are inconsistent with formation of the ore deposit by a metal-enriched pegmatite-like magma; instead these data support a model for porphyry formation by focused degassing of an evolved but "normal" rhyolitic magma located beneath the porphyry cupola. (Authors' abstract).

	Mean (ppm) and 1σ
Li	163 (51)
Be	10.2 (3)
B	48.6 (4)
F	4190 (460)
Mg	36 (8)
Ti	83 (10)
Rb	463 (33)
Sr	0.3 (0.3)
Y	79 (5)
Mo	3 (1)
Sn	14 (11)
Cs	19.7 (2.9)
Ba	0.5 (0.3)
W	8.4 (3.7)
Th	21.6 (3.3)
U	17.4 (2.2)

LOWRY, David, BOYCE, A.J., FALLICK, A.E. and STEPHENS, W.D., 1995, Genesis of porphyry and plutonic mineralisation systems in metaluminous granitoids of the Grampian Terrane, Scotland: Trans. Royal Society of Edinburgh: Earth Sci., v. 85, p. 221-237.

Mineralisation associated with Late Caledonian metaluminous granitoids has been investigated using stable isotope, FI and mineralogical techniques. A porphyry-stock-related style of mineralisation is characterised by a stockwork of veinlets and disseminations in dacite porphyries, consisting of quartz, dolomite, sulphides and late calcite, and well-developed wallrock alteration dominated by zones of phyllic, sericitic and propylitic alteration. On the basis $\delta^{34}S$ and $\delta^{18}O$, it is likely that initial mineralising components were orthomagmatic with an input of external fluids during the later parageneses. F were saline, boiling (≤560'C), deficient in CO_2, and ore deposition took place at depths of <3 km.

Plutonic-hosted mineralisation in appinites, diorites, tonalites and monzogranites is commonly represented by sporadic disseminations and occasional veins consisting of quartz, calcite and sulphides. Wallrock alteration is generally propylitic with phyllic vein selvages. Deposition from a cooling magma sourced F is indicated by $\delta^{34}S$ (+ 2-6 ± 1.5‰), $\delta^{13}C$ (- 7-2‰ to -4-5‰) and $\delta^{18}O$ (+9.5‰ to +11.8‰) data. F were CO_2-rich and were trapped <~460°C, and formed at estimated depths of 3-5 km. (From authors' abstract by H.E.B.)

LU, Ch. and MISRA, K.C., 1995, Geochemistry and sources of CO_2-bearing hydrothermal fluids at the Paleozoic Brewer gold hydrothermal system, South Carolina, U.S.A. (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 125-127. First author at Jacobs Engineering Groups, Inc., Oak Ridge, TN.

Au mineralization at the Brewer Mine, South Carolina, occurs in an intensely silicified zone composed primarily of multi-stage hydrothermal quartz-pyrite breccias in volcanics. The alteration pattern consists of concentric zones of silicic, advanced argillic, sericitic, and sporadically distributed propylitic alteration. The inner part of the aluminosilicate hydrothermal system is predominantly an acid-sulfate alteration assemblage characterized by quartz, pyrite, alunite, enargite, topaz, and andalusite.

Most of the FI contain CO_2-bearing F of three groups: CO_2-rich; $H_2O + CO_2$; and H_2O-rich. Heterogeneous trapping was probably the dominant process that resulted in the variable CO_2:H_2O ratios in FI, although limited episodic boiling could have played a role in the formation of CO_2-rich I [sic]. Th of the FI range from 160° to 330°C, reflecting repeated brecciation and hydrofracturing during mineralization.

The FI exhibited complex phase changes during freezing-heating cycles and often developed as many as five phases—aqueous L, ice, G hydrates, solid CO_2, CO_2-rich L, and CO_2-rich V—suggesting a complex chemical composition in a multi-component system. The CO_2 densities range from 0.95 to 0.51 g/cm^3 from Th-CO_2 T calculation. In general, CO_2-rich I have higher densities. The bulk density of the F and the CO_2 content were calculated using volumetric property of H_2O-CO_2 phases, salt content in H_2O, and Th-CO_2. The bulk densities of the FI range from 0.68 to 1.08 g/cm^3. The calculated XCO_2 values range from 0.275 for CO_2-rich I to 1.00 for nearly pure CO_2 I. The H_2O-CO_2 I have XCO_2 from 0.02 to 0.177.

Calculated salinities vary from 0.02 to 14.77 for H_2O-CO_2 I and from 1.16 to 14.98 for H_2O-rich I. A general trend of I with higher Th having relatively lower Tm ice and higher salinity may be attributed to the mixing of deeper hydrothermal F with cooler, less saline meteoric water during its ascent to the site of mineralization.

Laser Raman microprobe analysis revealed the presence of CO_2, SO_4^{2-}, and possibly SO_2 and $H_2S + HS^-$. Synchrotron x-ray fluorescence microprobe analysis of FI has indicated the presence of S, Cl, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, As, and Br in a H_2O-rich, H_2O-CO_2 I. The lack of CO and CH_4 in the I F may also be attributed to an relatively oxidized environment favoring CO_2.

The data indicate an epithermal acid-sulfate environment for the Au mineralization, but the F composition, with a high CO_2 content, is somewhat different from the typical Tertiary epithermal precious metal deposits. The Brewer hydrothermal system may represent a slightly deeper environment than the typical epithermal system, but salinity-Th relationship and the presence of mostly secondary H_2O-rich aqueous I suggest the likely mixing of meteoric water with magmatic F, especially during the later stage of mineralization. (From authors' abstract by E.R.)

LU, Fangqiong, ANDERSON, A.T. and DAVIS, A.M., 1995, Diffusional gradients at the crystal/melt interface and their effect on the composition of melt inclusions: J. Geol., v. 103, p. 591-597. First author at Dept. Geological Sciences, Univ. Texas at Austin, Austin, TX 78712.

MI are widely believed to represent M from which host crystals grew. MI represent M adjacent to growing crystals, where compositional gradients exist due to preferential incorporation or exclusion of components by the crystallizing mineral. The possibility arises, therefore, that M in I may differ significantly from M which was more remote from growing crystals at the time the crystals grew. We have tested this possibility by analyzing 45 major, minor, and trace components in 50 to 400 μm diameter MI in phenocrysts from the rhyolitic Bishop Tuff, California. The following observations indicate that the effects of compositional gradients on chemical compositions of MI are negligible: (1) MI in quartz and sanidine phenocrysts have indistinguishable compositions; (2) no correlation is observed between sizes of MI and their chemical compositions; (3) 10 MI in four quartz phenocrysts from a single pumice clast display well-defined negative correlations between the concentrations of U and La, Ce, Ca, Mg; and (4) MI have the same major element compositions as the matrix glass and whole rocks. MI >50 μm can, therefore, be used to represent the M from which their host crystals grew. The most likely explanation for the negligible compositional gradients is that a modest gradient of a major component would suppress local supercooling and constrain the crystal growth rate. For components that have diffusivities greater than or similar to the major component which controls the rate of crystal growth, the effect of chemical gradients on compositions of trapped MI is likely to be negligible. (Authors' abstract)

LU, Huanzhang and CHI, Guoxiang, 1994, Geochemical characteristics of fluids in shear zones, *in* "A comparative study on Chinese and Canadian gold deposits—CIDA II-17 paper collection: Inst. Geochemistry, p. 158-181. First author at Open Laboratory of Ore Deposit Geochemistry, Inst. Geochemistry, Acad. Sci., Guiyang, 550002, PRC.

In terms of the composition, stable isotope and trace element characteristics of ore-forming hydrothermal fluids in shear zone-hosted Au deposits, the authors consider that it is hard to draw a decisive conclusion on the source of ore fluids. There are four possible sources of ore F, i. e., metamorphic hydrothermal, magmatic, mantle degassing-lower crustal granulitization derived, and deeply recycling groundwater. The former three sources would be supported by the geochemical evidence of their own, and thus could not be ruled out completely. The forth source has not yet been accepted by the most majority of the scientific researchers because it is in conflict to such characteristics that shear zone F are low in salinity and high in P. There is a possibility of mixing of ore F of various sources. Isotopic homogenization of ore fluids in the same deposit or the same region provides evidence suggesting that such homogenization occur prior to the entrance of ore F into a shear zone. That is to say, there exists a homogeneous F zone beneath the shear zone.

The physicochemical parameters of ore F most closely related to the dynamic processes of the shear zone are T, P and phase state. F phase separation is a common feature of ore F in a shear zone, which can reflect the control of the shear zone over Au mineralization.

F are the media for shear-zone activity and minerogenesis. To study the geochemical characteristics of F is one of the important approaches to gaining a better understanding of the sources of ore F and ore-forming elements present in them. It is of great importance to understand the sources of ore-forming materials in the study of the connections between shear zones and minerogenesis. If there is no source of ore-forming materials, no minerogenesis would take place even in the most favourable structural environments such as shear zones. Moreover, the geochemical characteristics of F can also reflect the physicochemical environments of F activity and ore-forming material precipitation, which are closely related to the dynamic processes involved in the development of shear zones.

Shear-zone F are recorded in two ways. One is the altered mineral assemblage resulting from the interaction between F and country rocks and the other is the FI in altered minerals and gangue minerals. Both of them are the principal objects of study in the study of geochemical characteristics of shear-zone fluids. (Authors' abstract)

LU, Huanzhang and CHI, Guoxiang, 1995, Geochemical characteristics of fluids in shear zones and their significance for mineral exploration: J. Guilin Inst. Technology, v. 15, no. 1, p. 9-22. Authors at Univ. Quebec at Chicoutimi, Quebec G7H 2B1, Canada.

Ore-forming F of shear zone-controlled Au deposits in Archean greenstone belts consist of H_2O, SiO_2, CO_2, K, Na, Ca, Mg, Cl as well as CH_4. H_2S and N_2, etc. F phase separation appears to be a common phenomenon during mineralization. Possible sources of the ore-forming F include metamorphic, magmatic, mantle degassing-granulitization F and deep circulating ground waters. In addition to stable isotopes of C, H, O and S, lithophile elements and S/Se ratio have been used as tracers of the ore-forming F. An understanding of the geologic setting. alteration features, shear zone types and associated dilatancy is important for exploration. (Authors' abstract)

LÜ, Ruiying, 1995, Study of typomorphic characteristic of quartz from Kubusu gold ore deposit, Xinjiang: Earth Sci. (Diqiu Kexue), J. China Univ. Geosciences, v. 20, no. 1, p. 53-57.

Th and Td data are given. (H.E.B.)

LÜDERS, V. and PFLUGBEIL, B., 1995, Fluid inclusion studies in wolframite and sulphides—Applications of infra-red microscopy (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 128-129. First author at GeoForschungsZentrum Potsdam PB.4.3 Lagerstüttenbildung, Telegrafenberg A 50, D-14473 Potsdam, Germany.

The combination of the Olympus BHSM-IR microscope with an USGS gas-flow heating/freezing system allows the use of long working distance objectives (≤80x) for infra-red light observation in the near infrared spectrum (500-1800 nm) and measurements in the T range -195 to 600°C. The infra-red image is transmitted to a monitor by a high-resolution infrared TV camera with a detection capacity ≤2200 nm.FI were studied in wolframite from Panasqueira (Portugal) and various occurrences of the Erzgebirge (Saxony, Germany). Additionally, I in sulphides such as stibnite, bournonite (Tm ice -35.5°C, Th 124.5°C) and tetrahedrite from hydrothermal vein mineralizations of the Harz Mts./Germany and pyrites (Tm ice -3°C; Th 206-215.5°C) from the Murgul deposit (Turkey) were measured. The data obtained are compared with those of FI in gangue quartz in order to prove paragenetic relationships.FI in wolframite from all occurrences under investigation show higher salinities and lower homogenization Ts than I in coexisting [and presumably coeval] quartz.

A cogenetic formation which is assumed for stibnite/sulfosalt mineralization on a vein structure of the Lower Harz Mts. can also be excluded due to the results of infrared F inclusion studies in these minerals. Finally, it was possible for the first time to study FI in euhedral pyrite crystals which yield Th of ~210°C and indicate crystallization from KCl-rich F. (From authors' abstract by E.R.)

LUTZ, S.J., MOORE, J.N. and COPP, J.F., 1995, Lithology and alteration mineralogy of reservoir rocks at Coso geothermal area, California (abst): AAPG Bull., v. 79, no. 6, p. 922.

Indexed under FI. (E.R.)

MACALET, Viorel, TANASESCU, Ion, FRANGOI, Dan and MACALET, Rodica, 1995, The iron and barite mineralizations from the Delnita-Botosel zone (East Carpathians): Rom. J. Mineral Deposits, v. 76, p. 23-29.

Decrepitation data for quartz and barite is given. (H.E.B.)

MACHEL, H.G., KROUSE, H.R. and SASSEN, Roy, 1995, Products and distinguishing criteria of bacterial and thermochemical sulfate reduction: Appl. Geochem., v. 10, p. 373-389. First author at Dept. Earth and Atmospheric Sciences, Univ. Alberta, Edmonton, Alberta, T6G 2E3, Canada.

Bacterial and thermochemical sulfate reduction apparently occur in two mutually exclusive thermal regimes, i.e., low-T diagenetic environments with 0 < T < 60-80°C and high-T diagenetic environments with 80-100 < T < 150-200°C, respectively. (From authors' abstract by E.R.)

MAEKAWA, Tatsuo, IGARI, S.-I., SAKATA, Susumu, ITOH, Shiro and IMAI, Noboru, 1995, Synthetic experiments for determination of the dissociation conditions of methane hydrate: Bull. Geol. Surv. Japan, v. 46, p. 425-431 (in Japanese, English abstract).

See also next item. (E.R.)

MAEKAWA, Tatsuo, ITOH, Shiro, SAKATA, Susumu, IGARI, S.-I. and IMAI, Noboru, 1995, Pressure and temperature conditions for methane hydrate dissociation in sodium chloride solutions: Geochem. J., v. 29, p. 325-329. Authors at Geol. Surv. Japan, 1-1-3, Higashi, Tsukuba, Ibaraki 305, Japan.

The P and T conditions were experimentally determined for CH_4 hydrate dissociation in NaCl solutions, and an empirical equation of the conditions was obtained in the P range ≤18 MPa. The present results indicate that the maximum depth of oceanic sediments where CH_4 hydrate is stable increases as water depth to seafloor increases, and that the maximum depth in saline water is smaller than that in pure water. The difference in the depth between saline and pure waters increases with decreasing the depth, indicating that salinity of pore water affects significantly the amount of CH_4 hydrate in oceanic sediments, in particular, beneath seafloor at relatively shallow depths. (Authors' abstract)

Pertinent to FI cryometry. (E.R.)

MAGDE, L.S., DICK, H.J.B.and HART, S.R., 1995, Tectonics, alteration and the fractal distribution of hydrothermal veins in the lower ocean crust: Earth Planet. Sci. Lett., v. 129, p. 103-119.

MAGENHEIM, A.J., SPIVACK, A.J., MICHAEL, P.J. and GIESKES, J.M., 1995, Chlorine stable isotope composition of the oceanic crust: Implications for Earth's distribution of chlorine: Earth Planet. Sci. Lett., v. 131, p. 427-432. First author at Scripps Inst. Oceanography, Univ. California San Diego, La Jolla, CA 92093.

This first investigation of the Cl stable isotope composition of seafloor rocks reveals systematic variations in $^{37}Cl/^{35}Cl$ of the oceanic crust and its mantle source(s) relative to seawater. Cl isotopic measurements (expressed as $\delta^{37}Cl$ relative to the seawater $^{37}Cl/^{35}Cl$ ratio) of fresh MORB glass, hydrothermally produced amphibole-containing whole rocks and smectite veins are presented. All the samples analyzed are isotopically enriched (0.2-7.5‰) relative to seawater (0‰). Uptake of Cl into amphibole during axial hydrothermal alteration fractionates Cl relative to seawater. The isotopic compositions of MORB glasses are between 0.2 and 7.2‰. This range appears to be partially due to the assimilation of Cl from hydrothermally altered wallrock into MORB magmas. Samples which are unaffected by assimilation have $\delta^{37}Cl$ between 3 and 7.2‰. Overall, the data imply that Cl is isotopically fractionated between the surface and mantle reservoirs of Earth. Calculations based on the degree of fractionation suggest that ~40% of the Cl originally in the degassed mantle now resides on Earth's surface. (Authors' abstract)

Eventually pertinent to FI. (E.R.)

MAGLAMBAYAN, V.B., ISHIKAWA, Y., MIZUTA, T. and ISHIYAMA, D., 1995, Mineral assemblages, ore textures, and fluid inclusion studies of the Uwamuki No. 4 Kuroko deposit, Kosaka, Akita prefecture, Japan (abst.): Resource Geol., v. 45, p. 259-260. Authors at Mining College, Akita Univ., Japan.

The Uwamuki No. 4 deposit is a major Kuroko orebody in the Kosaka mine. P FI in the barite of massive ores have a range of salinity of 2.4 to 5.2 wt % NaCl. P FI in quartz of ores in Zones II and V have 4.9 wt % and 2.4 to 3.7 wt % NaCl salinities, respectively. Th of P FI in quartz of Zone V ores is ~350°C, while the corresponding T in Zone II quartz is ~340°C.

Very high salinity (41-46 wt % NaCl) S FI in quartz phenocrysts in hanging wall dacitic tuffs have a range of Th of 347° to 393°C. The possibility of phase separation which caused the extreme concentration of the dissolved salts can be due to the heating of fossil seawater by post-ore rhyolite. Another possibility is the earlier trapping of the highly saline F during the formation of primary phenocrysts from magma. (From authors' abstract by E.R.)

MAINERI, C. and LATTANZI, P., 1995a, Immiscibility phenomena in the Giglio Island pluton, southern Tuscany Italy (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 130. First author at Dip. Scienze della Terra, Univ. Firenze, Italy.

This is a preliminary report of an ongoing study on the magmatic to hydrothermal evolution at Isola del Giglio. The Isola del Giglio pluton is a 5 My-old acidic S-type intrusive monzogranite. Scattered throughout the stock, small miarolitic cavities and numerous aplitic and pegmatitic veins and pockets are found.

The following I types were observed in different proportions in such quartz:

(I) recrystallized silicate M;

(II) brine (L+V+Hn+Sn), extremely chloride-rich, with minor carbonates; and

(III) low density CO_2-rich G I.

On heating to high T, type I inclusions (from MF quartz) exsolve, ~700°C, one or more (≤6) small V bubbles and some solids. Raman analysis shows that the bubbles contain pure low density CO_2.

Type II inclusions exhibit strong reequilibration textures, probably corresponding to implosion phenomena. Homogenisation to L was observed before dissolution of solids, at T = ca. 300°C. The same behaviour was observed for brines in pegmatitic and miarolitic quartz, the only difference being the dissolution of some solids before bubble disappearance.

Raman and microthermometric analysis of type III inclusions indicate a very constant composition of the low-density phase in all samples, that is, 85% CO_2 and 15% CH_4.

Textural relationships and preliminary microthermometric and Raman data of studied inclusions suggest that at Isola del Giglio silicate melt/hydrosaline melt/low density F immiscibility phenomena occurred at the magmatic stage. Further measurements are currently underway, and will be presented at the meeting. (From authors' abstract by E.R.)

MAINERI, C. and LATTANZI, P., 1995b, The magmatic-hydrothermal system in the intrusions on the Isola del Giglio (Italy): Raman analysis and microthermometry of the fluid inclusions: Plinius, no. 14, p. 192-193 (in Italian).

See previous item. (E.R.)

MALINCONICO, M.L., 1995, Duration of rifting and thermal modeling of the Triassic Taylorsville Basin, Virginia, based on vitrinite reflectance, *in* C.R. Robison, ed., 12th Ann. Mtg. Society for Organic Petrology: Abstracts and Program, v. 12, p. 9-11. Author at Dept. Geology, Columbia Univ., Lamont-Doherty Earth Observatory, Palisades, NY 10964.

The thermal history in the kinetic model is constrained by data from fission track and FI studies. Apatite and zircon fission trace ages indicate heating >175-200°C at ~200 Ma, followed by slow cooling of 1-2°C/m.y. S two-phase FI Th at 10,128 ft (3069 m) is 210°C; trapping P and Th from coexisting aqueous and methane-rich I at the current 9672 ft (2931 m) are 162.5 ± 12.5°C at 3.6 km depth (= geothermal gradient of 40°C/km).

The thermal history can then be modeled two ways. (A) Geothermal gradient of 40°C/km from deposition to 160 Ma (the time of CH_4-rich F intrusion entrapment), cooling to 30°C/km by the time of coastal plain onlap at 120 Ma, followed by cooling to current gradient of 25°C/km; the thermal maximum would be at the time of maximum burial at 200 Ma and would only be due to deep burial; or (B) geothermal gradient of 30-32°C/km from deposition to maximum burial at 200 Ma, thermal pulse heating to a gradient 43°C/km from 201-204 Ma coincident with the time of lava flows and dike I along the rift system, sustained geothermal gradient of 40°C/km from 204-160 Ma, followed by the cooling history of (A). (From author's abstract by H.E.B.)

MALININ, S.D. and KRAVCHUK, I.F., 1995, Behavior of chlorine in equilibria between silicate melts and aqueous chloride fluids: Geokhimiya, no. 8, p. 1110-1130 (in Russian, English abstract). Authors at Vernadskiy Inst. Geochemistry and Analytical Chemistry, Russian Acad. Sci., Moscow, Russia.

A critical survey of the published data on the geochemistry of Cl (chlorides) in magmatic processes and of research on the behavior of Cl in equilibria between aqueous chloride F and silicate M is presented. The distribution of Cl between M and F depends on the oxide composition of the M, the T, the P, and the concentration of Cl. Examination of the existing physicochemical models of the behavior of Cl in natural systems shows that the models are in qualitative agreement as regards the main conclusions in spite of the variety of assumptions used in them. (From authors' abstract by

E.R.)

MANCANO, D.P. and CAMPBELL, A.R., 1995, Microthermometry of enargite-hosted fluid inclusions from the Lepanto, Philippines, high-sulfidation Cu-Au deposit: Geochim. Cosmochim. Acta, v. 59, p. 3909-3916.

Full paper for abstracts in FIR, v. 27, p. 85. (E.R.)

MANDEVILLE, C.W., CAREY, S.N. and SIGURDSSON, H., 1995, Magma mixing, fractional crystallization, and volatile discharge during the 1883 eruption of Krakatau (abst.): Eos, v. 76, no. 17, p. S268. Authors at Graduate School of Oceanography, Univ. Rhode Island, Narragansett, RI 02882.

The 1883 eruption of Krakatau volcano, Indonesia, produced ~12.4 km^3 (DRE) of magma, 90% white rhyodacite, 4% gray dacite, and 1% andesite. Melt compositions documented in 1883 eruption products from the study of MI and matrix glasses span a minimum range of 13 wt % SiO_2. Well-defined linear trends on major element variation diagrams have been successfully modelled by incremental fractional crystallization of andesite parental magma to produce rhyodacite. This fractional crystallization model is supported by trace element and Sr isotopic data.

The 1883 magma chamber was compositionally and thermally zoned with an upper portion of homogeneous rhyodacite at 880-890°C overlying more mafic gray dacite magma at 890°-913°C, and andesite magma. Gray dacite magma represents a hybrid magma formed by mixing small amounts of andesite magma with larger amounts of evolved rhyodacite. Evidence for magma mixing consists of banded pumices, MI more mafic than whole rock and matrix glass compositions, heterogeneous matrix glass compositions, and disequilibrium phenocrysts of orthopyroxene, clinopyroxene, and anorthite-rich plagioclase in white rhyodacite and gray dacite. The 1883 rhyodacite magma was probably not water saturated until reaching a shallow depth in the crust of 3-4.5 km. MI indicate pre-eruption volatile content in rhyodacite and gray dacite of 3.5-4.5 wt %.

Estimated S discharge from degassed magma is 2.7×10^{12} g S, and estimated Cl discharge is 9.2×10^{12} g Cl. Two potential sources of extra S from this eruption previously not accounted for may be vaporization of seawater during entrance of pyroclastic flows into the sea, and degassing of nonerupted andesitic parental magma lying beneath evolved rhyodacite magma in the zoned 1883 chamber. (Authors' abstract)

MANGAS, J. and GOMEZ-FERNANDEZ, F., 1995, Geological and FI characteristics of the Zn-Pb carbonate hosted mineralizations in the S.E. area of Picos de Europa (northern Spain) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 131-132. First author at Dpto. Geología, Univ. Las Palmas de G.C., Apdo. 550, Campus Univ. Tafira, 35080 Las Palmas de Gran Canaria, Spain.

The Pb-Zn mineralizations object of the study are located within the Cordillera Cantábrica, in the SE edge of the Picos de Europa region. The stratigraphic sequence is basically constituted of several carboniferous limestone formations. From a tectonic point of view, it is to be noted that the existence of imbricates thrusts of limestones, are present in each one most of the carboniferous sequence. [sic] Another important tectonic characteristic is the existence of a system of subvertical faults in the strike N105-120E, which had its origin at the end of Hercynian orogeny. A process of epigenetic dolomitization which affected large volumes of rock in the lower structural units and smaller volumes in upper units occurred in the area under study, prior to the deposition of the Zn-Pb mineralizations.

Two types of mineralizations have been found in most of the deposits. Type I mineralization is formed by granular sphalerite, galena, dolomite and calcite, and in lower proportions, chalcopyrite, tetrahedrite and pyrite, which have abundant granular, laminated and botroidal textures. Type II mineralization is characterized by toffee-coloured sphalerite, galena and calcite, and in lower amounts dolomite, pyrite and quartz. The type II sphalerite and galena may show large size crystals. Associated to this type of mineralization, fluorite appears added to it. The mineralizations of the two types are accompanied by graphitoid matter with sericite, microcrystalline quartz and carbonate minerals, which are products of the alteration caused by hydrothermal solutions upon the host carbonate rocks. Type II mineralizations are later than type I. Subsequent to these two phases, late (dolomite, calcite, galena, pyrite and fluorite) and secondary (hydrozincite, azurite, malachite, chalcocite, aurichalcite, cinnabar and Fe oxides) minerals were deposited.

The study of the FI by microthermometry and cryogenic scanning electron microscopy was carried out on samples of sphalerite I and II, dolomite I, calcite II and fluorite II. The I are L + V, frequently with mechanically trapped solids (calcite, dolomite, or clays).

The results suggest discontinuous hydrothermal evolution, as evidenced by spatial and temporal changes in sal. and T. Sal. ranges from 6.4 to 23.6 wt % eq. NaCl; Tm ice -4 to -21.3°C; Th 80-174°C. P corrections were estimated to be 20-50°C. In these deposits, P has been high enough to prevent the boiling of the F. The mineralizing F were possibly formation brines (S and O isotopic data show marine waters and that the S is of crustal origin). (From authors' abstract by E.R.)

See also FIR, v. 26, p. 106. (E.R.)

MANGAS, J. and PÉREZ-TORRADO, F.J., 1995, Fluid inclusion and stable isotope studies in Sn-W deposits of western Spain, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 473-476. Authors at Dept. Geology, Fac. Marine Sciences, Univ. Las Palmas de Gran Canaria, Spain.

Most of the Spanish Sn-W mineralizations are related to the syn- to late-tectonic Hercynian granites. FI and stable isotope studies have been carried out in quartz, cassiterite, scheelite and wolframite from different types of deposits: Sn disseminations in apogranites (Golpejas and Penouta), Sn pegmatites (Feli) and Sn, Sn-W, W quartz veins (Teba, San Finx, La Parrilla and Virgen de la Encina). The F probably responsible for the Sn-W mineralizations belong to $H_2O-NaCl-CO_2-CH_4-N_2-H_2S$ system with salinities <15 wt.% eq. NaCl and Th ranging between 240 and 430°C. $\delta^{18}O$(SMOW)‰ values show small variations: from 9.4 to 15.6 in quartz, -3.8 to 7.3 in cassiterite, 5.8 to 6.9 in scheelite, 4.9 in wolframite, and -2.9 to 8.2 in water of the melliferous fluids. These F are mainly magmatic or with incorporation of other isotopically lighter waters. (Authors' abstract)

MANLEY, C.R., 1995, Initial morphology and maturation of melt inclusions in successive populations of quartz phenocrysts from the Badlands rhyolite lava flow, SW Idaho (abst.): Eos, v. 76, no. 46, p. F656.

To fully exploit the information recorded in MI, we must understand their probable morphology and composition at the time of trapping, and how these may have changed after entrapment. Primary rhyolitic MI in three successively-nucleated populations of quartz phenocrysts in a single volcanic unit illustrate the change of I shape after trapping. The 14 Ma Badlands lava on the Owyhee Plateau of SW Idaho tapped a vertically-zoned chamber containing two contrasting rhyolitic magmas with three distinct populations of quartz phenocrysts differing in size and morphology. At the chamber's roof was a nearly aphyric magma with two populations of euhedral quartz ('tiny' [250 to 580 μm] and "intermediate" [750 to 1375 μm]). In the tiny crystals, which nucleated shortly before the eruption, large MI retain their initial, irregular shapes (ovoids, and elongate 'peanut shell' and 'boomerang' shapes) whereas the smallest MI show mature negative crystal shapes (i.e., bipyramidal, with edges and apices rounded). MI in the earlier-nucleated 'intermediate' quartz population all show either negative crystal shapes or faceted shapes transitional to negative crystals. Beneath the aphyric magma in the chamber was a large volume of phenocryst-rich (30%) rhyolite. Quartz phenocrysts in this magma are large (1.7 to at least 5.5 mm and corroded, and all MI in these crystals have negative crystal shapes regardless of MI size. Microprobe analyses show that maturation did not affect the composition of the trapped melt, which in all quartz populations was high-silica rhyolite. However, whereas MI from the two types of quartz in the aphyric magma revitrify to dense glass, MI in the large corroded quartzes contain many tiny bubbles, possibly indicating a higher content of CO_2 (?) which must have been lost from the system before growth of the younger quartz populations.

In silicic systems, irregularly shaped MI in quartz imply trapping just prior to quenching. Analyses of such MI should have the greatest likelihood of revealing the magmatic volatile conditions immediately preceding the eruption, providing constraints on magmatic evolution and crystallization processes, and eruption triggering and dynamics. (Authors' abstract)

MAO, Jingwen, CHEN, Yuchuan and WANG, Ping'an, 1995, Geology and geochemistry of the Dashuigou tellurium deposit, western Sichuan, China: Int'l Geol. Rev., v. 37, p. 526-546. First author at Inst. Mineral Deposits, Chinese Acad. Geological Sciences, Beijing 100037, PRC.

The Dashuigou Te deposit is unique. The orebodies occur as a group of parallel veins hosted by Triassic metabasalt. Mineralization developed in three stages: Stage I—pyrrhotite-pyrite, Stage II—tetradymite, and Stage III—chalcopyrite-pyrite. Stage II is the principal Te mineralization stage. The dominant gangue minerals are calcite and dolomite, with minor biotite, muscovite, albite, quartz, and chlorite.

FI studies of calcite, dolomite, and quartz from Stage I, II, and III yield Th of 356° to 260°C (mean = 320°C), 295° to 198°C (mean = 240°C), and 235° to 152°C (mean = 170°C), respectively. Salinities of P FI in all three stages are 1.5 to 5.8 wt % NaCl eq., 9 to 15.2 wt % NaCl eq., and 2.8 to 3.0 wt % NaCl eq., respectively. (From authors' abstract by E.R.)

MAO, Jingwen, CHEN, Yuchuan and WANG, Ping'an, 1995, Geology and geochemistry of the Dashuigou tellurium deposit, western Sichuan, China: Int'l Geol. Rev., v. 37, no. 6, p. 526-546.

Indexed under FI. See also next item. (E.R.)

MAO, Jingwen, CHEN, Yuchuan and WEI, Jiaxiu, 1995, The Dashuigou tellurium deposit in West Sichuan, China, *in* Pasava, Křîbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 149-152. Authors at Inst. Mineral Deposits, Chinese Acad. Geological Science, Beijing, PRC.

The Dashuigou Te deposit in West Sichuan province, China, occurs as steeply dipping veins hosted in Triassic basic volcanic rocks. Hydrothermally altered host rocks of different type form an extensive halo around the ore veins. The vein mineralogy consists of at least 32 minerals including eight tellurides. Three stages of vein mineralization, with different sulfides, are recognized. FI studies of carbonates and of 340°C-220°C, 260°C-160°C and 180°C-80°C, respectively. The $\delta^{34}S$ values of sulfides range between -2.2 and +2.8‰, the $\delta^{18}O$ and $\delta^{13}C$ values for carbonates between +10.9 and +13.1‰ and -5.3 to -7.42‰. The δD values of muscovite range from-61 to -54‰ and the $\delta^{18}O$ values of muscovite and quartz from 9.9 to 13.0‰. The stable isotope and geochemical data suggest that the Dasbuigou Te deposit is genetically linked with an ~140 Ma old, buried intrusive body. (From authors' abstract by E.R.)

See also previous item. (E.R.)

MARESCOTTI, P. and GIORGETTI, G., 1995, Fluid-mineral equilibrium in antitaxial quartz vein system in manganese-ore from Val Graveglia (northern Apennines, Italy) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 133-134. First author at Dip. Scienze della Terra, C. so Europa 26, I-16132 Genova, Italy.

During Upper Cretaceous-Lower Cenozoic orogenic events, sedimentary-diagenetic Mn oxides and hydroxides were completely replaced by braunite + quartz ± hematite assemblages, under prehnite-pumpellyite facies conditions ($T = 275 \pm 25°C$; $P = 2.5 \pm 0.5$ kb).

An antitaxial fibrous and euhedral quartz + bementite vein was chosen to characterize the synmetamorphic F possibly trapped during the veining process.

P FI in quartz can be divided in two compositionally distinct groups:

(1) low-salinity, NaCl-KCl-bearing F (avg. sal. ≤ 1 wt % in NaCl eq.) occurring in all the growth zones of euhedral quartz, and in the fibres; Th L decrease from 180 to 140°C.

(2) high-salinity F (avg. sal. of 12 wt % in NaCl eq.), characterized by a different chemical system (Te ~-35°C) and concentrated only in a narrow central part of large euhedral crystals; Th L are between 155 and 135 °C.

Isochores of successively trapped F are all consistent with the estimated conditions for the metamorphic event. Their distribution indicates that the system was cooling nearly isobarically. These F were circulating during the tectono-metamorphic event and were in equilibrium with the system as it cooled.

The high-salinity F is related to a temporally defined episode recorded only in the large euhedral crystals: It probably bears a Mn chloride in solution, and its salinity may explain a relatively high pH in the system during the mineralizing events.

Thus, considering the P-T-x characteristics of this F, we hypothesize that it represents the "mineralizing" F (i.e., the F which triggered the observed reactions) producing the new mineralogical assemblage. (From authors' abstract by E.R.)

MARIANELLI, P., CIONI, R. and SANTACROCE, R., 1995a, Melt inclusions in Ca-Mg-rich clinopyroxene from tephritic to phonolitic pyroclasts. A clue to the understanding of the feeding history of the Vesuvius magma chambers (extended abst.), *in* Volcanoes in Town, Roma 27-30 Sept. 1995: Periodico di Mineral., v. 64, p. 217-218. Authors at Dip Scienze della Terra, Univ. Pisa, Via S. Maria 53, I-56126 Pisa, Italy.

It is suggested that Mg-rich clinopyroxene with their MI testify to the different features of the Vesuvius plumbing system during periods of open or obstructed conduit conditions.

When conduit is open (e.g., 1906 and 1944 eruptions) a small magma chamber (0.1-0.5 km^3) progressively forms in the upper portions of the volcano (1-2 km depth). The K-tephritic glass I in pyroxene summarize the evolution of the resident magma, as resulted of the complex, dynamic processes (magma injection, magma mixing, crystal settling, magma extraction) acting throughout the lifetime of the chamber. The small volume of these chambers results in an easy thermal perturbability of the resident magma due to recurrent hot magma inputs. The oscillatory zoning of clinopyroxene precisely records the thermal fluctuations, with "hot" diopsidic zones marking each arrival of fresh magma.

When conduit is obstructed, larger (1-5 km^3), deeper (2-6 km), layered chambers grow, following the periodic arrival of deep mafic magma batches. Diopside (with phlogopite and olivine) results from rapid crystallization of these batches before reaching thermal equilibrium and mixing with magma in the lower portions of the chamber. The high-T crystals rapidly segregated to supply the mafic crystal mush plastering the inner-lower walls of the chamber, where they were uprooted during the eruption. The glass I in diopside therefore record the compositional range of the M having supplied the chambers. (From authors' abstract by H.E.B.)

MARIANELLI, P., CIONI, R. and SANTACROCE, R., 1995b, Melt inclusions in Ca-Mg-rich clinopyroxene from tephritic to phonolitic pyroclasts. A clue to the understanding of the feeding history of the Vesuvius magma chambers (abst.): Eos, v. 76, no. 46, p. F675-676.

MI-bearing, Ca-Mg-rich clinopyroxene recurrently occurs in pyroclasts from Somma-Vesuvius eruptions. In tephritic to phonotephritic lapilli from the 1631-1944 period of activity the pyroxene is typically characterized by developed oscillatory zoning. The pervasive sieve texture with drops of vesiculated glass spread along cleavage surfaces is interpreted as a result of abrupt decompression during eruption. Small to medium sized (10-50 micron) MI, partially or totally crystallized, are abundant along the growth surfaces of the crystals. Within single crystals, the I show variable Th (Thom = 1080-1200°C), increasing with decreasing Fe-content of the host zone. After homogenization and quenching the glass I exhibit K-tephritic composition, with MgO content increasing with Thom. In K-phonolitic pumice from Plinian and Subplinian eruptions mm-sized pyroxene sparsely occurs as compositionally homogeneous, perfectly shaped crystals including randomly distributed, completely crystallized, melt droplets (20-60 micron). Pyroxene crystals of different compositions occur within single sample, independently of either the eruption or the composition of the host pumice. MI homogenized between 1130 and 1170 C, increasing with their MgO content (after vitrification) and with decreasing Fe content of the host crystal. The I have near-primary (MgO > 7.0 wt %), K-basaltic (Avellino products) to K-tephritic (Pompei and Pollena products) compositions. It is suggested that these clinopyroxenes and their I testify the different state of the plumbing system. When conduit is open (e.g., 1906 and 1944 eruptions) a small reservoir (0.1-0.5 km3) forms in the upper portions of the volcano (1-2 km depth). The K-tephritic glass I summarize the evolution of the resident magma, as [a] result of the complex, dynamic processes (magma injection, magma mixing, crystal settling, magma extraction) acting throughout the life of the chamber. The small volume of these chambers results in an easy thermal perturbability of the resident magma due to recurrent hot magma inputs, precisely recorded by the oscillatory zoning of pyroxene, with "hot" diopsidic zones marking each arrival of fresh magma. When conduit is obstructed, larger (1-5 km^3), deeper (2-6 km), layered chambers grow, following the periodic arrival of deep mafic magma batches. Diopside (with phlogopite and olivine) results from rapid crystallization of these batches before reaching thermal equilibrium and mixing with magma in the lower portions of the chamber. The high-T crystals rapidly segregated to supply the mafic crystal mush plastering the walls of the chamber, from where they were uprooted during the eruption. The glass I in diopside record therefore the compositional range of the melt having supplied the chambers. (Authors' abstract)

MARSCIK, Robert and FONTBOTE, Lluis, 1995, Geology of the Cu(-Fe) deposits of the Punta del Cobre Belt, Northern Chile (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-466.

Chalcopyrite-pyrite-magnetite-hematite are the principal ore minerals. Ore grades are between 1 and 2 % Cu and may reach over 8 % Cu in veins. The total Cu metal provided by the hydrothermal system exceeds 5 Mt. Massive magnetite occurs as veins and irregular shaped bodies (Hopf, 1990). In the Punta del Cobre and Ladrillos districts, the mineralization appears to be controlled by NNW to NW-trending faults which were active since mid-Cretaceous. A mid-Cretaceous age for the mineralization is supported by preliminary whole-rock and biotite K-Ar and Ar/Ar ages of the alteration. The alteration pattern, preliminary FI data indicating saline F (own results and Holmgren, 1985), and T $\leq$400-500°C (Hopf, 1990) point to an association with deep-seated magmatic intrusion(s). (From authors' abstract by H.E.B.)

MARTIN-IZARD, Agustin, PANIAGUA, Andres, MOREIRAS, Damaso, ACEVEDO, R.D. and MARCOS-PASCUAL, Celia, 1995, Metasomatism at a granitic pegmatite-dunite contact in Galicia: The Franqueira occurrence of chrysoberyl (alexandrite), emerald, and phenakite: Canadian Mineral., v. 33, p. 775-792. First author at Dept. Geología, Univ. Oviedo, Arias de Velasco s/n, 33005 Oviedo, Spain.

Three types of FI have been distinguished. The FI populations of emerald and phenakite are similar. Two discontinuous hydrothermal stages have been identified. The first stage was characterized by the trapping of two types of aqueous FI with some volatile components. The two types of I may be contemporaneous, which suggests immiscibility in the system H_2O-NaCl-CH_4-CO_2-other volatile components. Th range between 318 and 381°C. The characteristics of type 3 I suggest an independent episode of F circulation during later tectonic events. The genetic model proposed involves emplacement of pegmatite and associated mobile elements (e.g., Be, B, P) into dunite, with subsequent metasomatism of the dunite into phlogopite and tremolite rocks near the pegmatite body. (From authors' abstract by E.R.)

MARTIN-ROMERA, C., VINDEL, E., LOPEZ-G, J.A. and CATHELINEAU, M., 1995, Relationships between F migration and regional stress field in mineralized pegmatites: An example from the Spanish Central System (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 135-136. First author at Dpto. Cristalografía y Mineralogía. Univ. Complutense. 28040 Madrid, Spain.

Late magmatic activity in the granites from the Spanish Central System result in the formation of pegmatites and miarolitic cavities, and is followed by F circulation and water rock interactions at the origin of the W-bearing quartz veins and greisen. As most of these processes are structurally controlled, it has been attempted to relate F events and related mineral crystallization to the regional succession of deformational events.

S FI were studied in wafers of Q1 samples from the inner zone of the miarolitic cavities. Three types have been distinguished: (i) Lw-s, containing brine, dps and trapped minerals, these represent an early F of high T (400-450°C). (ii) Lw-(c-m) I contain aqueous-carbonic F of moderate salinity plus dominant CO_2 and minor CH_4. They display moderate density (0.5 to 0.75) and Th ranging from 290° to 335°C.

The geometry of the orientations and textures in quartz grains were investigated using transmitted light microscopy on oriented thin sections and an interactive videographic analyzer which provides the strike and dip of linear microstructural markers.

This study shows that the F linked to earliest stages (magmatic) associated with the formation of the cavities have been mostly lost during the succession of deformational events (deformed I). Then a complex succession of microdeformation structures take place, with the trapping of aqueous F, the most represented being those in the FI band networks. (From authors' abstract by E.R.)

MARTINI, J.E.J., ERIKSSON, P.G. and SNYMAN, C.P., 1995, The Early Proterozoic Mississippi Valley-type Pb-Zn-F deposits of the Campbellrand and Malmani Subgroups, South Africa: Mineral. Deposita, v. 30, p. 135-145.

Quotes literature FI data. (E.R.)

MARTY Bernard, LENOBLE Madeleine and VASSARD Nicole, 1995, Nitrogen, helium and argon in basalt: a static mass spectrometry study: Chem. Geol. (Isotope Geosci. Sect.), v. 120, p. 183-195. Authors at URA 736 CNRS, Laboratoire MAGIE, Univ. Pierre et Marie Curies, 4, place Jussieu F-75252 Paris Cedex 05 France.

An analytical system for the simultaneous determination of nitrogen, He and Ar contents and ^{3}He/^{4}He, ^{40}Ar/^{36}Ar ratios in rocks by static mass spectrometry has been designed. Gases are extracted following either stepwise heating or vacuum crushing. The purification of nitrogen can be controlled by monitoring signals at masses 12, 14, 28 and 29. He and Ar isotopic ratios can be analysed in the same fraction, allowing control on the distribution of mantle-derived and atmosphere-derived components. Concentrations of nitrogen down to few ppb N are routinely measured. This work illustrates the potential of a combined rare gas-nitrogen approach when observing mantle-derived samples with very low amounts of nitrogen. (From authors' abstract by E.R.)

MASTALERZ, M., BUSTIN, R.M., SINCLAIR, A.J. and STANKIEWICZ, B.A., 1995, Carbon-rich material in the Erickson hydrothermal system, northern British Columbia, Canada: Origin and formation mechanisms: Econ. Geol., v. 90, p. 938-947. First author at Indiana Geol. Surv., Indiana Univ., 611 N. Walnut Grove, Bloomington, IN 47405.

C-rich material associated with Au-bearing quartz veins in the Erickson Au mine, Cassiar district of northern British Columbia, has been analyzed geochemically, petrographically, and isotopically. The results suggest that C was mobilized from carbonaceous material in siliciclastic rocks as CO_2, and to a lesser extent CH_4, and forced its way through fractures joining hydrothermal F. Precipitation of C occurred, probably due to reduction of CO_2 by H_2. Vein C is associated with Au-bearing quartz veins, and it is possible that organic matter played a significant role in Au precipitation. (From authors' abstract by E.R.)

See also Mastalerz et al. (1994) FIR, v. 27, p. 87. (E.R.)

MASTERS, R.L., WOODWELL, G.R. and BODNAR, R.J., 1995, Evidence for multiple crustal fluid sources associated with the Alleghanian orogeny in the eastern Piedmont of Virginia (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-217.

The eastern Piedmont of Virginia contains extensive bodies of moderate to high grade metamorphic rocks which have been cross cut by pegmatitic and quartz-rich veins as well as dikes of granitic composition. The host rocks are associated with several terranes which were sutured onto the growing Appalachian margin during the middle and late Paleozoic. With the exception of studies of quartz veins found in the Virginia Au-pyrite belt, little attention has been paid to possible FI data which may provide information concerning F associated with active margin tectonics in the eastern-most Piedmont. In this study vein-dikes have been sampled which occur in the Po River Metamorphic Suite located in Fredericksburg, VA. The host rock is a biotite gneiss of uncertain late Proterozoic-early Paleozoic age. The relative ages of three vein sets were determined by field and structural data. The oldest of the three sets is believed to correspond to Alleghanian deformation. Laser Raman spectroscopic analysis of I is quartz reveals that the intermediate age vein F are water-rich but also contain CO_2 and CH_4. Concentration of CO_2 in I from the vein margins were higher than those in the center of these antitaxial veins. No evidence of gases was found in I from either the youngest or the oldest veins. Salinities of I vary from 2.9 wt % NaCl in the oldest vein, to 1.7 wt % in the intermediate age veins, to 5.6 wt % for I in the youngest veins. Th of regularly-shaped I averaged 331°C, 289°C and 191°C for the oldest, intermediate and youngest veins I, respectively. The peak metamorphic T, derived from mineral assemblage data, is estimated to be 600°C. Extrapolation of the isochore for the oldest vein I to the peak metamorphic T yields a calculated peak P of 2.5 kb, equivalent to ~8 km of overburden. The data supports a model for at least two, and possibly three, separate F sources becoming activated during the late Paleozoic compression of the eastern Piedmont, with the CH_4 component suggesting a sedimentary origin for F in the intermediate age veins. (Authors' abstract)

MATHIAS, G.K., SIMMONS, S.F. and FLEMING, J., 1995, High sulfidation alteration at the Island Copper Porphyry Copper deposit, Vancouver Island, Canada: PACRIM '95, p. 365-370. First author at Geology Dept., Univ. Auckland, New Zealand.

Alteration and mineralisation at the Island Copper deposit is related to the intrusion of Early Jurassic quartz feldspar porphyry dikes into surrounding comagmatic Bonanza volcanic rocks. The pyrophyllite alteration zone forms an upward flaring cone, largely hosted within a breccia body that crosscuts the Cu, Mo, and Au-rich ore shell. This alteration zone contains pyrophyllite, dumortierite and diaspore and resembles alteration occurring in some high-sulfidation deposits, but which is barren. F-mineral equilibria and FI studies indicate formation at ~300°C from F dominated by steam and gases. These F appear highly acidic, but S poor, leading to extreme base leaching within the breccia body and surrounding rocks. (Authors' abstract)

L-rich FI (in quartz) have Th L avg. ~300°C, but V-rich I predominate. Much more work is in progress. (S. Simons)

MATO, L. and MATOVA, V., 1993, Gold mineralization of shear zones of Uderina prospect, southwestern part of the Veporicum crystalline complex, Central Slovakia: Mineralia Slovaca, v. 25, p. 327-340 (in Slovak, extended English abstract). First author at Geological Inst., Slovak Acad. Sci., Severna 5, 974 01 Banska Bystrica, Slovakia.

Au mineralization was found in the upper weathered horizon of the auriferous shear zones at the Uderina prospect area. The Au mineralization is hosted in quartz + albite and quartz + carbonate lenses. The highest Au contents (>1000 ppm) have been found in mylonitic bands. The Au is present in the form of Au-Hg-Ag nuggets. Two main types of the Au-Hg-Ag alloys and Au have been distinguished: (1) major type with mean composition 86.6% Au, 8.7% Hg and 4.4% Ag, and (2) minor type with 69.4% Au, 16.6% Ag, 13.4% Hg. Accessory Au leaves have a mean composition 92.8% Au, 3.98% Hg and 3.4% Ag. The alloys occur mainly in the form of nuggets, ≤15 mm in diameter. Accompanying minerals are represented by chalcopyrite, pyrite, sphalerite (≤2% Hg), tetrahedrite (≤10% Hg). Pyrite, chalcopyrite, bornite, cinnabar and Ag amalgam have been precipitated from disintegrated tetrahedrite.

FI data indicate that mineral-forming aqueous solutions have been low to moderately saline and enriched in CO_2 (± CH_4). Intensive fracturing resulting in crosscutting trails of S FI in all lens-shaped ore bodies imply polyphase dynamic deformation. Two main types of F have been distinguished: (A) $H_2O + CO_2 \pm CH_4$, and (B) H_2O without detectable gaseous components. All unambiguously PI belong to the A type. The B type PI are restricted to the quartz, postdating ore-bearing assemblage. Type A F have salinity ~8.5% NaCl eq. and homogenize to a L at ~350°C. FI data indicate the following episodes in the evolution of ore-bearing F: (1) circulation at $T = 400 \pm 30$°C and $P = 2$ kb of low saline aqueous F with minor content of volatiles, (2) P decrease to as low as 0.5 kb and entrapment of heterogeneous CO_2-enriched aqueous F at T 300 ± 20°C, and (3) circulation of volatile-depleted aqueous F at gradually decreasing T (250-110°C). (Authors' abstract)

MATSUBARA, K., MARTY, B., FRANCE-LANORD, C. and BEETS, C.J., 1995, Noble gases and stable isotopes in speleothems (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 330.

Cave calcite deposits (speleothems) may provide a reliable and continuous record of past climates.

We study a different system in this environment which may be more suitable to record the ancient T and atmospheric composition and fluctuations therein, namely the composition of noble G. Calcites are known to have FI within their mineralogical structure which contain the F and G of the ambient environment. The cave calcites can develop annual growth banding.

The physical principle of noble G thermometry is the dependence of the noble G solubilities (especially of Ar, Kr and Xe) in water which is equilibrated with air. The cave calcites are formed from saturated solutions which are equilibrated with the atmosphere. The measurement of atmospheric noble G trapped in the cave calcites may provide the tool for estimating continental paleotemperatures that can overcome many of the weaknesses of indirect paleotemperature indicators such as O isotopes. (From authors' abstract by E.R.)

MATSUDA, J., editor, 1994, Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), 386 p., ISBN 4-88704-114-4.

Pertinent papers are abstracted in this volume. (E.R.)

MATTHÄI, S.K., HENLEY, R.W. and HEINRICH, C.A., 1995, Gold precipitation by fluid mixing in bedding-parallel fractures near carbonaceous slates at the Cosmopolitan Howley gold deposit, northern Australia: Econ. Geol., v. 90, p. 2123-xxxx. First author at Dept. Geological and Environmental Sciences, Stanford Univ., Stanford, CA 94305.

This paper focuses on the F flow and chemical processes that formed the Au-bearing quartz veins. It is argued that lateral focusing of F flow into the subvertical vein-hosting fractures led to mixing of the ascending magmatic brine (± some metamorphic F) with hydrocarbon-rich F advected through carbonaceous slate in the steeply dipping fold limbs. Crack-seal textures in some of the Au quartz veins indicate that this F flow and mixing were locally episodic.

The magmatic brine involved in the mixing was expelled from a crystallizing I-type granite at depth (≤1.5 km below the deposit). This granite is highly fractionated and has I-SC characteristics: hornblende, pink K feldspar, accessory sphene and fluorite and whole-rock $Fe^{3+}/Fe^{2+} \geq 0.24$. These features indicate a redox state of the magmatic F at or above the NNO buffer. By contrast, Au deposition occurred at 2 to 3 log fO_2 units below NNO, a weakly acid pH of 4.3 to 4.7, 550° ≤ T ≤ 620°C, and ~200 MPa, from F with 1 to 5 m Cl. The vein sulfide paragenesis pyrrhotite + arsenopyrite ± loellingite indicates redox conditions compatible with the local carbonaceous units. This implies a redox contrast between the regime of Au deposition and the magmatic F source regime. It is inferred that reduction of the magmatic brine by F mixing in the vicinity of carbonaceous metasediments was responsible for localized Au deposition. (From authors' abstract by E.R.)

MATTHÄI, S.K., HENLEY, R.W., BACIGALUPO-ROSE, Stephen, BINNS, R.A., ANDREW, A.S., CARR, G.R., FRENCH, D.H., McANDREW, John and KANANAGH, M.E., 1995, Intrusion-related, high-temperature gold quartz veining in the Cosmopolitan Howley metasedimentary rock-hosted gold deposit, Northern Territory, Australia: Econ. Geol., v. 90, p. 1012-1045. First author at Dept. Geological and Environmental Sciences, Stanford Univ., Stanford, CA 94305.

The involvement of a magmatic F in ore genesis at the Cosmo Howley deposit is indicated by: (1) high fluorine contents in biotite from the alteration selvages of the Au quartz veins, (2) mutual crosscutting relations of Au quartz veins with aplite dikes, (3) the location of the deposit above I-type granite at a vertical distance of <2 km, and (4) the high salinity of the mineralizing F as estimated from the Cl content of biotite in the alteration halos of the veins. A magmatic derivation of the S in the auriferous sulfides is consistent with isotopic data. Calculated O isotope compositions of the F which precipitated the successive generations of quartz veins indicate that the isotopically heavy country rock was infiltrated by an isotopically light component such as magmatic F. (From authors' abstract by E.R.)

MATVEEV, S.V., BALLHAUS, C., ZIEGENBEIN, D., TRUCKENBRODT, J. and FRICKE, K., 1995, Synthesis of CHO fluids at high pressure (abst.): Eos, v. 76, no. 6, p. 17, p. 271.

Indexed under FI. (E.R.)

MAUK, J.L. and ST. GEORGE, J.D., editors, 1995, PACRIM Congress 1995: Proc. 1995 PACRIM Congress, Auckland, New Zealand, 19-22 November 1995, Australasian Inst. Mining and Metallurgy Publ. Series No. 9/95.

Individual pertinent abstracts entered in this volume. (E.R.)

MAVROGENES, J.A., BODNAR, R.J., ANDERSON, A.J., BAJT, S., SUTTON, S.R. and RIVERS, M.L., 1995, Assessment of the uncertainties and limitations of quantitative elemental analysis of individual fluid inclusions using synchrotron X-ray fluorescence (SXRF): Geochim. Cosmochim. Acta, v. 59, p. 3987-3995. First author at Research School of Earth Sciences, Australian Nat'l Univ., Canberra, ACT 0200, Australia.

Full paper for abstract in FIR, v. 27, p. 88-89. (E.R.)

MAVROGENES, J.A., BODNAR, R.J., GRANEY, J.R., McQUEEN, K.G. and BURLINSON, Kingsley, 1995, Comparison of decrepitation, microthermometric and compositional characteristics of fluid inclusions in barren and auriferous mesothermal quartz veins of the Cowra Creek Gold District, New South Wales, Australia: J. Geochem. Exploration, v. 54, p. 167-175. First author at Research School of Earth Sciences, Australian Nat'l Univ., Canberra, ACT 0200, Australia.

FI in quartz from barren and Au-sulfide-bearing veins from the Cowra Creek Gold District, New South Wales, Australia, have been characterized based on their decrepitation behavior and G geochemistry. Inclusions in Au-sulfide veins, and some regional sulfide-bearing veins, show distinctly higher CO_2/CH_4 ratios compared to barren quartz-only and quartz-sulfide veins from the deposit environment. Additionally, the occurrence of low-T peaks in acoustic decrepigrams from Au-sulfide veins that had previously been attributed to the presence of CO_2-bearing FI has been confirmed using optical techniques. This characteristic peak is absent from quartz-sulfide and quartz-only veins. These results suggest that the G content of FI can distinguish Au-bearing from barren quartz veins, and that the acoustic decrepitation technique may provide a rapid and simple means of identifying different generations of quartz, and potentially productive veins in mesothermal environments. (Authors' abstract)

MAYEGOV, V.I., 1995, Petrogenetic significance and formation mechanism for potassium-rich inclusions in plagioclase from gabbros in the Ioko-Dovyren intrusion in North Cisbaykalia and the Khabarna intrusion in the South Urals: Dokl. Ross. Akad. Nauk, v. 345, no. 3, p. 367-371 (in Russian).

Dxls of K-feldspar, clinopyroxene, chromite, biotite and amphibole. Six analyses of MI given. (E.R.)

McCAIG, A.M., WAYNE, D.M., MARSHALL, J.D., BANKS, Dave and HENDERSON, Iain, 1995, Isotopic and fluid inclusion studies of fluid movement along the Gavarnie thrust, central Pyrenees: Reaction fronts in carbonate mylonites: Am. J. Sci., v. 295, p. 309-343. First author at Dept. Earth Sciences, The University, Leeds LS2 9JT, UK.

Geochemical fronts for Sr isotopes have been identified within carbonate mylonites along the Gavarnie Thrust in the central Pyrenees. The data show that Sr was transported southward along a 2 m thick mylonite zone for at least 1.5 km. FI crush-leach analyses show that a Sr-rich hypersaline brine with a high $^{87}Sr/^{86}Sr$ ratio was trapped within Triassic redbeds beneath the Thrust; this is a likely candidate for the F that passed through the mylonites, increasing their $^{87}Sr/^{86}Sr$ ratios from depositional values close to that of Cretaceous seawater. Comparison of the Sr content of FI and calcite in the same vein systems allows the solid-F partition coefficient, $K_{V\text{-}Sr}$ to be estimated. Values range from 0.5 in the northern part of the thrust system to 1.9 farther south, where F are more dilute. These values can be combined with minimum transport distances for the geochemical fronts to give minimum time-integrated fluxes of between 1800 and 3000 m^3/m^2. The estimates of $K_{V\text{-}Sr}$ are supported by $\delta^{18}O$ data on carbonates. Overall, F flow can be explained by a fault-valve model, with slow pervasive flow through the mylonite during plastic deformation punctuated by rapid flow into veins during seismic events. (From authors' abstract by E.R.)

McCONNELL, J.D.C., LIN, J.S. and HEINE, Volker, 1995, The solubility of $[4H]_{Si}$ defects in α-quartz and their role in the formation of molecular water and related weakening on heating: Phys. Chem. Minerals, v. 22, p. 357-366. First author at Dept. Earth Sciences, Univ. Oxford, Parks Rd., Oxford OX1 3PR, UK.

The nature of the solubility of water as $[4H]_{Si}$ defects in quartz, and their role in providing a source of molecular water on heating, is investigated. Existing *ab initio* energy calculations on the incorporation of water in quartz are used to show that energetically 4H for Si substitution is likely to constitute the most prevalent mode of water uptake on the atomic scale in quartz under equilibrium conditions, and that the planar defects previously observed by a number of different authors by electron microscopy in wet quartz are likely to be planar rafts of aggregated $[4H]_{Si}$ defects which are formed on supersaturation. These new conclusions call into question the previous identification of the planar defects as high P water clusters and require that their role in the production of molecular water in the context of recent theories of hydrolytic weakening be re-assessed. Accordingly the existing *ab initio* results have been used to establish the characteristics of the phase diagram for the system quartz-water in the T and P range of interest in hydrolytic weakening. Additional electron-optical experiments on wet quartz show that, on annealing at T in the electron microscope, similar planar defects develop in wet quartz by a diffusion process. In the context of existing theories of hydrolytic weakening it is now proposed that the conversion of $[4H]_{Si}$ defects to molecular water, where this is dictated by the equilibrium phase diagram, leads to a relatively large increase in volume and to the appearance of the bubbles of free water and the nucleation of associated prismatic dislocation loops of Burgers vector $b = 1/3\ a\langle 1120\rangle$ as previously observed. Ultimately the development of these loops leads to dislocation-induced plasticity. (Authors' abstract)

McCOY, D.T., NEWBERRY, R.J. and LAYER, Paul, 1995, Geological, geochemical, and geochronologic evidence for both metamorphic and intrusive metallogenesis in Alaskan gold deposits (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 5, p. 63. Authors at Dept. Geology and Geophysics, Univ. Alaska, Fairbanks, AK 99775.

Alaska's most productive lode Au districts possess low salinity, moderate T, high CO_2 FI similar to those present in most mesothermal Au districts worldwide. These F were responsible for an abundance of sericite and carbonate alteration associated with mineralization. Despite these similarities, metallogenesis differs significantly from district to district. End member models for large Alaskan Au deposits are:

(1) "Extrinsic" deposits: Mineralization is coeval with, or slightly later than metamorphism and deformation and >10 Ma younger than hosting plutonic rocks. Mineralization occurs within a major regional structure. Elevated levels of As, Pb and Zn are associated with Au mineralization. Mineral equilibria and FI geobarometry indicate P of ca. 3-4 kb and T of ca. 350-400°C. Isotope data is as follows: $\delta^{14}S_{sulfides} = -5$ to $-16‰$; $\delta^{18}O_{fluid} > 10‰$; $\delta^{14}C_{carbonate} < -10‰$; vein Pb are highly radiogenic. F contain abundant CO_2 contaminated with highly variable N_2, CH_4 and H_2S. Examples of extrinsic deposits are the Alaska-Juneau mine and several other deposits in the Alaska-Juneau Au belt.

(2) "Intrinsic" deposits: Mineralization is coeval with plutonism and 10-15 Ma younger than hosting metamorphic rocks. Au was emplaced into intrusion-hosted/related breccias and shears at P of 0-1.5 kb and T of 250-450°C. Elevated levels of As, Sb, Bi, Te, W and Mo are associated with Au mineralization. Isotope data is as follows: $\delta^{14}S_{sulfides} = -5$ to $+5‰$; $\delta^{18}O_{fluid} > 5\text{-}7‰$; $\delta^{14}C_{carbonate} > -10‰$; vein Pb plot within the same field as magmatic K-spars and similar to that of subduction-related intrusive porphyry metal deposits in the western U.S. F contain relatively pure CO_2. Examples of intrinsic deposits are ~90 Ma calc-alkaline intrusion-associated deposits of eastern Interior Alaska and ~70 Ma alkalic intrusion-associated deposits of western Interior Alaska.

Geological, geochemical, and geochronological data point to "extrinsic" deposit formation by deep (+3 kb) crustal metamorphic devolatilization and Au leaching from a thick sedimentary pile during orogenesis at a major suture zone. In contrast, "intrinsic" deposits formed due to Au fractionation into volatile phases during evolution of subduction-related, reduced alkaline and calc-alkaline intrusions at shallow (0 kb) to moderate (1.5 kb) depths. (Authors' abstract)

McCUAIG, T.C. and KERRICH, Robert, 1994, P-T-t deformation-fluid characteristics of lode gold deposits: Evidence from alteration systematics, *in* D.R. Lentz, ed., Alteration and Alteration Processes associated with Ore-forming Systems: Geol. Assoc. Canada, Short Course Notes, v. 11, p. 339-379.

Includes a section on FI, reviewing problems in interpretation, and numerous deposits, using literature data. (E.R.)

McCUAIG, T.C. and KISSIN, S.A., 1995, The Port Coldwell veins, northern Ontario: Pb-Zn-Ag deposits in a rift setting: Proc. Int'l Conf. on Basement Tectonics, v. 10, p. 15-18.

Indexed under FI. (E.R.)

McDONOUGH, W.F. and DANYUSHEVSKY, L.V., 1995, Water and sulfur contents of melt inclusions from Archean komatiites (abst.): Eos, v. 76, no. 17, p. S266. First author at Dept. Earth and Planetary Sciences, Harvard Univ., Cambridge, MA 02138.

Fresh olivine phenocrysts with glass I come from komatiite units in the 2.7 Ga Reliance formation of the Belingwe greenstone belt, Zimbabwe. Incompatible trace element compositions of these I show similarities to modern intraplate basalts, and are distinct from modern mid-ocean-ridge and convergent-margin basalts (McDonough and Ireland, Nature, 1993). We measured the S contents of these glass I by electron microprobe and their H2O contents by FTIR spectroscopy. We find a range of S contents (350-540 ppm) in the I, suggesting a S content of ~200-250 ppm in the initial 25 wt % MgO komatiitic L. These S contents may reflect either the primary S content of the komatiitic L, or some amount of degassing of the M prior to its entrapment in the olivine host. Determination of the H2O contents of the I presented significant technological challenges, their small (~20 microns) size. Our preliminary results are based on data from three I from the B4 unit. We found ~0.19 wt % H2O in the initial 25 wt % MgO komatiitic L, K2O/H2O of ~0.25 and H2O/(Ce+Nd) of ~30. This K2O/H2O value is the same as that measured for modern N-type MORB, whereas the H2O/(Ce+Nd) value is much lower than that seen in MORBs and modern intraplate basalts. The high H2O/TiO2 and K2O/TiO2 values of these komatiites imply a more fertile source than N-MORB. Like the S results, these data may reflect either the primary H2O content of the komatiitic L, or some amount of degassing of the M prior to its entrapment in the olivine host. These data place lower limits to the volatile contents of komatiitic magmas and document their non-anhydrous nature, and this in turn implies lower potential T for their source regions. (Authors' abstract)

McEWAN, C.J.A., FALLICK, A.E. and RICE, D.M., 1995, The Rosita Hills epithermal Ag-base metal deposits, Colorado, USA: A stable isotope and fluid inclusion study: Mineral. Deposita, v. 31, p. 41-51.

McNEIL, B., SHAW, H.F. and RANKIN, A.H., 1995, Diagenesis of the Rotliegend Sandstones in the V-Fields, southern North Sea: A fluid inclusion study, *in* J.M. Cubitt and W.A. England, eds., The Geochemistry of Reservoirs: Geol. Society [London] Special Pub. No. 86, p. 125-139. First author at Dept. Geology, Imperial College, London SW7 2BP, UK.

Illite, quartz, Fe-dolomite (with some dolomite), anhydrite and barite are the principal pore-filling cements in the analysed samples of the Rotliegend sandstones from the Vulcan, South Valiant and Vanguard Fields of the southern North Sea. Apart from illite, these cements also infill fractures cutting the Rotliegend sandstones, but in the fractures there is a predominance of anhydrite and barite whereas in the pore infills, quartz and Fe-dolomite predominate. The quartz, Fe-dolomite and sulphate cements have been studied using a variety of analytical techniques but with the emphasis on FI microthermometry. The results indicate that F at T of 70 to 125°C, with salinities of 17 to 24 eq. wt % NaCl and an overall composition of Na-Ca-Mg-K-Cl-SO_4, were involved in authigenic mineral formation in pore spaces and fractures. Hydrocarbons were detected in the FI hosted in the cements and indicate that cementation occurred in the presence predominantly of CH_4 and only rarely L hydrocarbons. Relating the microthermometry Th/Tf to the burial history, quartz cementation occurred mainly in the late Permian to late Cretaceous, Fe-dolomite during the Jurassic to mid-Cretaceous, and anhydrite and barite mainly in the mid-to-late Cretaceous. (Authors' abstract)

McPHAIL, D.C., 1995, Thermodynamic properties of aqueous tellurium species between 25 and 350°C: Geochim. Cosmochim. Acta, v. 59, p. 851-866. Author at Victorian Inst. Earth and Planetary Sciences, Dept. Earth Sciences, Monash Univ., Clayton, Victoria 3168, Australia.

Measured Te concentrations in experiments on the solubility of hessite + native Te + chlorargyrite in HCl solutions at 300°C are much higher (1's to 1000's of ppm) than predicted (10's to 100's of ppb) and may be evidence for unknown Te species (e.g., metal-Te complexes or aqueous Te in other valence states). The low predicted concentrations of aqueous Te may also indicate that V-phase transport of Te is important in the formation of telluride-bearing epithermal ore deposits. (From author's abstract by E.R.)

McQUEEN, K.G. and PERKINS, Caroline, 1995, The nature and origin of a granitoid-related gold deposit at Dargue's Reef, Major's Creek, New South Wales: Econ. Geol., v. 90, p. 1646-1662. First author at Fac. Applied Science, Univ. Canberra, PO Box 1, Belconnen, ACT 2616, Australia.

FI data indicate that Au-bearing hydrothermal FI were CO_2 bearing, of low to moderate salinity, and medium to low T (<350°C). S isotope ratios are consistent with a magmatic S source. C isotope data for calcites from the mineralization indicate $\delta^{13}C$ values for the F close to 0‰. These are not inconsistent with a magmatic C source, but they are also consistent with derivation of CO_2 from minor limestones n the country rocks. Textural and FI evidence suggest that CO_2 activity in the F increased with time, which could be explained by late-stage introduction of country-rock F or possibly influx of F from a later intrusion at depth. O isotope data for calcites from the ores and late-stage veinlets implicate F similar to those in porphyry-mineralizing systems with some intermixing of $\delta^{18}O$-depleted, probably meteoric F. (From authors' abstract by E.R.)

Th values range from 100 to 340°C. Most CO_2-bearing FI have Th 140-260°C, with sal. 4-11%. (E.R.)

MEANS, W.D. and LI, T., 1995, Experimental antitaxial growth of fibrous crystals. II: Internal structures (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 70.
Indexed under FI. (E.R.)

MECHUM, T.A., WHITNEY, D.L., KUEHNER, S.M. and DILEK, Y.R., 1995, Progressive metamorphism of pelitic rock from protolith to granulite facies, Dutchess County, NY (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-438.

A complete Barrovian sequence ranging from unmetamorphosed sedimentary rock to sillimanite-potassium feldspar zone metapelitic gneisses crops out in a region extending from the Hudson River in SE NY state, to the high-grade core of the Taconic Range in western CT. A series of NNE trending subparallel chlorite, biotite, garnet, staurolite, kyanite, sillimanite, and sillimanite-potassium feldspar isograds have been identified (Barth, 1936), although the assignment of Barrovian zones in the high grade rock is complicated by the appearance of fibrolite at the kyanite isograd. Thermobarometric results and reaction textures have been used to characterize the metamorphic history of the sequence. P-T estimates indicate an increase in metamorphic conditions from ~450°C, ~3-4 kb in the garnet zone to > 710°C, ~5-6 kb in the highest grade rocks. Kyanite zone rocks yield anomalously low P-T conditions compared to staurolite zone rocks as a result of post-crystallization modification of garnet compositions along fractures. Petrographic and mineral chemical information indicates that the entire sequence, with the exception of the granulite facies, was infiltrated by a H_2O-rich F subsequent to major growth of porphyroblasts, but at T and P high enough to result in impartial dissolution and reprecipitation of garnet. Modification of garnet by F-assisted reaction occurred along fractures and near mineral I, particularly in garnets adjacent to quartz veins. The abundance of FI trails in garnet suggests that FI was pervasive. The truncation of FI trails by later garnet rim growth/recrystallization indicates that garnet growth continued subsequent to infiltration. Post-crystallization reactions involving garnet will affect any petrologic application that utilizes garnet major (and perhaps trace) element compositions. (Authors' abstract)

MEERE, P.A., 1995a, High and low density fluids in a quartz vein from the Irish Variscides: J. Struct. Geol., v. 17, p. 435-446. Author at Dept. Earth Science, The University, Leeds LS2 9JT, UK.

Combined microstructural and FI studies on a multiple quartz vein from the Irish Variscides reveal a kinematic history consisting of three separate, dynamically distinct, extensional opening events. The first of these is characterized by trapped F at densities of 0.87-0.98 g cm^{-3}, indicative of P approximating the estimated lithostatic load, while F densities associated with the following two events (0.76-0.91 g cm^{-3}) clearly indicate sub-lithostatic F P. The combined evidence suggests that these later two opening events were extensional fractures occurring well below the critical depth for tensional σ_3 (least effective principal stress). It is argued here that the preservation of such low density F, in an environment that conventionally requires supra-lithostatic F P for hydraulic failure, is due to (i) the influence of a preexisting material anisotropy in the rock that would result in hybrid extensional failure, (ii) the effect of stress heterogeneities associated with the development of crude boudins in the vein. (Author's abstract)

MEERE, P.A., 1995b, Sub-greenschist facies metamorphism from the Variscides of SW Ireland: An early syn-extensional peat thermal event: J. Geol. Soc. London, v. 152, part 3, p. 511-521.

Illite crystallinity studies on metaclastics from the Variscides of SW Ireland range in value from 0.18 to 0.25° $\Delta 2\theta$ indicating a metamorphic grade in the upper anchizone-lower epizone (c. 275-325°C). Chlorite geothermometry yields a similar metamorphic T range (280-315°C). Combining these data with known overburden estimates for the area (c. 5 km) implies late Palaeozoic geothermal gradients >60°C km^{-1}. FI studies on quartz veins in these metaclastics reveal two vein types characterized by F densities of 0.7-0.93 g cm^{-3} (Group 1) and 0.9-1.0 g cm^{-1} (Group 2), respectively. This variation in F density is thought to be dominantly controlled by T, with Group 1 veins linked to late Palaeozoic extension and high geothermal gradients and Group 2 veins associated with subsequent Variscan deformation and lower T conditions. (Author's abstract)

MEERE, P.A. and BANKS, D.A., 1995, Upper crustal F migration during an orogenic cycle: An example from the Variscides of south west Ireland (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 137-138. First author at Dept. Geology, Univ. College, Cork, Ireland

Single generation F in quartz veins from two similar host lithologies located either side of the Irish Variscan front were investigated.

Variscan veins north of the front have medium salinities (4-14 wt %) and densities (0.97-1.08 g/cm3) generally compatible with the expected P-T conditions of deformation in the area. F in veins south of the cleavage front can be grouped into those in (a) syncompressional veins with moderate salinities (8-16 wt %) and (b) late stage veins associated with post-orogenic extensional faults which have trapped high salinity F (22-27 wt %). Again F densities for both vein types (0.87-1.12 g/cm3) are broadly compatible with estimated P-T conditions of both trapping events.

Crush-leach analyses (Banks and Yardley 1992) reveal that all the F analysed have Br/Cl ratios close to seawater, clearly indicating a marine origin. The moderate to high salinities observed had therefore to be produced by evaporation of seawater during the Late Palaeozoic marginal marine sedimentary history of the area. Variations in I/Cl ratios indicate significant water/rock interaction for medium salinity F either side of the front. The cation content of the F also indicate that significant modifications to the composition of an evaporated sea water have taken place. Na is depleted and K is elevated with respect to expected values. This can be ascribed to the destruction of K-feldspars by Na-rich F to produce albite which is present in quartz veins. As the concentration of K increases (representing increasing K-feldspar destruction) there are strong positive correlations with the trace elements Sr, Pb and Zn which are commonly found in feldspars, further supporting the argument that dissolution and reprecipitation of feldspars was a major control on F composition.

The marked internal consistency in Br/Cl ratios from northern and southern F coupled with broad ranges of cation to chloride ratios suggests that an early homogenous F was subsequently modified by differing migration histories during the Late Palaeozoic tectosedimentary evolution of the area. (From authors' abstract by E.R.)

MEERE, P.A., CATHELINEAU, M., DUBOIS, M., AYT-OUGOUGDAL, M. and ROYER, J.J., 1995, Are quartz veins forming under Strasbourg today? A fluid inclusion study (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 185.

The Upper Rhine Graben is an area hosting an actively circulating upper crustal F system, the nature of which is currently being investigated by the EU HDR project at Soultz-sous-Forêts, France. Two drill holes (GPK 1, EPS 1) were drilled in a geothermal anomaly in an area geologically characterised by Hercynian granitic basement overlain by a Mesozoic and Tertiary sedimentary sequence. Modern F have an average salinity of 10 wt % NaCl eq. that show little variation with depth and have a Br/Cl ratio of 0.0051, i.e., close to seawater (SMOW: 0.0035). Palaeofluids trapped in veins were investigated utilizing FI microthermometry and crush leach analysis. Trapped palaeofluids exhibit a salinity range of 1-28 wt. % NaCl eq. and Br/Cl ratios ranging between 0.0038 and 0.0088. This salinity range is observed within individual veins. The P corrected T-depth profile for palaeofluids in these veins is close to the profile obtained from modern F during drilling. The similarity in salinity, T and halogen ratios of the trapped F with modern circulating F suggests the later are being trapped in these structures and suggests the possibility of a mixing of low salinity (<5 wt % NaCl eq.) F ascending from depth with lower T (130-160°C) higher salinity (>20 wt. % NaCl eq.) Ca-Mg brines associated with overlying Triassic sandstones. The low salinity F are probably gravity driven from the horst block margins of the graben, down into granitic basement to ascend along a series of localised extensional faults in the Soultz area. The presence of higher T F (160-250°C) from one sample at 1915m in basement granite supports the possibility of deeper F being tapped at depth along faults during seismic activity. The presence of high salinity brines within the upper basement attests to a broad F mixing zone and subsequent downward penetration of F equilibrated with the sedimentary cover. (See also Yardley et al., this issue (E.R.))

MELCHER, F., STUMPFL, E.F. and SIMON, G., 1995, Platinum-group minerals and associated inclusions in chrome spinel of the Kempirsai ultramafic massif, Southern Urals, Kazakhstan, *in* Pasava, Krfbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 153-156. First author at Inst. Geological Sciences, Mining Univ., Leoben, Austria.

During serpentinization, Cl-bearing reducing F introduced As and mobilized Ir, Ni, and Cr from preexisting minerals. (From authors' abstract by E.R.)

FI are rarely observed in main ore field chromites. Chrome spinel in the amphibole-chlorite-chromite rock mentioned above contains characteristic I trails which also form polygonal networks. Such trails contain minute I of silicates, base metal sulfides, and F. The morphology of the trails suggests that they formed during overgrowth of preexisting chromite. Comparatively large (≤20 µm) two-phase L+V I are sometimes concentrated in the cores of an earlier chromite generation. (From authors' text by E.R.)

MELFOS, V. and VAVELIDIS, M., 1995, Fluid inclusion studies on the porphyry type Cu-Mo (±Au) mineralization in the Maronia area, Thrace County, Greece (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 139-141. Authors at Aristotle Univ. Thessaloniki, Greece.

The present study refers to the microthermometric research of the mineralization, which is associated with a porphyry microgranite. Three alteration zones have been distinguished, the phyllic, argillic and propylitic zones. The ore shows Cu, Mo and Au ≤5460 ppm, 6900 ppm and 12 ppm, respectively.

Four I types were recognized. *Type 1* contains a L H_2O and V; Te ~-21.4°C. Tm ice -4.5 to -12.3°C correspond to a salinity between 7 and 16.4 wt % eq. NaCl. The FI show Th L between 260 and 460°C, with two maximum values at 330 and 370°C. *Type 2* contains a colorless isotropic solid cube, probably halite. Tm NaCl ranges between 130 and 500°C, indicating a salinity from 28 to 55 wt % eq. NaCl. The [L + V of the?] FI homogenize into the L phase at T mainly from 260 to 440°C with a distinct peak at 310°C. *Type 3* FI consist of L + V, with the V bubble occupying 50 to 90% by volume. Tm ice = -3.4 to -10°C, yielding sal. 5.5 to 14 wt % eq. NaCl. Th V vary from 340 to 420°C, displaying a maximum at 380°C. *Type 4* FI were found rarely and consist of a L phase, a V bubble (50 to 85% of the total volume) and a dm, probably halite. They homogenize into the V phase from 307 to 444°C. Halite dissolves at T between 315 and 450°C, indicating a sal. of 38 to 51 wt % eq. NaCl. In many cases an accidental trapped opaque phase, possibly pyrite, was observed in type 1 and 2 FI. Th of the different types of the FI displays dominant values from 260 to 440°C, with a distinct peak at 370°C.

Figure 1 indicates that two F, the high and the low- to moderate-salinity ones, participated simultaneously in the ore deposition. This is characteristic to the porphyry type ore deposits. The Th of the majority of the FI (260 to 420°C, maximum at 370°C) represent the ore Tf. The estimating trapping P range from 150 to 450 bars for the low-salinity I and 160 to 510 bars for the high-salinity I. The density of the highly saline F were >0.85 g/cm^3 and of the low- to moderate-salinity F <0.95 g/cm^3. (From authors' abstract by E.R.)

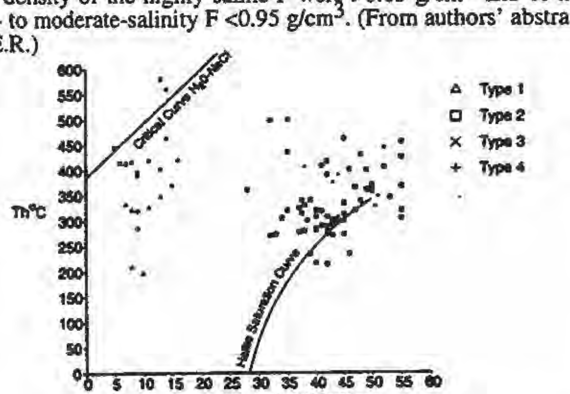


Figure 1. Th vs. sal. diagram displaying two distinct groups.

MENARD, Thomas, 1995, Synmetamoprhic alteration of hydrothermally altered volcanic rocks in VMS deposits, Snow Lake, Manitoba (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 117.

Indexed under FI. (E.R.)

MENDOUSSE, Claudine, 1994, Example of a fossil hydrothermal system: Miocene volcanogenic sulphides (abst.): 15th Reunion Sci. de la Terre, p. 76 (in French). Author at Laboratoire d'Etude des Systemes Hydrothermaux, JEDRED "Magmas et Metaux," Univ. Nancy I, France.

The Pb-Zn-Cu-Au and barite deposits of Oued el Kebir and Bou Soufa (Algeria) are located within a dacite unit corresponding to the first products infilling a 7 km diameter caldera. They were set up by the juxtaposition and recurrence on the restricted surfaces (0.5 to 1.5 km^2), resulting in mineralized complexes with dimensions varying between a hundred and several hundreds of meters. Defined by their alteration paragenesis, their distributions and volumes altered, two types of submarine hydrothermal plume systems are envisaged to account for the distribution of mineralized sites and their internal structures: those diffused through the pyroclastics, cut by stockworks, disseminations and impregnations; and those more channeled by a group of regional E-W normal-dextral faults associated with a period of Burdigalian-Langhian transtension, which controlled the sulphide placement, the veins and dacite domes.

The minerals were emplaced in three stages, augmented by T ≤340°C for the first stage, followed by a reduction to 120°C. the F responsible for the most important mineralization, in terms of tonnage, show a T lowering from 320°C to 180°C, under a S fugacity of 10^{-6} to 10^{-14} atm. Fracturing not only played a role [for providing F flow] but also provided a mechanism for mixing between seawater and heated F. The seawater [hydrothermal] F ratios calculated on the basis of FI vary between 0.8 and 6, with two episodes between 320-200°C and 200-180°C. The plumes were related to convection cells of diameters and depths of 1 to 3 km, with a geothermal gradient on the order of 50-60°C per km. (Author's abstract; translation courtesy of Dr. A.P. Gize)

MENZIES, M.A., 1995, The mineralogy, geology and occurrence of topaz: Mineral. Record, v. 26, p. 5-53.

Discusses the FI found in topaz in relation to various topaz parageneses based on literature data. (H.E.B.)

MERNAGH, T.P. and LOUCKS, R.R., 1995, Advances and trends in fluid inclusion research in Australisia: APIFIS Newsletter 1995, Univ. Science and Technology Beijing, p. 5-10. First author at Australian Geol. Surv. Organization, GPO Box 378, Canberra, ACT 2601, Australia.

A review of the equipment, facilities and methods available in Australia for FI research. The methods covered included PIXE; infrared laser microbeam release of gases from individual I into fast-scanning quadrupole mass spectrometer (L I are decrepitated, MI are melted); UV laser-ICP MS for I solutes. For most elements, including Cu, Ag, Au, and the Pt group, the analytical sensitivity is in the range of 1 part in 10 billion to 1 part in 10 million, the sensitivity increasing with the size of the ablated spot. The laser beam diameter and size of the ablation spot can be adjusted from ~10 to 100 micrometres. A 10- to 30-element analysis takes <1 min of instrument time. The instrumentation will be operational in early 1995. (From authors' abstract by E.R.)

MERTIG, H.J., 1995, Geology and origin of the Dom copper skarn deposit, Ertsberg (Gunung Bijih) District, Irian Jaya, Indonesia: Unpub. Masters thesis, Univ. Texas, Austin, Texas, 169 p.

Skarn mineralogy is roughly zoned away from the Ertsberg intrusion, from a monticellite-rich zone to garnet-magnetite-rich zones. Chalcopyrite is the dominant ore mineral. Early skarn formation coincides with emplacement and initial crystallization of the Ertsberg intrusion and consists of Ca-Al and Ca-Mg silicates including monticellite, vesuvianite, grandite garnet, and diopside. The presence of vesuvianite requires high ratios of H_2O/CO_2, on the order of $X(CO_2) < 0.05$. Three-phase FI in monticellite yield an average Th of 392°C and average salinity of 46 eq. wt % NaCl. Early-stage quartz FI, also three-phase, average 436°C with 41 eq. wt % NaCl, and two-phase I in early-stage garnet average 386°C with 22 wt % NaCl. Main-stage skarn formation is dominated by garnet and magnetite, each representing multiple pulses of Fe-metasomatism, probably as a result of continued crystallization of the Ensberg [Ertsberg?] intrusion. Ore deposition occurs in the early retrograde stage of events. Intense retrograde alteration overprints most of the Dom skarn and represents rapidly declining T probably resulting from an increasing flux of meteoric F. FI in late-stage quartz average 303°C and 12 wt % NaCl, and FI in calcite average 297°C and 12 wt % NaCl. Skarn formation occurred at <2 km depth, corresponding to P < 0.6 kb, under strongly oxidizing conditions. Chemical compositions of garnet show progressive increases in ferric Fe content with time, implying an increase in oxidation state with time. (From author's abstract by E.R.)

MESA, M., LOREDO, J. and GARCIA-IGLESIAS, J., 1995, Fluid inclusions study in quartz related to the auriferous gold mineralization of La Grueba, Asturias, northern Spain (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 142-143. Authors at Dept. Explotación y Prospección de Minas, Escuela de Minas, Univ. de Oviedo, Spain.

The As-Fe-Cu-Ag-Au mineralization of La Grueba is related to El Courio igneous stock, classified as leucogabbro.

Microthermometric analyses of P FI in quartz of veinlets in arsenopyrite (quartz I), reveal Th L with the maximum in the interval 300°C-320°C. Te = <-25°C and Tm ice between 0 and -3°C, corresponding to sal. <5. FI in geodic quartz (quartz II), later than most sulphides, show Th L between 120°C and 280°C (mean = 150°C); corresponding to values of S FI in quartz of I.

The application of arsenopyrite geothermometer gives values of arsenopyrite crystallization between 395°C and 425°C. On the other hand, the analysis of pyrrhotite in equilibrium with pyrite, both included inside the igneous rocks in proximity to breccia, gives values of 46% Fe, corresponding to crystallization T of pyrrhotite in the order of 600°C.

The isochore for P FI in quartz I (0.7 g/cc), considering 395°C as upper limit for quartz I deposition yields an estimated P of 1 kb. (From authors' abstract by E.R.)

METCALFE, R., ROCHELLE, C.A., SAVAGE, D. and HIGGO, J.W., 1994, Fluid-rock interactions during continental red bed diagenesis: Implications for theoretical models of mineralization in sedimentary basins, *in* J. Parnell, ed., Geofluids: Origin, Migration and Evolution of Fluids in Sedimentary Basins: Geol. Soc. (London) Spec. Publ. No. 78, p. 301-324. First author at British Geol. Surv., Keyworth, Nottingham NG12 5GG, UK.

Mixing between F of different redox states is likely to be a critical control on heavy metal mobility. Many diagenetic features can be explained largely by the chemical heterogeneity of red beds, and by the diagenetic ranges of redox conditions and pH which are among the greatest for any type of sediment. In order to develop theoretical models of F/rock interactions during such diagenesis, it is important to consider the interrelationships between F flow, mineral dissolution and precipitation, and sorption. At the present time such models are at an early stage of development. (From authors' abstract by E.R.)

Uses literature FI data. (E.R.)

METRICH, N. and CLOCCHIATTI, R., 1995, Sulfur abundance and speciation in alkaline to potassic melts: Melt inclusion data (abst.): Eos, v. 76, no. 17, p. S269. Authors at Laboratoire Pierre Sue GST CNRS-CEA, CE/Saclay 91191 Gif, Yvette, France.

The determination of S abundance of the primary magmas is one [of] the main parameters to constrain the S budget during the volcanic eruptions. S has been systematically determined in MI which cover a wide range of compositions (transitional to alkali basalt to leucite basanite). Samples were collected from different sites in Italy, and from Piton de la Fournaise (Reunion Island). The MI are trapped in olivine Fo90 to Fo85, and therefore correspond to primary to slightly evolved melts, for a range of T from 1180 to 1230°C. T were obtained by optical thermometry measurements or calculated on the basis of olivine-L geothermometers. The S^{6+}/S^{tot} ratio was measured, following the method based on the wavelength shift of the S(*Ka*) X-rays, described by Carroll and Rutherford (Am. Mineral., 73, 845, 1988). It varies from <0.01 in basaltic MI from Piton de la Fournaise to 0.64 in samples from Vulcano, Etna and Stromboli. There is no clear relationship between the S abundance and the S^{6+}/S^{tot} ratio. For most of the samples, the O fugacity was calculated on the basis of the olivine-spinel equilibrium. The results suggest that the S^{6+}/S^{tot} ratio increases with the O fugacity, in agreement with Wallace and Carmichael (Geochim. Cosmochim. Acta, 56, 1863-1874, 1994). (Authors' abstract)

Sample	Sulfur wt %	FeOtot wt %	Host Olivine	Type
Vesuvius	0.18	7.5	Fo90.5	Tephr.
Vulsini	0.18-0.32	6.5-8.0	Fo91.6-89.5	Basan.
Vulcano	0.18-0.28	8.5-9.5	Fo90.2-90.7	Shosh.
Etna	0.29-0.31	7.7-8.8	Fo85	Alk.
Bas.				
Stromboli	0.20	8.0	Fo85-86.5	Shosh.
P. Fournaise	0.15	9.3	Fo86.5	Tr. Bas.

MEURER, W.P. and BOUDREAU, A.E., 1995, F-Cl-OH evolution in apatite of the Middle Banded Series of the Stillwater Complex, Montana (abst.): Eos, v. 76, no. 17, p. S298. Authors at Dept. Geology, Duke Univ., Durham, NC 27708.

Extreme variations in the F-Cl-OH content of apatite (X^{Cl} ranges from 0.10 to 0.70) occur over <150 m in stratigraphic height in the Middle Banded Series (MBS) of the Stillwater Complex, while the Mg# and An content of cumulus minerals remain essentially constant. Detailed study, using back-scattered electron imaging and transmitted light microscopy, reveals that apatite occurs in three distinct settings. In order of decreasing abundance these are: (type-1) interstitial to cumulus minerals, (type-2) in polyphase domains often included in cumulus minerals (cf. Loferski and Arculus, 1993), and (type-3) as isolated I in cumulus, and less commonly heteradcumulus, minerals, We interpret the polyphase domains to be the crystallized products of immiscible L, i.e., MI.

Detailed study of multiple thin sections from a single sample provided apatite compositions from all three settings. Compositions of type-2 apatite show a wide range (F = 0.15-0.40,Cl = 0.15-0.65, OH = 0.25-0.60), suggesting that local immiscibility took place during much of the latter crystallization of this sample, thereby recording the evolving volatile composition of the system. Type-1 apatite shows a range in composition similar to type-2 and is thought to have crystallized from F/V migrating through the cumulus pile. Type-3 apatite have more restricted Cl-rich compositions (F = 0.05-0.35, Cl = 0.40-0.70, OH = 0.20-0.35) and may have been included in cumulus minerals during recrystallization or partial melting.

The data support the conclusion that apatite compositional variability in the MBS is caused by an upward moving Cl-rich V phase exsolved from intercumulus L lower in the section. Apatite isolated prior to the onset of this V migration has higher F and OH as recorded in some type-1 and type-2 apatites. Later crystallized apatite records the progressive enrichment in Cl caused by V infiltration. Movement of this V phase into portions of a cumulus pile that were volatile undersaturated induced partial melting and allowed more Cl-rich apatites to be included in "cumulus" minerals. (Authors' abstract)

MICHAEL, P.J., CORNELL, W.C. and NIELSEN, R.L., 1995, Volatile concentrations in plagioclase-hosted melt inclusions in MORB from the Gorda Ridge (abst.): Eos, v. 76, no. 17, p. S267. First author at Dept. Geosciences, Univ. Tulsa, Tulsa, OK 74104.

We determined concentrations of volatiles in the host glass and in unhomogenized MI in high-An plagioclase in a densely phyric, depleted MORB (Mg# = 67.7; $La/Sm_n = 0.38$; $K_2O = 0.06\%$) from Gorda Ridge. We examined primitive I (Mg# = 74) and I that were similar to the host glass. Our goals are: (1) to constrain the depth of entrapment of the I by comparing their CO_2 concentrations to experimentally determined solubilities for CO_2 in basaltic L; (2) to determine the behavior of H_2O relative to incompatible trace elements; and (3) to determine whether the magma was affected by assimilation of altered material, and to constrain the timing of this process relative to crystallization, by examining Cl contents. Cl, F and S were determined by electron microprobe. H_2O and CO_2 were analyzed by micro-Fourier Transform Infrared spectroscopy.

The host glass has 80 ± 80 ppm CO_2, which is less than or equal to the solubility limit at its depth of eruption (3048 m), suggesting that the lava was emplaced slowly enough for CO_2 to exsolve into bubbles. Primitive I have 190 ± 100 ppm CO_2, corresponding to a depth of ~500 m below the seafloor. Dissolved CO_2 may be low in these I because it has migrated into a V bubble. It is also possible that CO_2 was low at the time of entrapment because crystallization occurred at shallow depths after exsolution, or because the highly depleted L has inherently low CO_2 and was undersaturated when it was entrapped. The low H_2O contents (0.114%) of the host glass are tyical of depleted MORB from the Pacific. Primitive I have 0.068% H_2O, 0.02% K_2O, and 0.37% TiO_2, yielding K_2O/H_2O ratios that are slightly lower and TiO_2/H_2O ratios that are much lower than the host glass. Thus H_2O behaves slightly less incompatibly than K_2O, similar to inter-MORB trends. It does not show the anomalous low values of TiO_2. Non-primitive I have H_2O and K_2O contents that are similar to the host glass. Cl contents and Cl/K ratios of the host glass are very low, suggesting that this magma did not assimilate significant amounts of hydrothermally altered material. Not surprisingly, the I also have low Cl and Cl/K. (Authors' abstract)

MIGASZEWSKI, Z.M., HALAS, Stanisław and DURAKIEWICZ, Tomasz, 1995, Paleotemperatures of carbonate minerals and barites from the Holy Cross Mts. (Central Poland): Przeglad Geol., v. 43, no. 12, p. 1011-1016 (in Polish, English summary).

Th of gaseous-L I and $\delta^{18}O$ determinations carried out of the same crystals of "rose-like" calcites from the Holy Cross Mts indicated that the $\delta^{18}O$(SMOW) of F (hybridized seawater) had varied from 0 to 2‰. (From authors' abstract by E.R.)

MILAN, Haber, STANISLAV, Jelen, KOVALENKER, Vladimir and LEVIN, Konstantin, 1995, Mineral-forming processes of the epithermal deposit at the Banska Stivnica (Western Carpathians, Slovak Republic): Geol. Soc. Greece, Sp. Publ., No. 4, p. 727-730. First author at Geological Inst., Slovak Acad. Sci., Severna 5, 97401 Banska Bystrica, Slovak Republic.

Epithermal Au-Ag-base metal veins from Banska Stiavnica originated in two cycles. The mineralization of the first cycle consists of three mineralization stages (hematite-quartz, sphalerite and rhodonite-carbonate-quartz). It was formed at >300-200°C, pH 4.7 to -6.0, log aS_2 from -11 to -14 and log aO_2 from -32 to -41 in depth from 0.72 to 1.60 km. The mineralization of second cycle is created in two stages (galenite-chalcopyrite and sulphosalts-barite). This second one originated at 310-350°C, pH 3.5 to 7.6, log aS_2 from -8 to -17 a log aO_2 from -30 to -46 in depth from 0.4 to 1.1 km. The salinity of the hydrothermal solutions with content of CO_2, CH_4, N_2, Na^+, K^+, F^-, Cl^-, SO_4^{2-}, Cu, Pb, Ag, Fe, Zn range from 0.4 to 11.5 wt % NaCl eq. The assumed age of the mineralization is 12.3-13.3 Ma. (Authors' abstract)

FI data presented. (H.E.B.)

MILLER, C.A. and BARTON, Michael, 1995, Kaersutite-bearing melt inclusions in the Precambrian Egersund Dolerites, SW Norway: evidence for a high pressure origin and new mode of occurrence for kaersutite (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-434.

Spherical to irregularly shaped patches 50-300 µm in size are enclosed by olivine phenocrysts in tholeiitic basalt samples from the Egersund Dolerites, SW Norway. The patches are interpreted to represent crystallized MI. The I consist of Ca-pyroxene + plagioclase ± amphibole ± Fe-Ti oxide together with very rare spinel and apatite. Euhedral grains occur in most I and record equilibrium crystallization, but quenched morphologies are also observed. The host olivine phenocrysts are in equilibrium with their respective bulk rock compositions, and range in composition from Fo_{82} to Fo_{84}.

The Ca-pyroxenes that occur in MI have higher Al_2O_3 (12-18 wt %) than groundmass pyroxenes (1-4 wt %). Plagioclase in the I have compositions between An_{76} and An_{20} and are more sodic than groundmass and phenocryst feldspars ($\leq An_{83}$). Comparison with experimental data indicates that the pyroxenes and feldspars have compositions that are consistent with crystallization at high P (8-10 kb). The amphiboles are kaersutitic to ferro-kaersutitic in composition. Kaersutite has previously been described as occurring in xenoliths, mineral aggregates, mafic I, as megacrysts, xenocrysts and phenocrysts in alkaline volcanic rocks, and, less commonly, as interstitial grains and veins in xenoliths and alkaline lavas. Kaersutite rarely occurs in rocks of tholeiitic composition and its occurrence in MI has not been previously described. The mode of occurrence for kaersutite in the Egersund dikes is thus unusual. Kaersutite is stable over a wide P-T interval and its presence is consistent with the high P origin suggested by the coexisting phases.

The Egersund Dolerites were intruded into Precambrian basement in SW Norway at ~650 Ma. The dikes are ≤20 m thick and over 60 km in length. Chemically, the dolerites are Ol-tholeiites, tholeiites, and trachybasalts. Projections into the Fo-Di-Sil and CMAS system define an evolutionary trend along the 8-10 kb cotectic. We interpret the MI as primary crystallization products of a trapped cognate parental magma. The I provide additional evidence for the high P-history inferred for the Egersund Dolerites from whole-rock compositional data. (Authors' abstract)

MILLER, L.D., GOLDFARB, R.J., SNEE, L.W., GENT, C.A. and KIRKHAM, R.A., 1995, Structural geology, age, and mechanisms of gold vein formation at the Kensington and Jualin deposits, Berners Bay district, southeast Alaska: Econ. Geol., v. 90, p. 343-368. First author at

Au occurs in mesothermal quartz carbonate veins containing pyrite and tellurides and with distinctive ankeritic alteration zones. Au-bearing veins were deposited at ~200° to 235°C and a depth of 3 km. The ore F were composed of 93 to 97 mol % H_2O, 2 to 5 mol % CO_2, 1 to 2 mol % NaCl, <0.5 mol % N_2, and traces of CH_4, H_2S, and SO_2. Isotopic study of silicate gangue indicates a $\delta^{18}O$(fluid) value of 6‰ and a δD(fluid) value of ~-25‰. These data suggest that prograde devolatilization reactions in rocks of the Wrangellia terrane, perhaps triggered by heat from magmatic-arc emplacement, are the most likely F source. Measured $\delta^{34}S$ values of -2.5 to +1.6‰ for sulfide minerals are consistent with ore-fluid S being leached either from metabasalt of the Wrangellia terrane or from the Jualin Diorite. (From authors' abstract by E.R.)

MINARIK, W.G. and WATSON, E.B., 1995, Interconnectivity of carbonate melt at low melt fraction: Earth Planet. Sci. Lett., v. 133, no. 3/4, p. 423-437. Authors at Dept. Earth and Environmental Sciences, Rensselaer Polytechnic Inst., Troy, NY 12180.

Experiments were performed to investigate the interconnectivity of sodium carbonate M in a synthetic dunite at low M fractions at 1 GPa and 1300°C. Carbonate M was found to remain interconnected to 0.05 wt % M in fine-grained olivine (all grains initially 263 µm). The presence of this interconnected M enhances the bulk transport of Fe through the polycrystalline sample by two to almost three orders of magnitude, depending on M fraction. This effectively reduces the diffusive length scale of the bulk sample to that of the individual grains, with transport limited by the rate of lattice diffusion for those species soluble in the carbonate M. These experiments also show that 0.03-0.07 wt % M demarcates a lower limit to M interconnectivity, despite a M-olivine dihedral angle of 25-30°, less than the critical dihedral angle of 60°. In this range of M abundance grain-edge tubules pinch off and diffusion is short-circuited only for the length of the M pores. Interconnectivity is likely present to M fractions < 0.05 wt % in carbonated olivine-rich mantle with grain size on the order of 1 mm. Combining bulk diffusivity measurements with models of permeability suggests that carbonate M may be more mobile at low M fraction than previously estimated, increasing the potential of carbonate M to transport soluble elements and C-rich volatiles through the upper mantle. (Authors' abstract)

MIRONOVA, O.F., SALAZKIN, A.N. and MAUMOV, V.B., 1995, Bulk and local techniques of analysis of volatile components in fluid inclusions: Geokhimiya, v. ??, no. 7, p. 974-984 (in Russian, English abstract).

Destructive and nondestructive techniques of analysis of G phase of FI in minerals have been considered. Thermometry, Raman spectroscopy, and G chromatography have been compared taking quartz, topaz, and cassiterite as examples. It has been shown that the degree of agreement of data taken by these techniques depends mainly on the individual features of a sample. The purer the mineral, as well as the more I it has and the more uniform the I are the closer the data of these different techniques. We conclude that to choose a technique one should consider the features of both sample, FI in there and the task. Sometimes it can be only destructive or nondestructive techniques; otherwise, any of them of a combination. (Authors' abstract)

MIRZEKHANOV, G.S., NEMENMAN, I.S. and BERDNIKOV, N.V., 1995, The peculiarities of ore-metasomatic zoning and fluid regime of the gold-quartz assemblage mineralization, Khudzhakh-Berelakh interriver area: Tikhookeanskaya Geol., no. 1, p. 62-77 (in Russian; translation courtesy of Dr. N.V. Berdnikov).

FI were studied on a number of typical sites of Au-quartz in the SE of the Yano-Kolymsky Au-bearing belt (Russia's NE). Three types of I were ascertained in the quartz of ore-bearing and ore-free veins: H_2O, H_2O-CO_2 and CO_2. H_2O I contain 70-100% of a L phase with concentration of 0.7 % NaCl eq. And Th = 180-280°C.

H_2O-CO_2 I are rare, but their presence indicates a homogeneous H_2O-CO_2 F when veins are formed. $TmCO_2$ = -58 to -59°C, which is suggestive of admixtures of other gases. Quenching of the I readily results in G hydrates with an exsolution T of -7 to -11°C.

Monophase CO_2 I (Tm = -56.6 to -60°C, Th = -30 to +23°C) are very common, but P calculations were not made due to undetermined admixtures.

According to statistical definitions, CO_2 I are associated with ore-bearing veins, while ore-free Alpine veins showed only H_2O I with low NaCl concentrations. This supports the conclusion on the ore-free nature of regional metamorphism on the studied area. The ore-bearing veins resulted from the consequent carbonate-sulphide-carbonic metasomatis.

MISRA, K.C. and TORSSANDER, Peter, 1995, Sulfur and carbon isotopic data for the Central Tennessee zinc district: Constraints on mechanism of sulfide precipitation (abst.): Geol. Soc. Am., Absts.

with Programs, v. 27, no. 2, p. 76. First author at Dept. Geological Sciences, Univ. Tennessee, Knoxville, TN 37996.

MVT mineralization in the Elmwood-Gordonsville deposits of the Central Tennessee zinc district is hosted in a Lower Ordovician carbonate sequence (upper Knox Group). The mineralization, localized in collapse breccia bodies below a regionally extensive unconformity, is predominantly of the cavity-filling type and has the following generalized paragenetic sequence: early-stage calcite (white), sphalerite, galena (minor), fluorite, main-stage calcite (white to lavender), barite, and late-stage calcite (clear to amber).

The mechanism of sulfide precipitation in these deposits, as for most other MVT Pb-Zn deposits, is an unresolved problem largely related to the source of reduced S. The three textural varieties of sphalerite (disseminated, massive, and vug-fill), which are indistinguishable in terms of their FI thermometry, have a very narrow range of $\delta^{34}S$ values (-3.37 to -0.54‰), suggesting a uniform S source. The $\delta^{34}S$ values of galena ranges from -5.57 to -4.09‰ and those of barite range from +27.42 to +30.43‰. The $\delta^{13}C$ values of the main-stage calcite (-2.8 to -2.3‰) are very similar to those of the host limestones and dolostones, whereas the late-stage calcite is noticeably more depleted ($\delta^{13}C$ = -5.4 to -3.4‰).

Such low and narrow range of $\delta^{34}S$ values, which are among the lowest known for MVT deposits, are incompatible with derivation of reduced S by thermochemical or bacterial reduction of sulfate. The isotopic data are compatible with H_2S generated by desulfurization of petroleum. However, the C for the main-stage calcite appears to have been derived from the host carbonate sequence and even the $\delta^{13}C$ values of late-stage calcite are not low enough to indicate the involvement of organic C, although this calcite is commonly associated with oily material. The $\delta^{34}S$ values of barite indicate precipitation in an open system, an interpretation that is consistent with the significantly lower FI T and salinity suggestive of meteoric water influx during the later stage of mineralization. (Authors' abstract)

MITROFANOV, F.P., IKORSKIY, S.V. and KAMENSKIY, I.L., 1995, Helium isotopes in Paleozoic alkalic intrusions of the Kola Peninsula and northern Karelia: Dokl. Ross. Akad. Nauk, v. 345, no. 2, p. 243-246 (in Russian).

^3He and ^4He were determined on 15 samples from Khibiny pluton and accompanying alkalic-ultramafic intrusions, as well as 19 mineral separations by several techniques. The results suggest that He entering with the magma and derived from the mantle was concentrated in a F phase, which, having separated from the M, was then preserved as FI, chiefly in the dark-colored minerals formed in the closing stage of magma crystallization. (E.R.)

MIXA, Petr, FOJT, Bohuslav, HLADÍKOVÁ, Jana and KRÍBEK, Bohdan, 1995, The origin of the Horní Benesov base metal deposit, Czech Republic: A case study, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 295-298. First author at Czech Geol. Surv., Jeseník, Czech Republic.

The Pb-Zn-Ag-Ba deposit Horní Benesov represents the submarine-exhalative mineralization of Devonian age with many similar features with the sediment-hosted, as much as volcanic-hosted deposits. The deposit was probably formed within a local anoxic basin, at the volcanic elevation rimmed by carbonate buildups. The negative values of isotopic composition of S and C and oxidation derivatives of organic matter in the ores support the significant reaction of the ore-bearing solution with the seafloor anoxic sediments. (From authors' abstract by E.R.)

FI were studied in sphalerite, barite, quartz and calcite. Only S H_2O-rich I were observed oriented in planar arrays. In sphalerite the Th ranges from 83 to 170°C and salinity from 1 to 7 wt % NaCl eq. In coarse-grained barite FI of H_2O-CO_2 + higher hydrocarbons (HHC) are present. The amount of CO_2 + HHC phase does not exceed 10 mol %, total Th reached 210 ≤ 250°C. (From authors' text by E.R.)

MOINE, B., RACOTONDRAZAFY, M. and CUNEY, M., 1995, Physical-chemical controls on hibonite stability in granulite facies occurrences (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 314-315.

The main equilibria controlling the stability of hibonite are Hb + CO_2 = 6Co + Cc and Hb + $2SiO_2$ = 5Co + An. The available thermodynamic, mineralogical and FI data have been used to estimate the controls of hibonite crystallization (Table). A low value of the ideal activity of $CaAl_{12}O_{19}$ (0.1-0.3 compared with 0.7-0.9 for Hb from meteorites), mainly due to the incorporation of REE and Ti, as well as a very strong undersaturation with respect to quartz (log a_{Qz}~(+0.06) the Bd-Zc buffer or lower (by 0.2 to 0.32); Bd present at Md) are essential. These features probably explain the extreme scarcity of terrestrial hibonite. On the contrary, X_{CO2} may be high as evidenced by the occurrence of carbonic FI in hibonite from Md.

An = anorthite; Bd = baddeleyite; Cc = calcite; Co = corundum; Cz = clinozoisite; Gr = grossular; Hb = hibonite, $CaAl_{12}O_{19}$; Hc = hercynite; Ks = kalsilite; Qz = quartz; Sp = spinel; Zc = zircon. (From authors' abstract by E.R.)

MOISSETTE, A., SHEPHERD, T.J. and CHENERY, S.R., 1995, Elemental analysis of individual aqueous fluid inclusions. Part II: Calibration strategies for the optimisation of laser ablation ICP-MS (LAMP-ICP-MS) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 144. First author at CREGU, B.P.23, 54501 Vandoeuvre les Nancy cedex, France.

Using a combination of synthetic FI in halite, microvolume standard solutions and NIST glasses, elemental ratio calibration curves have been established for the laser ablation ICP-MS analysis of individual aqueous FI. Synthetic chloride solutions were made up, containing up to 13 major and minor cations from 100 to 1000 ppm (Li, Mg, K, Ca, Rb, Sr, Cs, Ba, Mn, Cu, Zn, Pb, B) for various Cl/Br ratios. The microvolume standards comprised small wells ($3x3x2 mm^3$) drilled into perspex sheet, filled with a standard solution and hermetically sealed. To check the efficiency of laser ablation on I and wells, standard NIST glasses were analysed under the same conditions. The three types of test material were characterized by calculating the relative standard deviation (RSD) for each element relative to Sr and this provided a measure of the analytical repeatability. Inspection of bivariate plots indicated that elemental ratios to Sr were linear over a wide range of responses. Synthetic I from 20 m to 80 µm in diameter at various depths (10-80 µm) were investigated. Whatever their size and depth, the I gave similar elemental ratios. However, it was noted that for very flat I (i.e., low total volumes) ICP-MS responses were poor due to small amount of material release for analysis.

The RSDs of elemental ratios for the synthetic FI and microvolume "wells" are generally better than 25%; those for Li, Mg, Ba and Rb being less than 15%. By comparison, RSD values for the glasses range between 5 and 10% for most elements. The latter are regarded as a repeatability reference for routine analysis using this particular laser-ICP-MS configuration. The well data not only confirm the results obtained with glasses and synthetic I but also highlight potential matrix effects. In combination, the three types of standards tested provide ideal calibration curves for the study of natural FI. Preliminary data will also be presented for *in situ* determination of Cl/Br ratios in single I.

N.B. Our experience indicates that the process and manner of laser ablation remains a critical and as yet unconstrained parameter controlling the quality of single I. (Authors' abstract)

MOLLOY, R.M., MORAND, V. and RAMSAY, W.R.H., 1995, Structural controls in the Tarnagulla Goldfield, central Victoria: Implications for metamorphically-derived auriferous fluids: Australasian Inst. Mining and Metallurgy, Publication Series, 9/95, p. 383-388.

Indexed under FI. (E.R.)

MÖLLER, P. and RICHERT, B., 1995, Mixing of fluids and ore deposition: An experimental approach, *in* Pasava, Krîbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 361-364. Authors at GeoForschungsZentrum Potsdam, Germany.

Experimental studies of F of different densities indicate that mixing is not diffusion controlled. Exchange of heat and matter takes place through the interface between the water volumes enforced by convection in both volumes. Movement of the interface becomes more "vivid" with time, and homogenization of both F occurs within a few minutes. Superimposed chemical reactions, e.g., neutralization, take place mainly along the interface, which is dispersed over some volume. Progress of reaction is focused towards the F volume which hosts the lesser component of the reaction product. (Authors' abstract)

MOLNÁR, F., 1992, Paleotemperature reconstruction by fluid inclusion studies (Mesozoic carbonate basement, southern Great Plain, Hungary): Általános Földtani Szemle, v. 16, p. 169-180 (in Hungarian, English abstract).

The economically important hydrocarbon deposits of Hungary were accumulated in the Upper Miocene-Pliocene (Pannonian) sandstone sequence of the Hungarian Great Plain (Pannonian Basin). The basement is built up of Mesozoic carbonate rocks in the southern area of the young basin. These carbonate sequences are predominantly in the upper hydrocarbon generation windows (above the light oil-gas zone) according to the recent T and depth data. However, the thermal history of these formations is very important for further hydrocarbon exploration. To answer this question the FI of the late diagenetic/epigenetic calcite and quartz veinlets and vug fillings from a Triassic dolomite (borehole Forráskút-2, 2973 m) and Lower Cretaceous limestone (boreholes Kiskunmajsa D-10, 2165 m; Ruzsa-14, 2288 m and 2394 m; Üllés-3, 2862 m and 3090 m) were studied.

The distribution of Th of the samples have several maxima, and Th values of the P FI show great deviations within the same sample. This behavior suggests that the P FI were refilled during the subsidence of the rock sequences. The Th values [are] usually higher than the recent T (126-197°C) of the formations. The maximum values of the paleotemperatures (i.e., the P corrected max. Th) are between 164 and 280°C in the various boreholes. These indicate that the paleogeothermal gradients were higher than the recent geothermal gradients (4.6-6°C/100 m), because the studied sequences probably were not in deeper positions during earth history. The minimum paleogeothermal gradient was determined with the assumption that the hottest F migrated in the recent (deepest) positions of the formations and the P was hydrostatic. The calculated paleogeothermal gradients are between 5.9 and 8.9°C/100 m. These high values are characteristic to the volcanic areas and young basins, which is in agreement with the real geological position of the Pannonian basin and with opinions (based on the vitrinite reflectance data) that in the past the average T of the basin was higher than the recent one.

On the basis of the cryoscopic measurements, the composition of the FI are predominantly $NaCl\text{-}CaCl_2\text{-}H_2O$ type, but the lower T (older) F are $NaCl\text{-}NaHCO_3\text{-}H_2O$ type at some places. The concentration values are between 0.35 and 13.21 NaCl eq. wt %, and the highest ones occur in the deepest sequences.

The results of the FI studies suggest that the carbonate formations had higher positions in the oil generation zones (i.e., over the main hydrocarbon "windows") than their recent ones. (Author's abstract)

MOLNÁR, F., 1994, Reconstruction of hydrothermal processes accompanied by precious metal enrichment in the area between Sátoraljaujhely-Rudabányácska and Vágáshuta, Tokaj Mts., NE Hungary: Földtani Közlöny, v. 124, p. 25-42 (in Hungarian, English abstract).

The hydrothermal alteration of rhyolitic tuff and amphibole dacite (Middle-Upper Miocene) host rocks of the study area took place in several steps. During the early metasomatic processes the plagioclase crystals of dacite have been replaced by K feldspar. Later, these replacements and the sanidine of rhyolitic tuff suffered sericite alteration. The opening of the hydrothermal fracture system was accompanied by precipitation of the quartz-adularia-pyrite assemblage in the rhyolitic tuff, but adularia was absent and hematite was present in the fracture infillings of dacite.

According to the results of FI studies the hydrothermal processes took place between 130°C and 300°C. The composition of F can be modeled by the $NaCl\text{-}CaCl_2\text{-}H_2O$ system. The total salinity of solutions varied between 4-7.5 NaCl eq. wt %. The mixing of F with different T and salinity and the periodic boiling of hydrothermal solutions were also proved by FI studies.

On the basis of the modeling of Au precipitation it was outlined that the T drop caused by the F-mixing processes could be responsible for the Au enrichment in the high-T (200-300°C) stage of hydrothermal activity (quartz-adularia-pyrite paragenesis). In the late stages the local changes in the O activity reflected by the contemporaneous presence of hematite and pyrite could also cause some enrichment of Au.

The paleodepth of hydrothermal processes was ~200-300 m. (Author's abstract)

MOLNÁR, Ferenc, 1995, Mineralization in a Variscan monzogranite intrusion, Velence Mountains, western Hungary: Fluid inclusion evidence of polystage metallogeny, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 487-490. Author at Dept. Mineralogy, Eötvös Loránd Univ., 1088 Budapest, Hungary.

FI studies prove that the ore deposition in the Variscan granite of Velence Mts. occurred during the postmagmatic stage of the granite emplacement and during a much younger volcanic-hydrothermal event. Although the T regime of these systems was similar, the separation of the various metallogenic stages can be identified on the basis of FI studies, petrography and mineralogy. (Author's abstract)

PI from pegmatites have Th 350-370° and Tm(ice) of -2 to -3°C; quartz-tourmaline veinlets—Th 360-400°C and Tm(ice) -0.2 to -0.7; quartz-molybdenite veinlets—(+ CO_2) Th 210-300°C and Tm(ice) -0.7 to -9.8°; polymetallic veins—Th 80-210 and Tm(ice) -0.2 T -328°C; enargite bodies—Th 220-450° and Tm(ice) 0.4 to -16.2. (E.R.)

MOLNÁR, F. and GATTER, I., 1994, Comparative mineralogic-genetic studies of sedimentary and hydrothermal barite crystals from Hungary: Földtani Közlöny, v. 124, p. 43-57 (in English).

Barite crystals from the postvolcanic-hydrothermal polymetallic mineralization of Gyöngyösoroszi and from other, sediment-hosted mineralizations (Buda Mts., Gerecse Mts., Rudabánya, Mecsek Mts.) with uncertain origin have been studied. The results of comparative studies suggest that there is some correlation between the morphological characteristics and conditions of crystallization. The Sr content varies, depending on the locality and morphology of crystals. According to the FI characteristics the crystallization of barites in sedimentary environment was also related to postvolcanic activity. (Authors' abstract)

MOLNÁR, F., TOROK, K. and JONES, P., 1995, Crystallization conditions of pegmatites from the Velence Mts., western Hungary, on the basis of thermobarometric studies: Acta Geol. Hungarica, v. 38, p. 57-80 (in English).

The pegmatite nests and miarolitic cavities occurring in the Variscan (280 Ma) biotitic monzogranite of the Velence Mts. are characterized by simple mineralogy (K-feldspar, plagioclase, quartz, mica). The FI studies carried out on quartz revealed that the pegmatites were formed from high T, relatively dilute (<10 wt % NaCl eq.) solutions. The composition of these F was determined by microprobe analyses of opened I, and the results show that the parent solutions had $NaCl\text{-}CaCl_2\text{-}H_2O$ type composition with variable Na/Ca atomic proportions. The combination of two-feldspar thermometry and FI data indicate that the pegmatites were formed in two T ranges, between 500 and 600°C and 300 to 400°C at ~2 kb P. Studies of S FI also yield data about the character of post-pegmatite, more saline hydrothermal F. The occurrence of very dilute boiling F related to Eocene volcanic activity was also detected in the quartz crystals of pegmatites, and the data suggest that the depth of the granite intrusion was ~1700-1900 m at the time of that igneous activity. (Authors' abstract)

MOLNÁR, Ferenc and ZELENKA, Tibor, 1995, Fluid inclusion characteristics and paleothermal structure of the adularia-sericite type epithermal deposit at Telkibánya Tokaj Mts., northeast Hungary: Geol. Carpathica, v. 46, no. 4, p. 205-215. First author at Dept. Mineralogy, Eötvös Loránd Univ., 1088 Budapest, Hungary.

FI data for quartz, adularia, calcite and sphalerite related to mineralization hosted by Neogene volcanic rocks at Telkibánya in NE Hungary indicate that the T varied between 270°C and 130°C during hydrothermal activity. Intensive boiling of F took place at ~230°C, and the apparent salinity of the hydrothermal solution was ≤5 NaCl eq. wt %. The CO_2-content of initial solutions (pre-boiling F on 240-250°C) was ~0.8 mol/kg on the basis of the model calculations. As a consequence of boiling, a V-rich, nearly isothermal system developed in the vuggy-brecciated zones of host rocks around ore veins. Euhedral quartz that precipitated in these zones is morphologically different from the vein-filling quartz aggregates. Th indicate that the quartz veins formed under non-isothermal conditions. The paleotemperature distribution was reconstructed on the basis of the spatial distribution of average Th of quartz vein samples, and taking into account the level differences of sampling. A comparison of the paleotemperature map with the volcanotectonic map indicates that some of the areas of high paleotemperature are located along the major faults mapped in the studied area. The spatial coincidence of some of these thermal centres with the area of the highest residual Bouguer-anomaly values suggests that the heat source of the hydrothermal convection cells was a subvolcanic intrusion. The minimum depth under the paleowater table of the mineralization now exposed at the surface was ~200-400 m. (Authors' abstract)

See also FIR, v. 27, p. 92.

MONTINI, G., LATTANZI, P., RUGGIERI, G., MAINERI, C. and TANELLI, G., 1995, The epithermal system bearing Sb-Au of Frassine (Grosseto) [Italy]: Plinius, no. 14, p. 238-239 (in Italian).

MOORE, J.N. and GUNDERSON, R.P., 1995, Fluid inclusion and isotopic systematics of an evolving magmatic-hydrothermal system: Geochim. Cosmochim. Acta, v. 59, p. 3887-3907. First author at Earth Sciences and Resources Inst., 391 Chipeta Way, Salt Lake City, UT 84108.

The Geysers, California, is the site of an active hydrothermal system that initially developed between ~1.5 and 2 Ma in response to intrusion of a hypabyssal granitic pluton. Mineralogic and FI data demonstrate that the present V-dominated regime evolved from an earlier and more extensive, L-dominated hydrothermal system.

P-corrected Th and apparent salinities of FI in these veins range from 440'C and 44 wt % NaCl eq. within the hornfels (<600 m from the pluton) to 325'C and 5 wt % NaCl eq. at ~1500 m from the intrusion. We suggest that the shallow, moderate-salinity F are crustal waters modified by water-rock interactions and that the high-salinity fluids are interpreted as magmatic brines. Halite-dissolution T of I in the hornfels and pluton indicate that the magmatic F were trapped at lithostatic p (300-900 bars). In contrast, Th of the connate F suggest trapping under hydrostatic P of less than several hundred bars.

The formation of V-dominated conditions is reflected in the abrupt appearance of low salinity (0.0 to 0.4 wt % NaCl eq.) FI with Th ~265'C. These I F are thought to represent steam condensate that formed as the early L-dominated system boiled off. Bladed calcite, which is corroded in places, and late-stage clays provide mineralogic evidence of boiling and the formation of an acidic condensate in the upper part of the reservoir and in the overlying caprock. At greater depths, however, clear mineralogic evidence of boiling is lacking. (From authors' abstract by E.R.)

See also next item. (E.R.)

MOORE, J.N. and HULEN, J.B. , 1995, Igneous, thermal, and chemical evolution of the Geysers hydrothermal system, California (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-327.

The Geyseres, California, is the site of a high-T hydrothermal system that initially developed 1.5 to 2 m.y. ago in response to intrusion of a large (>100 km^3), hypabyssal, granitic pluton beneath the Pliocene-Pleistocene Clear Lake volcanic field. Radiometric dates, FI data, and zoning characteristics of distinctive vein-mineral assemblages place constraints on the evolution of this system. These data demonstrate that the present V-dominated regime (T = 230-345°C) evolved from an earlier and more extensive, L-dominated hydrothermal system. F circulating in this system deposited a well-zoned suite of vein minerals characterized by (1) tourmaline-biotite-actinolite-orthoclase in hornfels mantling the pluton; (2) epidote-actinolite-adularia + ferroaxinite to ~1500 m from the igneous body; and (3) bladed calcite ± adularia, extending outward at least another several hundred meters. Concurrently, older metamorphic vein calcite was hydrothermally dissolved to create or enhance porosity. Peak T and salinities of the early, vein-forming F ranged from 440°C and 44 wt % NaCl equivalent in the hornfels to 325°C and 5 wt % NaCl equivalent ~1500 m from the intrusive. Establishment of V-dominated conditions is recorded by the abrupt appearance of low-salinity (0.0 to 0.4 wt % NaCl equivalent) FI that homogenize ~265°C. These F are thought to represent steam condensate formed as the L-dominated system boiled off. Modern, mildly acidic steam condensates above the steam field are believed to have deposited, at ~160°-230°C, mixed-layer clays in open veins, creating an effective cap on what might otherwise have been steam-reservoir rock. (Authors' abstract)

MOORE, J.N., HULEN, J.B. and NORMAN, D.I., 1995, Evolution of The Geysers (US)—Data from fluid-inclusion microthermometry and gas geochemistry, *in* M.P. Hochstein, J. Brotheridge and S.F. Simmons, eds., Proc. 17th NZ Geothermal Workshop, p. 77-82: Thermal Inst., Univ. Auckland, NZ.

The Geysers, California, is the site of an active hydrothermal system that initially developed between ~1.5 and 2 Ma in response to intrusion of a hypabyssal granitic pluton. Mineralogic and FI data demonstrate that the present V-dominated regime evolved from an earlier and more extensive, L-dominated hydrothermal system. Circulation of these early F produced veins characterized by tourmaline and/or biotite ± actinolite ± clinopyroxene within the pluton and adjacent biotite-rich hornfels, actinolite ± ferroaxinite ± epidote ± chlorite ± wairakite within the intermediate parts of the thermal system, and calcite in the outer parts. K feldspar and quartz are present in all assemblages. Maximum P-corrected Th and apparent salinities of FI in these veins range from 440'C and 44 wt % NaCl eq. Within the hornfels (<600 m from the pluton) to 325'C and 5 wt % NaCl eq. At ~1500 m from the intrusion. We suggest that the shallow, moderate-salinity F are crustal waters modified by water-rock interactions and that the high-salinity F are magmatic brines. The formation of V-dominated conditions is reflected in the abrupt appearance of low salinity (0.0 to 0.4 wt % NaCl eq.) FI with Th ~265'C. These I F are thought to present steam condensate formed as the L-dominated system boiled off. (Authors' abstract)

N_2-Ar-He-CH_4 gas data are also reported. See also previous item. (E.R.)

See also previous item. (E.R.)

MOORE, S.L.O. and SPENCER, R.J., 1995, A summary of the dolomitization history of the Pika and Eldon formations, Yoho National park, B.C., Canada (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 145-146.

See FIR, v. 26, p. 118. (E.R.)

MORALES, S., BARBANSON, L., FENOLL HACH-ALÍ, P. and TOURAY, J.C., 1995, The stratabound Zn-Pb-(Ge-F) Cerro del Toro ore deposit (Alpujarride carbonate formation, Betic cordillera, southern Spain): Mineralogy and fluid inclusions studies (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 294-296. First author at Inst. Andaluz de Ciencias de la Tierra and Dept. Mineralogía-Petrología, CSIC-Univ. Granada, Fuentenueva s/n, 18002 Granada, Spain.

P L + V I in sphalerite show two compositional types: (1) H_2O-CO_2-(CH_4?)-NaCl and (2) H_2O-NaCl-$CaCl_2$. Type 1 has Tm CO_2 -60.1 to -57.7°C; Te -22 ± 1°C; Tm ice -12.9 to -5.0°C; Tm clath +7.7 to +9.9°C; Th CO_2 LV (V) +11.2 to +12.9°C. Type 2 has Te -55 to -49°C; Tm hydrohalite -40 to -33°C (probably metastable); Tm ice -24.9 to -11.0°C. A possible explanation of these two very different F compositions, both in PI, is that early MVT-forming brine I were refilled with later CO_2-bearing F. (E.R.)

MORALES, S., QUILEZ, E. and FENOLL-HACH-ALÍ, P., 1995, The evolution of polysaline fluids during the ore genesis of the hydrothermal deposits at Aguilas-Sierra Almagrera (SE Spain) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 292-293. First author at Inst. Andaluz de Ciencias de la Tierra and Dept. Mineralogía-Petrología, CSIC-Univ. Granada, Fuentenueva s/n, 18002 Granada, Spain.

The aim of this work has been to study the F involved in the mineralization of the base-metal deposits in the Aguilas region (El Charcón, Ermita de la Cuesta de Gos y Reina del Cielo) and the Sierra Almagrera (El Arteal and El Jaroso).

This study has been based on a microthermometric analysis of the scarce P L-V I in the quartz at Aguilas and in the barite at Sierra Almagrera. At room T, the I comprise aqueous L and H_2O V in the typical two-phase forms with a volumetric ratio, Vg/Vt, ranging between 10% and 50% [sic].

On freezing to -100°C the I become dark and opaque and tend to contract, disappearing completely on occasions, compressed by ice. Te = -30 to -55°C; Tm hydrohalite -22 to -33°C; sal. [from Tm ice] 1-19; sal. [from?] 2-22 [both in % NaCl eq.?]; Th 160-508°C. Various possible interpretations of these widely ranging conditions and F compositions are discussed. (E.R.)

MORALES RUANO, S., BOTH, R.A. and HACH-ALÍ, P.F., 1995, Fluid evolution and mineral deposition in the Aguilas-Sierra Almagrera base metal ores, Southeastern Spain, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 365-368. First author at ESEM-EREM, Univ. Orléans, France.

The evolution of hydrothermal F that deposited base metal veins in the Aguitas and Sierra Almagrera zones, SE Spain, has been studied by means of FI, S isotopes and thermochemical calculations. The first stage F in the Agudas zone was a high T (>400°C) F of magmatic hydrothermal origin. F of subsequent stages in this zone, and of all stages in the Sierra Almagrera zone, were of lower T (<300°C) and involved mixing of magmatic F with modified seawater circulating through heated rocks. (Authors' abstract)

The data for three deposits are given in Table 1.

See also FIR, v. 27, p. 93. (E.R.)

Table 1. Summary of measured T and salinity data from FI and calculated values of pH, fO_2, fS_2 and fH_2S for stage II of Aguilas deposits. A value of $\Sigma S = 0.01$ molal was used in each case.

	El Charcon	Ermita	Reina
Th	160-310 (231)	203-402 (285)	180-320 (253)
Salinity	2-8	2-22.5	14-22
pH	<4.5	<5.8	<5.4
log fO_2	-42.2/-43.2	-36.1/-36.6	-39.1/-39.6
log fS_2	-14.2/-15.2	-13.1/-13.8	-13.0/-13.6
fH_2S	10-2/10-3	10-3	10-2/10-3

T (°C, range and mean); salinity (wt % NaCl eq.)

MORGAN, G.B. VI, LONDON, D. and LUEDKE, R.G., 1995, Melt inclusion, matrix glass and mineral compositions from a zoned S-type peraluminous rhyolite suite, Morococala volcanic field, Bolivia (abst.), *in* M. Brown and P.M. Piccoli, eds., The Origin of Granites and Related Rocks, Third Hutton Symp., College Park, Maryland, Aug. 26-Sept. 2, 1995: U.S. Geol. Surv. Circ. 1129, p. 99-100. First author at School of Geology and Geophysics, Univ. Oklahoma, Norman, OK 73019.

The Miocene peraluminous tuffs and domal flows of the Morococala volcanic field, Bolivia, record a temporal sequence of early (basal) andalusite ± biotite ± muscovite rhyolites (AR), middle cordierite + biotite rhyolites (CR), and latest biotite quartz latites (QL). Quartz phenocrysts in all three rock types contain abundant euhedral (negative crystal-shaped) MI. MI in the QL and CR are glassy, whereas those in the AR are typically devitrified; prior to analysis, the solids in the latter I were homogenized to glass in R-41 cold-seal reaction vessels (750°C, $PH_2O = 0.5$ kb). MI are homogeneous within and between two samples of the QL (ASI = 1.15-1.23, Na/K = 0.92-1.08, F = 0.21-0.29, Cl = 0.15-0.19), but have higher Al and Na vs. lower Si and Fe than perlitic glass in the matrix of one sample. Similarly, MI compositions are fairly homogeneous within and between four samples of the CR (ASI = 1.21-1.27, Na/K = 0.80-1.09, F = 0.35-0.42, Cl = 0.16-0.20), and with the exception of slightly higher F, are essentially identical to matrix glasses in all samples. Among four samples of the AR, MI compositions show considerable scatter both within and between samples (ASI = 1.21-1.40, Na/K = 1.05-1.80, F = 0.20-0.60, Cl = 0.04-0.09), even among different I within a single phenocryst. EMPA totals for all the MI are high (avg. wt %: QL = 97.4, CR = 97.9, AR = 98.1), suggesting low H_2O contents. All MI show lower contents (by 0.5-0.1 x) of Ca, Mg, and Fe than do their whole rocks.

The compositions of MI, matrix glasses, whole-rocks, and phenocrysts are all consistent with the origin of this sequence from a single zoned rhyolitic magma chamber in which the AR represent the apical most evolved portion. Core-rim increases of F in biotite could be explained by increased F activity in M accompanying either progressive M fractionation or devolatilization, but a lack of Cl zonation in biotite is inconsistent with the latter. The lower average Cl contents of both MI and biotite in the AR suggests a greater degree of M devolatilization in the apical portion of the magma chamber. Homogeneity of MI in the QL and CR suggest little lateral heterogeneity within the lower regions of the magma chamber. MI within the AR apparently record a quite different scenario for the apical portion of the chamber. Variations in average compositions between individual samples suggest the operation of processes giving rise to heterogeneity at length scales of tens to thousands of meters, and could involve gradients in T or volatile contents, or variable degrees of country rock (roof pendant) assimilation. Variability of MI in individual samples and phenocrysts, and variability in Al contents of quartz phenocrysts also suggest fine-scale disequilibrium in the AR. (From authors' abstract by H.E.B.)

MORIKIYO, T., 1992, A study of fluid inclusions in Ryoke metamorphic rocks in the Narai-Komagane area, Nagano Prefecture, central Japan: Gekkan Chikyu, v. 14, p. 675-680 (in Japanese).

FI in Ryoke metamorphic rocks are composed mainly of H_2O-CO_2 F. Microthermometric data and G analyses of the FI show that density of CO_2-phase is low and the phase contains N_2 and CH_4, and that CO_2-rich and H_2O-free I occur in the metamorphic rocks. (Authors' abstract, translated courtesy of Dr. Takayuki Sawakii)

MORITZ, R. and GHAZBAN, F., 1995a, Fluid evolution and gold mineralization in the Precambrian basement of the Zagros belt at Muteh, Esfahan Province, Iran (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 147-148. First author at

MORITZ, R. and GHAZBAN, F., 1995a

Table 1. Microthermometric results

FI type	Occurrence	$TmCO_2$	$ThCO_2$	Tm Clat	Tm ice	Th bulk
I	Regional quartz veins	-58.1; -56.9 (-57.0) n = 6	8.3; 23.6 (18.5) n = 8	-0.9; 7.5 (3.1) n = 17	-12.9; -6.7 n = 4	148; 257 (208) n = 14
II	Regional quartz veins	-58.5; -57.2 (-57.3) n = 12	-23.8; 12.0 (-5.7) n = 12	8.7; 9.4 n = 2		
III	Late Au quartz veins and regional quartz near Au occurrences			6.4; 8.7 (7.6) n = 27		181; 302 (221) n = 28
IV	Late Au quartz veins and regional quartz veins				-26.9; -21.0 (-23.5) n = 22	84; 191 (122) n = 33

First and second values = range; in brackets = mode; n = number of measurements; $ThCO_2$ and Th bulk are to the liquid; all values in °C.

Dép. Minéralogie, Univ. Genève, rue des Maraîchers 13, 1211 Genève 4, Switzerland.

The Muteh mine consists mostly of silicified rocks enriched in Au and of some Au-bearing quartz-pyrite-carbonate veins. The alteration associated with the Au mineralization overprints the metamorphic assemblage of the host rocks. The aim of this study is to contrast regional F with respect to the ore-bearing F and to constrain possible genetic scenarios. Four FI types are recognized (Table 1):

Type I and type II inclusions occur in the regional quartz veins that are unrelated to the Au occurrences. Both types occur as secondaries in separate trails or together in clusters. Type III inclusions are only present in late stage quartz-carbonate-pyrite veins and silicified rocks at the Au occurrences, as well as in some regional quartz veins in the direct neighbourhood of the ore bodies. Type IV inclusions occur as secondaries in both late-stage veins in the ore bodies and in regional quartz veins.

Type I and type II inclusions may represent immiscibility of a saline CO_2-bearing aqueous F during the geological evolution of the Precambrian basement rocks. The high salinities of type I FI can be explained by interaction of the F with evaporite-rich units or alternatively by F evolution during retrograde metamorphic reactions. The CO_2-rich nature of type I and type II inclusions most likely reflects decarbonation reactions of carbonate rocks that are present in the Precambrian basement.

Type III are the less saline F observed in the Precambrian basement rocks. These FI are spatially confined to the Au ore bodies at Muteh and are likely related to the ore formation process. Two possible scenarios are offered.

Type IV inclusions are late-stage, low T brines that have circulated in the Precambrian basement rocks following the ore formation stage at Muteh. The high salinities most certainly reflect the interaction of these F with evaporite-rich units. (From authors' abstract by E.R.)

See also next item. (E.R.)

MORITZ, Robert and GHAZBAN, Fereydoun, 1995b, Gold mineralisation in the Precambrian basement of the Zagros Belt, Esfahan Province, Iran, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 161-164. First author at Dept. Minéralogie, Univ. de Genève, Switzerland.

The Precambrian metamorphic basement of the Zagros orogenic belt hosts the Muteh mining district, a major Au producer of Iran. Alteration and vein mineralogy are characteristic of mesothermal Au deposits, and overprint the metamorphic mineral assemblage. F concomitant with ore formation are aqueous with a low salinity and a low CO_2-content. (From authors' abstract by E.R.)

See previous item. (E.R.)

MOROGAN, Viorica and LINDBLOM, Sten, 1995, Volatiles associated with the alkaline-carbonatite magmatism at Alnö, Sweden: A study of fluid and solid inclusions in minerals from the Långarsholmen ring complex: Contrib. Mineral. Petrol., v. 122, p. 262-274. Authors at Dept. Geology and Geochemistry, Stockholm Univ., S-106 91 Stockholm, Sweden.

The petrography, mineral chemistry and F/solid I studies suggest that the ring complex and the main intrusion at Alnö have had a somewhat different magmatic evolution, implying different evolution of F phases also. At Långarsholmen, a mafic silicate magma started to crystallize Al-diopside at ~5-6 kb and 1175°C. At that stage, the mafic magma was coexisting with a Mg-bearing calcitic M, recorded in the abundant I, trapped by the crystallizing Al-diopside. The two immiscible M appear to have separated at ca. 5 kb and 1150°C, in good agreement with recent experimental studies. The silicate magma crystallized di + ap + magnetite during its ascent, and was in contact with a saline hydrocarbonic F trapped as I in diopside (di) and apatite (ap) (type B2 I reluctant to dissolution ≤550°C). As PH_2O started to increase, Fe-pargasite began to replace the pyroxene. It appears that the F present at that stage was aqueous and contained ca. 40% NaCl. With decreasing PT, the F separated into two immiscible phases of high- and low-salinity (type B1 of 65% NaCl and C1 of 7% NaCl), respectively. Around 4 kb, a CO_2-bearing aqueous F of low salinity (d = 0.85) was coexisting with the M, and became trapped in the apatite formed during the mid-crustal stage (type A1 FI). The residual M was emplaced into the shallow crust and gave rise to phlogopite-bearing sövite. FI (type A2) trapped in calcite and in recrystallized apatite indicate that the F phase evolved towards a late (Na + K) hydrocarbonic F during cooling at the shallow depths of the final emplacement. The ijolite does not show signs of L immiscibility with the sövite at Långarsholmen, and exhibits mostly host-magmatic activity of F phases. (From authors' abstract by E.R.)

MORRISON, C.A., LAMBERT, D.D., MORRISON, R.J.S., AHLERS, W.W. and NICHOLLS, I.A., 1995, Laser ablation-inductively coupled plasma-mass spectrometry: An investigation of elemental responses and matrix effects in the analysis of geostandard materials: Chem. Geol., v. 119, p. 13-29.

MORROW, D.W. and AULSTEAD, K.L., 1995, The Manetoe dolomite: A Cretaceous-Tertiary or a Paleozoic event? Fluid inclusion and isotopic evidence: Bull. Canadian Petrol. Geol., v. 43, p. 267-280.

FI Th of dolomite cements from the Manetoe Dolomite exhibit a close correspondence to their $\delta^{18}O$ values if these dolomites precipitated from residual Devonian seawater brines ($\delta^{18}O$ -2.0 to +5.0‰) at shallow depths. P corrections, which must be applied to these T if dolomite cementation occurred during deeper Late Cretaceous to Tertiary burial, and the lower $\delta^{18}O$ values of subsurface F during this time period result in non-correspondence between the corrected FI paleotemperatures and those calculated directly from the $\delta^{18}O$ values of dolomite cements. (Authors' abstract)

MOUNTJOY, E., QING, H., DRIVET, E., MARQUEZ, X. and WILLIAMS-JONES, A., 1995a, Hydrothermal fluid movement along three regional Devonian dolomite conduit systems, Western Canada sedimentary basin (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-118. Authors at Dept. Earth and Planetary Sciences, McGill Univ., Montreal, H3A 2A7, Canada.

From NE British Columbia to Pine Point over a lateral distance of 400 km, dolomite cements show general trends of decreasing $^{87}Sr/^{86}Sr$ ratios (0.7116 to 0.7081) and Th (178 to 92°C), with some increase in δ18O values (-16‰ to -7‰ PDB). These regional trends suggest that hotter and more radiogenetic basinal F moved eastward updip along the Presqu'ile Barrier and mixed with cooler ambient formation waters. This barrier appears to have acted as a deeply buried regional conduit system that played an important role in focusing and channeling these basinal F.

In the SE Peace River Arch the geochemistry off Upper Devonian Leduc and Wabamun replacement dolomites and dolomite cements are similar. The distribution, geochemistry and FI data from the Wabamun replacement dolomites and dolomites cements indicate that they formed from saline hydrothermal F (between 100 and 200°C) that moved upwards, possibly as early as the Early Carboniferous, along extensive fault and fracture system that extend into the underlying Leduc.

Along the Rimbey-Meadowbrook reef trend C and O isotopes of replacement dolomites are relatively uniform. With increasing burial depth, later dolomite and calcite cements are characterized by (1) a slight decrease in $\delta^{18}O$ values (-4 to -7‰ PDB), (2) slightly more radiogenic Sr, and (3) no trend in Sr vs. O isotopes. This contrasts markedly with the distinctive regional geochemical trends along the Presqu'ile barrier. P corrected FI T are 20 to 70°C higher than a geothermal gradient of 30°C/km and Early Tertiary maximum burial T. Dolomite cements show no depth trend supporting formation during shallow burial from hydrothermal F. Calcite cements follow a 30°C/km geothermal gradient, and also require a high geothermal gradient or the upward movement of hydrothermal F. TSR calcites are lower T. Large-scale movement of hydrothermal F appears to be related to tectonic compression and sedimentary loading during early burial (Late Devonian and Early Carboniferous), or during deeper burial (Late Jurassic and Early Tertiary). (Authors' abstract).

See also next item. (E.R.)

MOUNTJOY, E., QING, H., DRIVET, E., MARQUEZ, X. and WILLIAMS-JONES, A., 1995b, Movements of hydrothermal fluids along three regional Devonian dolomite conduit systems, Western Canada sedimentary basin: Presqu'ile barrier, Rimbey-Meadowbrook reef trend, and Southeast Peace River Arch fault conduits (abst.): AAPG Abstracts, v. 4, p. 69.

See also previous item. (E.R.)

MOURA, A.J., NORONHA, F. and FERREIRA, A., 1995, Fluids from the Rubane and fissural ores of the Corvo orebody, Neves-Corvo mine, Portugal (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 149-150. First author at Centro de Geologia, Fac. Ciencias da Univ. Porto, 4050 Porto, Portugal.

The Neves-Corvo mine is certainly one of the richest Cu mines in the world, with proven and inferred reserves of over 30 Mt at 8% Cu. The mineralization consists of five lens-shaped bodies mainly of massive sulphides plus cassiterite.

The general model for the formation of the massive sulphide deposits is precipitation at or near the coeval sea floor, either during the waning stages of local volcanic activity and/or shortly thereafter, from hot, reducing, slightly acidic metal-bearing solutions largely of sea-water derivation.

Petrographic studies have revealed the presence of three types of quartz in the studied types of ore: Q1, the oldest one, very deformed; Q2, poorly deformed and considered coeval with a main mineralized event; Q3, younger recrystallized quartz mainly derived from the two other types.

Two main types of F have been distinguished in Q2:

Aquo-carbonic fluids: These F are represented as different types P FI: (i) H_2O-CO_2-NaCl-(CH_4) L (Lc-w or Vc-w) showing three-phase I at room T with CO_2 homogenizing to L phase or V phase but with global homogenization in L phase; (ii) H_2O-NaCl-(CO_2-CH_4) L (Lw-(c-m)) occur as two-phase I. Raman shows H_2O ~92; CO_2 ~6; CH_4 <1; NaCl ~1; Th ~250; pH 50-140 MPa. *Aqueous fluids*, dominantly aqueous with low salinity, are represented by secondary Lw two-phase I in trails.

The mode of occurrence and the composition of the F present in Q2 coeval with cassiterite and sulphide remobilization (mainly chalcopyrite) suggest the crystallization of cassiterite from CO_2 richer F and the sulphides from CO_2-CH_4 bearing F and the importance of the metamorphic F, on the epigenetic ore evolution processes in a rock-dominated system. The regional geological history and the macroscopic observations (at all scales) support this statement. (From authors' abstract by E.R.)

MUCHEZ, Philippe, HEIN, U.F., BROECH, K. Van den and VANDECASTEELE, Carlo, 1994, Lithological influence on the composition of vein cements in the Carboniferous of the Campine Basin (northern Belgium): Eur. J. Mineral., v. 6, p. 985-994. First author at Fysico-chemische geologie, K.U. Leuven, Celestijnenlaan 200C, B-3001 Heverlee, Belgium.

In the upper Visean limestones of the Campine Basin, the volumetrically most important vein type is represented by non-ferroan blocky calcites. In the overlying Namurian shales and sandstones this cement phase is absent and ankerite and quartz veins dominate. Both carbonate cements are one of the earliest fracture-filling cements in the upper Visean and Namurian. The O isotopic composition of the non-ferroan (40-200 ppm Fe) calcite veins lies between - 16.6‰ and - 8‰ PDB. The $\delta^{13}C$ values vary between - 3.1‰ and + 2.4‰ PDB.

Stable isotope analyses of the ankerites (6.2-12.5% Fe) give $\delta^{18}O$ values between -13.6‰, and - 10.8‰ PDB and $\delta^{13}C$ values ~0‰ PDB. FI microthermometry of the non-ferroan calcites and the first ankerite and quartz generation indicate precipitation of both cements in the same T range (45°-93°C) from a F with a broad range in salinity (9-26 eq. wt % $CaCl_2$). The estimated O isotopic composition of the F from which the ankerites precipitated is -6.6‰ SMOW, indicative for meteoric water. The blocky calcites probably formed from a "marine-derived" F which mixed with meteoric water between -4‰. (From authors' abstract by H.E.B.)

MUCHEZ, Ph., SLOBODNIK, M., VIAENE, W.A. and KEPPENS, E., 1995, Geochemical constraints on the origin and migration of palaeofluids at the northern margin of the Variscan foreland, southern Belgium (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 151-152. First author at Fysico-chemische geologie, K.U. Leuven, Celestijnenlaan 200C, B-3001 Leuven, Belgium.

The aim of this study is to investigate the importance of tectonism in the origin and migration of F yielding calcite veins. These veins, and the surrounding limestones, have both a similar dull brown-orange luminescence and stable isotopic composition ($\delta^{18}O$ = -11 to -8‰ PDB and $\delta^{13}C$ = 0 to +3‰ PDB). This indicates precipitation of the calcite cement from a F buffered by the rock.

Measurable P and S two-phase (L and V) FI have only been found in a few samples. The Th of the I varies between 115° and 150°C, corresponding to Tt between 150° and 185°C. The salinity of the I is between 2.0 and 7.8 eq. wt % NaCl. The lowest Tt is similar to the maximum burial T deduced from the conodont alteration index (150°C). The low salinity supports the interpretation that the ambient F had a meteoric origin.

Inclusions in distinctly recrystallized syn-Variscan veins contain besides a few low salinity F, numerous high salinity $CaCl_2$-NaCl-H_2O I (Tfm -52°C). The salinity of the I is between 10.3 and 26.3 eq. wt % $CaCl_2$. The Th values range between 130° and 170°C. So, the original Tt were >170°C. This indicates that after the migration of relatively low salinity F, and therefore after the main period of Variscan deformation, high salinity F circulated upward through the fractures at a T higher than that of the surrounding limestones.

After the Variscan deformation, five successive Fe-rich fracture-filling calcite generations occur associated with MVT mineralisations in southern Belgium. FI evidence indicates that all the calcites formed from F with a salinity between 16.0 and 23.1 eq. wt % NaCl. The Tt of the FI decreases from ~125°C in the first two calcite generations to 50°C in the last two vein cements. The O isotopic composition of the ambient F, calculated from the Tt and the isotopic composition of the calcites varies between -5.2 and +7.6‰ SMOW. The highly variable O isotopic composition of the F, the low $\delta^{18}O$ value of -5.2‰ SMOW and the intense water-rock interaction necessary to leach metals indicate that the original F had a low $\delta^{18}O$, and that these F became enriched in ^{18}O by water-rock interaction. Flow of this water into the deeper subsurface was likely gravity-driven and took place from the uplifted parts of the Variscan orogen towards the foreland basin.

Non-ferroan calcites filling transversal fractures, formed later during the Mesozoic or Tertiary. Two types of FI have been distinguished in these calcites. The first type consists of NaCl-$CaCl_2$-H_2O I with a salinity between 11-28 eq. wt % $CaCl_2$ and a Th between 42° and 55°C. Very high salinity NaCl-$CaCl_2$ F are very common at depths ≤10 km and represent basement brines. Tentatively we propose that such brines have been intersected by the transversal fractures and faults. The second type of FI contain pure H_2O or NaCl-H_2O and have a salinity between 0 and 12.6 eq. wt % NaCl. The near zero salinities indicate meteoric water. The higher salinities are interpreted to be the result of the interaction between the meteoric water and the rocks. These F likely had a local gravity-driven origin, determined by fold and fault patterns. (From authors' abstract by E.R.)

See also next item. (E.R.)

MUCHEZ, P., SLOBODNIK, M., VIAENE, W.A. and KEPPENS, E., 1995, Geochemical constraints on the origin and migration of palaeofluids at the northern margin of the Variscan foreland, southern Belgium: Sed. Geol., v. 96, p. 191-200.

Three major fracture types in the Dinantian of the Namur syncline at the northern margin of the Variscan foreland in southern Belgium have been investigated by FI and stable isotope analysis. The oldest and volumetrically most important fracture type is characterized by conjugated and sigmoidal *en echelon* calcite veins which formed during the Variscan folding. These veins, and the surrounding limestones, have both a similar dull brown-orange luminescence and stable isotopic composition ($\delta^{18}O$) = -11‰ to -8‰ PDB and $\delta^{13}C$ = 0‰ to +3‰ PDB). This indicates precipitation of the calcite cement from a F buffered by the rock. In the area studied, only a limited amount of F was expelled through the Dinantian during the main phase of Variscan compressional tectonism. Fractures filled with ferroan calcites crosscut the Variscan folds. FI and stable isotopic evidence indicates that the calcites precipitated at 40°-60°C from a saline F (9.2 to 23.2 eq. wt % NaCl) with an estimated $\delta^{18}O$ composition between -2‰ and -0.6‰ SMOW. The most likely origin of these high-salinity F with a relatively low-O isotopic composition is a gravity-driven meteoric water that underwent an intense water-rock interaction. The topographic relief created by the Variscan tectonism could have allowed groundwater to penetrate into the deeper subsurface and to

MULSHAW, S.C., 1995

Table 1. Comparison of FI data from San Bartolomé and Bolivia (Bolivia data from Kelly and Turneaure, Econ. Geol., 1970).

	Bolivia		San Bartolomé	
	Th range/°C	Mode/°C	Th range/°C	Mode/°C
Primary inclusion fluids:				
Early quartz	200-530	340-380 250-280	200-400	300-330
Secondary inclusion fluids:				
Early quartz	140-440	350-400		
Late fluorite	70-190	150?	-	-
Late quartz			200-400	230-255 280-305
Late carbonate			210-260	240-250
Salinity:				
Early fluids	<46%	35-40%		
Late fluids	<10%		<15%	

migrate towards the margin of the foreland basin. Non-ferroan, fracture-filling calcites formed later during the Mesozoic or Tertiary. Low-salinity meteoric waters and high-salinity $CaCl_2$-NaCl brines with T ~50°C migrated through this fracture system. Along these fractures, meteoric water migrated down into the subsurface, and the brines could have flowed upward from the basement. (Authors' abstract)

See also previous item. (E.R.)

MULLIS, A.M. and HASZELDINE, R.S., 1995, Numerical modelling of diagenetic quartz hydrogeology at a graben edge: Brent oilfields, North Sea: J. Petrol. Geol., v. 18, no. 4, p. 421-438.

Indexed under FI. (E.R.)

MULLIS, J., 1995, PT-time-path, fluid evolution and crystal growth in the Aar- and Gotthard massifs during late plate collision and exhumation of the Central Alps (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 153. Authors at Mineralogisch-Petrographisches Inst., Bernoullistrasse 30, CH-4056 Basel, Switzerland.

FI in fissure quartz from Zinggenstock in the Aar Massif and La Fibbia in the Gotthard Massif were studied by microthermometry, Raman spectroscopy and sodium-potassium thermometry yielding composition, density, T and P of F trapping and crystal growth. Combining this knowledge with radiometric data from the vicinity, F evolution and crystal growth is approximately defined in space and time.

The mineralizing F was an aqueous chloride solution. Only the earliest growth stage from La Fibbia in the south of the Gotthard Massif crystallized in a CO_2-enriched environment. The main quartz precipitation occurred 20 to 15 Ma ago, between 430 ± 20 and 220°C and 350 ± 50 and 180 MPa.

Assuming that Pfluid equals Plith, the studied extensional veins opened at a depth of 14 ± 2 km ~20 Ma ago. At this depth rocks were affected by compressional tectonics of the African and European plate close to the brittle-ductile transition. During further collision and thickening the Central Alps were discontinuously exhumed. F composition evolved towards lower salinity and CO_2-content. P and T decreased, leading to mineral precipitation in the fissure systems. (Authors' abstract)

MULSHAW, S.C., 1995, Possible metallogenic significance of epizonal, polymetallic vein mineralisation at San Bartolome in the Ecuadorian Andes: a working hypothesis: PACRIM '95, p. 407-412. Author at Dept. Geology, Imperial College of Science, Technology and Medicine, London, UK.

The epizonal Ag-Pb-Zn vein deposit at San Bartolomé is characterised by a base-metal sulphide assemblage containing the spectacular development of interpenetrating, bladed networks of pyrrhotite which have been replaced by marcasite and pyrite. A similar assemblage displaying the same crystal habits and textures are also a diagnostic feature of the Sn and Sn-Ag deposits of Bolivia: On this basis, it is reasonable to conclude that both deposits were formed from F of similar nature and origin. Although no economic accumulation of Sn is known in San Bartolomé, further comparison of the geologic setting, age, mineralogy, FI data and magmatic association of this deposit with the Bolivian systems has highlighted additional similarities consistent with a hypothesis that more extensive Sn mineralisation might exist in the San Bartolomé area. [See Table 1.] (Authors' abstract)

MUMIN, A.H. and FLEET, M.E., 1995, Evolution of gold mineralization in the Ashanti Gold Belt, Ghana: evidence from carbonate compositions and parageneses: Mineral. and Petrol., v. 55, p. 265-280. Authors at Dept. Earth Sciencès, Univ. Western Ontario, London, Ontario, Canada.

T derived from the ankerite-siderite composition geothermometer are generally consistent with those from calcite-dolomite, arsenopyrite, C and O stable isotope, and FI geothermometers, and are ~360°C for the metamorphic peak, 400 to 350°C for carbonate alteration of mafic dikes, and 340 to 140°C for Au deposition. The latter range occurs on a thin-section scale and represents separate pulses of F in the ore conduit. (From authors' abstract by E.R.)

MUÑOZ, César and FONTBOTÉ, Lluis, 1995, El Yacimiento de Zn-As-(Au) Azulcocha asociado a la falla de desgarre Cochas-Gran Bretaña (Perú Central): Soc. Geol. del Perú, Vol. Jubilar Alberto Benavides, Oct. 1995, p. 205-230 (in Spanish, English abstract). First author at Newmont Peru Ltd., Av. El Golf Los Incas 216, Urbanización Monterrico, Lima 33, Peru.

The Zn-As-(Au)-Azulcocha ore deposit is located in the Central Peruvian Andes, 270 km east of Lima. Main rocks in the Azulcocha area are marine and continental sediments of Mesozoic and Cenozoic age. West of the Azulcocha ore deposit occur a granitic to alkali feldspar granitic rock (Chuquipita stock) and a rhyolitic to alkali feldspar rhyolitic dome (Jesús María dome).

Four main depositional stages have been distinguished. Stage II is the main stage and comprises sphalerite (schalenblende), subordinate barite, rhodochrosite, marcasite and minor amounts of galena and Pb-As-sulphosalts. Stage III consists mainly of marcasite, "melnikovite," in part Au-bearing, orpiment, realgar and small acicular I of a not known Pb-As-sulphosalt ("mineral X" - $5PbS.3As_2S_3$). Hydrothermal alteration is not observed in the ore deposit area. However, in the southern part silicification and dolomitization occur associated with secondary transversal faults trending NE-SW. Geochemical analyses on bulk-concentrates show relatively high values of the Ge (20-115 ppm), Cd (100-2500 ppm), In (1-40 ppm), Hg (10-120 ppm) and Tl (10-280 ppm). A particularity of the Azulcocha ore deposit is the high Au contents in some ore-concentrates (2-14 ppm) and in As-rich-marcasite-"melnikovite" concentrates (≥7.8% As) which show the highest Au values (≥70 ppm).

FI on barite from stages II and III give similar Th, which range from 90° to 177°C (avg. 131°C). Salinities range from 5 to 20 eq. wt % NaCl (avg. 12 wt %). The low T FI correlate reasonably well with the mineral paragenesis and textures of the ore deposit. This fact together with the scarce alteration suggest a low T metal precipitation. Pb isotope composition in galena and sulphosalts from Azulcocha and other neighbor ore deposits indicates two Pb sources: a less radiogenic source represented by the volcanic and volcanoclastic rocks of the Mitu Group, and a more radiogenic source probably from the pre-Permian basement or sediments and/or intrusive rocks derived from it. The S isotopic analyses in sphalerite and barite show a small variations range, between +2‰ to +6‰ for sphalerite and +20‰ to +24‰ for barite. The narrow span of the $\delta^{34}S$ ratios indicates an homogeneous source, not abrupt changes of the physicochemical conditions during sulfide precipitation, and absence of bacterial sulphate reduction. A mixing of magmatic S, as main component, with S of intercalated evaporites in the Eocene Capas Rojas Formation is proposed.

The present work shows that there are similarities with other polymetallic Zn-As rich ore deposits associated to Tertiary magmatism in central Peru, like Huarón and Colquijirca. These ore deposits are at least spatially associated to deep fractures. Azulcocha could be considered as a low T equivalent of these ore deposits. (From authors' abstract by H.E.B.)

MUNOZ, M., BOYCE, A.J., BANKS, D., COURJAULT-RADE, P., FALLICK, A.E., POLVE, M. and TOLLON, F., 1995, Evidence of basinal brine ore fluids for the S-W Massif Central (France) Zn and F veins: Fluid inclusions, stable isotopes and halogens data (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 198.

FI composition is fairly homogeneous all over the district. The H_2O-NaCl-$CaCl_2$ F are characterised by high salinity (20-25 wt % eq. NaCl) and low Th (100-180°C). At Saint-Salvy, stable isotope data indicate the involvement of meteoric F which have built their salinity by leaching of evaporites, most probably from the adjacent Aquitain Basin. The involvement of hydrocarbon material is also implied from very low δD (~-110‰) during the main mineralization. Br/Cl ratios of the F show a clear depletion of Br relative to Cl, from c. 0.010 to 0.002, as mineralization progressed. This suggests that meteoric F have first increased their Br/Cl ratio by leaching interstitial evaporitic F and then derived their halogen content from halite dissolution. At Peyrebrune, stable isotope data are very similar to Saint-Salvy (depleted δD) and the Br/Cl ratio trend is continued for the fluorite paragenesis. At Mont-Roc and Le Burc, stable isotopes data also indicate that the mineralizing F are meteoric waters, the salinity of which is consistent with interaction with sediments containing evaporites, as shown by their positive $\delta^{18}O$ values and their halogen signatures. However, they display a less depleted δD.

Timing of mineralization must have been after deposition of the adjacent evaporite beds in the Aquitain Basin. We speculate it occurred during a major tensional event as the Lias/Dog transition. (From authors' abstract by E.R.)

MUNOZ, M., NESBITT, R.W. and POLVE, M., 1995, REE ICP-MS analyses of fluid inclusions within fluorite from southwestern Massif Central (France): Contribution to the characterization of brine evolution (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 154-155. First author at Univ. Paul Sabatier, Laboratoire de Géochimie, 38 rue des 36 ponts, 31400 Toulouse, France.

Fluorite samples from four vein deposits located in the Paleozoic basement of the SW Massif Central in France have been crushed and leached for conventional solution ICP-MS analyses. In three deposits (Mont-Roc, Le-Burc and Embournegade) the mineralization is F-dominated while in the other (Peyrebrune) it is Zn-dominated with the fluorite stage post-dating the Zn stage.

Microthermometry of FI indicates in the four veins that mineralization has been deposited by an high salinity H_2O-NaCl-$CaCl_2$ F (20-24 wt % eq. NaCl) similar in composition to basinal formation waters.

Sr, Rb and the whole serie[s] of REE have been analysed in the leachate and in the fluorite residue. Sr and Rb have also been analysed in individual FI (previously selected as PI) within fluorite using a Laser equipment attached to the ICP-MS. The Sr/Rb ratio obtained on individual FI is similar to the Sr/Rb ratio obtained on FI leachate from the same sample. This indicates that the leachate solution is representative of the same P FI population characterized by microthermometry.

REE data have been shales normalized [figure deleted]. The Eu anomalies displayed by the fluorite are also displayed by the FI, consequently they were already present in the mineralizing solution. Together with the presence of sulfides in the paragenesis of the Peyrebrune deposit, the negative anomaly is indicative of reducing conditions while the positive anomalies of the Mont-Roc, Le-Burc and Embournegade deposits are indicative of a change from reducing to more oxydizing conditions. This could be a major constraint for the deposits specialization sulfide/fluorite.

FI display a negative Gd anomaly which is not displayed by the mineral. An exceptional behavior of Gd has been observed in seawater where positive anomalies have been reported (Kim et al., 1991). A complementary negative anomaly can be expected in minerals precipitated from seawater, such as evaporites. With regard to the basinal origin of the mineralizing F suggested by the microthermometric data, this Gd anomaly would be consistent with an acquisition of the salinity by the F through evaporites dissolution rather than through concentration of elements in seawater during evaporite sequences formation. (Authors' abstract)

See also FIR, v. 26, p. 121. (E.R.)

MUNZ, I.A., YARDLEY, B.W.D., BANKS, D.A. and WAYNE, D., 1995, Deep penetration of sedimentary fluids in basement rocks from southern Norway: Evidence from hydrocarbon and brine inclusions in quartz veins: Geochim. Cosmochim. Acta, v. 59, p. 239-254. First author at Mineralogisk-Geologisk Museum, Univ. Oslo, N-0562 Oslo, Norway.

This paper presents evidence for F flow and F-rock interaction at upper crustal levels within the crystalline basement of southern Norway. In the high-grade Modum Complex postmetamorphic veins of quartz occur in association with albitisation of metagabbros and metasediments. P-T conditions for the formation of these veins are in the range 250-300°C and ca. 1-2 kb. P and PS FI in the quartz veins show two F: (1) hydrocarbon ± CO_2 I and (2) aqueous I with variable salinities. Dark carbonaceous solid I are also present. The hydrocarbon I are CH_4 dominated (ca. 80-100 mol %), and the presence of higher, complex hydrocarbons is demonstrated. The aqueous I in the metagabbro-hosted veins show more saline compositions than the metasediment-hosted veins. A salinity range of ca. 23-0 wt % NaCl eq. is found. Some of the aqueous I may contain $NaHCO_3$. Crush-leach analyses of I F show Na-Ca-K-Cl dominated compositions, with Na >>Ca >K. Hydrocarbon-poor concentrates yield Br/Cl ratios close to seawater, while hydrocarbon-rich concentrates show higher values. The types and chemistry of the hydrocarbons in these veins indicate a biogenic origin of the hydrocarbon F. The I F are interpreted as derived from an overlying sedimentary basin in late Precambrian or Permian times. The veining is interpreted as the deep expression of the percolation of basinal F into the metamorphic basement during crustal extension. (Authors' abstract)

MURAMATSU, Y., 1994, Considerations on application of fluid inclusion geothermometry for evaluation of geothermal well: Geothermal Energy, v. 18, p. 90-103 (in Japanese).

There are four distribution patterns of Th of FI at geothermal wells: (a) the lowest Th is higher than well T; (b) the lowest Th is nearly equal to well T; (c) average Th is nearly equal to well temperatures; (d) the highest Th is nearly equal to well T. In many cases, only one pattern appears in a developed geothermal area (3-4 km^2). Determination of the pattern is useful to evaluate geothermal resources in the geothermal area. (Abstract courtesy T. Sawaki)

MURATA, A., MIZUTA, T. and ISHIYAMA, D., 1995, Geochemical study of the Wage-sennin hematite deposit, Iwate Prefecture, Japan (abst.): J. Soc. Resource Geol., v. 45, no. 4, p. 273 (in Japanese).

Indexed under FI. (E.R.)

MURPHY, P.J. and ROBERTS, S., 1995a, Observations on the melting and nucleation behaviour of clathrates in multivolatile fluid inclusions (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 156-157.

Disequilibrium conditions during microthermometry can cause misinterpretation; various experimental procedures to avoid these problems are described. See also FIR, v. 26, p. 121 and next item. (E.R.)

MURPHY, P.J. and ROBERTS, S., 1995b, Laser Raman spectroscopy of differential partitioning in mixed-gas clathrates in H_2O-CO_2-N_2-CH_4 fluid inclusions: Implications for microthermometry: Geochim. Cosmochim. Acta, v. 59, p. 4809-4824. Authors at Dept. Geology, Univ. Southampton, Highfield, Southampton SO17 1BJ, UK.

Combined microthermometric and laser Raman microspectroscopic techniques were used to investigate the compositional effects of G hydrates (clathrates) on the residual F in aqueo-carbonic FI. By attaching a Linkam heating-freezing stage to a Raman spectrometer, it was possible to analyse the volatile content of a single I (composition 49% CO_2, 42% N_2, 9% CH_4, aqueous fill = 0.8) at a variety of T, under the normal conditions of microthermometric analysis. The results reveal that, not only does the volatile composition of the F change dramatically on clathration, but it also becomes progressively more depleted in CO_2 relative to N_2 and CH_4 with decreasing T, resulting in a composition of 5% CO_2, 86% N_2, and 9% CH_4 at -60°C. This has a major effect on the microthermometric properties of the F. The preferential incorporation of CH_4 into the clathrate relative to CO_2 described by previous workers was not observed here, and the recorded change in composition of the residual F is far greater than has previously been described.

The reaction kinetics of clathrates, generally assumed to be "sluggish," are in fact rapid enough to cause major compositional changes during microthermometric analysis. Besides T and P, the degree of aqueous fill, equilibration time, and T cycling can all affect the composition of the clathrate, and therefore, also the residual F. (Authors' abstract)

See also FIR, v. 27, p. 95. (E.R.)

MUTCHLER, S.R., 1995, Oxygen stable isotope analysis of calcite by Raman microprobe spectrometry: MS thesis, Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA.

Pertinent to the possible use of Raman for isotopic analysis of FI. (E.R.)

MUTEMERI, N., 1995, Fluid evolution and gold mineralisation in the Archaean, Harare Greenstone Belt: 26th Ann. Report 156, Feb. 1995, Inst. Mining Research, Univ. Zimbabwe, Harare, Zimbabwe.

FI data is presented as part of a proposal for an expanded project. (H.E.B.)

MUTEMERI, N., BLENKINSOP, T. and TOURET, J.L.R., 1995, Fluid inclusion evidence from two generations of quartz-veins in the Archaean gold-bearing Venus shear zone of the Arcturus Mine, Zimbabwe (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 158-159. First author at Inst. Mining Research, Univ. Zimbabwe, Harare, Zimbabwe.

Structural analysis, spatial distribution of some quartz veins, ore microscopy and FI studies reveal part of the F evolution.

The earlier of two fabrics in silicified biotite-actinolite schist is associated with quartz lenses and veins; a result of localised brittle behaviour in an otherwise ductile deformational regime. A later generation of quartz veining has been distinguished (there may be several others); it cuts across the foliation of the biotite-actinolite schist ore bodies and has an orientation similar to that the latter planar fabric.

FI study of these two generations of quartz veins reveals the presence of three types of inclusions, distinguished on the basis of composition, I-gaseous, II-aqueous and III-mixed (I+II). Several chronological populations have been distinguished, some as primary and others as secondary.

The mineralising F were silica-rich, low salinity (10 wt % NaCl) aqueous/G-rich (CO_2/CH_4). The $XCO_2/(XCO_2+XCH_4)$ ratios estimated for the primary G-rich I are within the same range (0.38-0.7) for both generations of quartz, indicating that the primary source of the F is similar. Mineralisation which must have commenced post-peak metamorphism at P-T conditions ranging between 300°-400°C and 1-2 kb, was probably due to immiscibility and produced sulphides intimately associated with Au (in solid solution). O fugacities were calculated by COHFLUID (Huizenga, 1995), for a fixed P and T of 1.5 kb and 350°C and graphite activity of 1.

The molar volume of the PI indicated higher density F in the early generation of quartz veins (68-43 cm^3/mol) than in the later (78-90 cm^3/mol). This indicates a progressive decrease in P-T conditions in the shear zone. Some of the secondary trails which show greater abundance of aqueous I could have trapped meteoric water after uplift to higher crustal levels. Uplift is evidenced by decrepitated I. (From authors' abstract by E.R.)

MYZNIKOV, I.K., KOVALENKER, V.A. and NAUMOV, V.B., 1995, Ryabinovoye porphyry copper-precious metals ore field: Geochemical characteristics, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 169-171. First author at Inst. Geology of Ore Deposits, Moscow, Russia.

Mineralogy, geochemistry, stable isotope geochemistry. and fluid inclusions of the Ryabinovoye alkaline rock-hosted porphyry copper-precious metals ore field were studied. New information is compared with literary data to show specific features of the ore field. Interpretation of the data provides evidence of (1) magmatic source of hydrothermal F; (2) possible ascent of F in subduction zone; (3) chlorine complexes as possible transport agents for precious metals; (4) evolution of S and O fugacities, which control Cu, Fe, and precious metals deposition. (Authors' abstract)

(5) Quartz hosted FI were examined by thermometric and ion-chromatographic methods. Three types of FI were recognized in quartz using the former method: (1) the CO_2 (7-30 vol %)-H_2O (70-93 vol %) I. They are characteristic of high density CO_2 (0.89-0.97 g/cm^3) and of high salinity (8-16.4 wt % NaCl); (2) mostly H_2O I without any volatiles. Their salinity ranges from 7.6 to 25 wt % NaCl; (3) the H_2O (15-20 vol %)-CO_2 (80-85 vol %) I. They contain only high density CO_2 (0.82-0.97 g/cm^3); other gases are missing. F density of many I was so high (0.78-1.13 g/cm^3) that they decrepitated long before Th. If the T of mineralizing F was ~350°C, then the P of ~6 kb must be supposed in time of their formation.

Such high P have not been reported yet from any porphyry type deposit. Similar values were reported only from the Kollar deposit, India (Naumov et al., 1988).

The ion-chromatographic analysis showed that H_2O (96-98 mol %) and CO_2 (2.2-3.5 mol %) represent common volatiles contained in F. They may be accompanied by some N_2 (0-0.8 mol %) and CH_4 (0.03 mol %). F^-, Cl^-, SO_4^{2-} ions were identified in L phase of FI. Their contents (expressed in mol/kg H_2O units) are 0.01-0.78, 0.14-0.35, and 0.11-0.52, respectively. (From authors' text by E.R.)

NADEN, J., LENG, M.L., CHELIOTIS, Y. and ELIOPOULOS, D., 1995, Fluid inclusion and stable isotope studies of epithermal precious and base metal mineralisation, Lesvos Island, Greece (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 160-161. First author at British Geol. Surv., Nottingham, UK.

A suite of samples, including geothermal waters, was collected for FI and stable isotope analysis. Analyses include: CO_2, N_2, CH_4 and δD on I F; $\delta^{18}O$ on associated quartz; $\delta^{34}S$ on pyrite, galena and sulphate in the geothermal waters.

Preliminary geochemical and isotopic data indicate that the mineralising F are low in G content (CO_2, N_2, CH_4). Generally, there is no correlation between G contents of the F and Au grade. However, cumulative frequency plots indicate a bimodal distribution of CO_2/H_2O, at present the relationship between this distribution and mineralisation is not known. Stable isotope data suggest a complex history of F-rock interaction. Present day geothermal waters show a meteoric water signature ($\delta^{18}O$ = -5.9‰; δD = -36.2‰). However, the S isotope composition ($\delta^{34}S$ = 15.1‰) of sulphate in present day geothermal F indicate an ancient source rather than present day seawater. The paleo-geothermal F responsible for mineralisation show a narrow range of $\delta^{18}O$ values (5.1 to 6.7‰) and a slightly broader range of δD (-41 to -67‰). These data plot close to the field for magmatic waters. This can, probably, be accounted for by F-rock reaction between meteoric water and the host volcanic rocks. S isotopes suggest an igneous source for S (-2.6 to -5.1‰ for pyrite, -4.5 to -6.6‰ for galena).

The data indicate an epithermal origin for the mineralisation. (From authors' abstract by E.R.)

NAEGLER, T.F., PETTKE, T. and MARSHALL, D., 1995a, Initial isotopic heterogeneity and secondary disturbance of the Sm-Nd system in fluorites and fluid inclusions: A study on mesothermal veins from the central and western Swiss Alps: Chem. Geol., v. 125, p. 241-248.

This paper presents Sm-Nd data on hydrothermal fluorites, FI and leach experiments on samples from the Mont-Blanc and Gotthard units, Swiss Alps. Both areas have experienced Alpine greenschist-facies overprint (≤350° and differs from 450°C, respectively). Mont-Blanc samples represent late Variscan fluorites from three individual veins whereas Gotthard samples were taken from one hand-specimen of probable late Variscan age. Nd concentrations of fluorites range from 3.6 to 23 ppm, $^{147}Sm/^{144}Nd$ ratios from 0.12 to 0.35. None of the sample sets yielded an isochron relationship. Imperfect correlations indicate apparent ages between late Variscan and Alpine, reflecting neither the formation nor the age of metamorphic overprint. Reasons are wall-rock influence during formation and post-formation disturbance. Secondary fluorite (Gotthard) shows the highest Nd concentration and a low Sm/Nd ratio, close to that of FI fractions. A leach experiment showed the same trend even more pronounced: differs from 7% of Nd and differs from 2% of Sm were removed from fluorite by 0.18 N HCl at 100°C. Hence, secondary F are likely to leach and fractionate Sm and Nd, and may easily cause dissolution and reprecipitation of fluorite. Consequently, the system is highly suspicious if secondary F flow cannot totally be ruled out. This is in sharp contrast to previously published conclusions. However, evidence for rejuvenation of the Sm-Nd system in fluorites is also found in published data sets. (Authors' abstract)

NÄGLER, T.F., PETTKE, T. and MARSHALL, D., 1995b, Trouble with dating fluorite veins from the Central and Western Alps: A Sm-Nd study of fluorites and fluid inclusions (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 348-349.

Vein-systems from the Mont-Blanc (MB) and Gotthard (G) massifs were studied to test the ability of Sm-Nd dating of fluorites that have experienced a greenschist facies overprint. MB samples were taken 4-6 km SW of Martigny. Deformed qtz-fluorite-carbonate-barite veins (0.05-1 m thick) were sampled from 3 localities. They cut the basement gneisses and the MB granite. The T of the overprint is 300-350°C. Veins have not been observed to extend into overlying sediments, thus a formation age >240 Ma is indicated. As one vein extends into the rhyolitic phase of the MB granite a max. age of ≈307 Ma is given (Bussy, 1990). The G fluorite vein (<2 m thick) cuts the pre-Mesozoic, polymetamorphic basement and late Variscan lamprophyres. The regional Alpine metamorphic overprint is 450-500°C. The vein paragenesis mainly consists of fluorite, galena, and qtz. Undulous extinction of qtz indicates an Alpine overprint >300°C, and thus a pre-Alpine formation.

Four fluorite samples from the MB define an isochron of 109 + 53 Ma. The poor precision is due to the narrow spread in Sm/Nd. Neither a post-Variscan nor an Alpine age is covered within error limits. A fifth sample was found not to be co-genetic at all. It is the most deformed one taken 4 km from the others. Six samples of coarse-grained fluorite of the G vein also show a very narrow spread in Sm/Nd. They do not define an isochron, even through they have been sampled within a few cm of each other. A brownish fluorite sample and the FI-leachate of clear fluorite yield similar Sm/Nd ratios and identical Nd isotope compositions. Both samples are attributed to recrystallization during the Alpine overprint. The slope of a regression line calculated through all G samples corresponds to an apparent age of 37 ± 44.

As no geologically meaningful ages can be deduced, in both areas a post formation disturbance of the Sm-Nd system must be assumed, most probably an Alpine metamorphic overprint on post-Variscan fluorite veins. Thus, the fluorite Sm-Nd system may be disturbed under T <350°C, at least if F are present. The degree of resetting may be related to the peak metamorphic T (pT), as the apparent age of the MB fluorites (pT = 350°C) is still older than that of the G samples (pT = 450°C). (Authors' abstract.)

NAKASHIMA, Satoru, MATAYOSHI, Hiromi, YUKO, Takako, MICHIBAYSHI, Katsuyoshi, MASUDA, Toshiaki, KUROKI, Noriko, YAMAGISHI, Hiraku, ITO, Yuki and NAKAMURA, Akira, 1995, Infrared microspectroscopy analysis of water distribution in deformed and metamorphosed rocks: Tectonophysics, v. 245, p. 263-276. First author at Geological Inst., Univ. Tokyo, Hongo 7-3-1, Tokyo 113, Japan.

Infrared microspectroscopy has been applied to thin sections of various deformed and metamorphosed rocks in order to investigate H_2O content of quartz in these rocks. The broad IR band absorbance ~3400 cm^{-1} probably due to FI molecular H_2O was used to calculate H_2O contents. Deformed granitic rocks showed an increase of H_2O content in quartz from ~300 ppm to 2500 ppm with increasing degree of deformation. H_2O contents in high-P metamorphic rocks in Japan are mostly of the order of 500 ppm (300-700 ppm), except for those from Kurosegawa with a H_2O content as high as 1700 ppm. These results represent an exploratory analysis of intragranular H_2O contents in quartz in various deformed and metamorphosed rocks. Further micro FTIR studies of the distribution of H_2O in crustal rocks will provide a quantitative basis for examining the geochemical cycle of H_2O in the earth's crust. (From authors' abstract by E.R.)

NAUMOV, V.B., KOVALENKER, V.A., MYZNIKOV, I.K., SALAZKIN, A.N., MIRONOVA, O.F. and SAVEL'YEVA, N.I., 1995, Inclusions of high-pressure fluids in hydrothermal veins of the Ryabinovaya alkalic pluton, central Aldan: : Dokl. Ross. Akad. Nauk, v. 343, no. 1, p. 99-102 (in Russian).

Th clathrate, Tm ice, Th CO_2, salinity, G analyses (H_2O, CO_2, N_2 and CH_4), and F, Cl and SO_4 data are given. (E.R.)

NAUMOV, V.B., KOVALENKO, V.I. and IVANITSKY, O.M., 1995, Concentrations of H_2O and CO_2 in magmatic melts, the results of study of inclusions in minerals: Geokhimiya, no. 12, p. 1745-1759 (in Russian, English abstract).

Data [from literature] are summarized on H_2O and CO_2 in homogeneous magmatic silicate MI and quenched volcanic glasses from the oceanic bottom. Average contents of H_2O and CO_2 equal to 0.831 and 0.047 wt %, respectively, for magmas of basic composition (SiO_2 <53 wt %), whereas for intermediate magmas (SiO_2 = 53 to 64 wt %)—2.271 and 0.163 wt % and for acid magmas (SiO_2 > 64 wt %) - 3.292 and 0.017 wt %, respectively. The ratio H_2O/CO_2 equals 17.7 for basic and increases remarkably (≤194) for acid magmas. Bearing in mind different abundances of these types of magma in continents, oceans, average contents of H_2O and CO_2 in magmas equal 1.555 and 0.083 wt %, respectively, for the whole continental block ($H_2O/CO_2 = 18.7$). Average contents of H_2O and CO_2 in magmas equal 1.001 and 0.056 wt %, respectively, for continents, continental margins and oceanic bottom (the ratio $H_2O/CO_2 = 17.9$). (From authors' abstract by E.R.)

NAUMOV, V.B., KOVALENKO, V.I., IVANITSKY, O.M. and SAVEL'EVA, N., 1995, Chlorine content in magmatic melts according to mineral inclusion data: Geokhimiya, no. 6, p. 798-808 (in Russian, English abstract).

Data are given on 363 determinations of Cl and main rockforming elements from homogeneous MI. It was found that the Cl contents are [significantly?] above previous estimates. Basic and ultrabasic magmas (SiO_2 < 53%) contain 0.132 wt % of Cl (average of 87 determinations within 0.00 ≤ 0.41% range); intermediate magmas (SiO_2 = 53-64%) - 0.224 wt % (average of 59 determinations within 0.00-1.20%); acidic magmas (SiO_2 > 64%) - 0.258 wt % (average of 217 determinations within 0.00-1.13%). The average Cl content of all magmatic types is estimated as 0.226 wt %. Taking into account the abundances of different magmatic types at continents it was estimated as 0.176 wt % for the continental block as a whole, whereas the average Cl content of continents, continental margins and oceanic bottom is corresponding to 0.142 wt %. (Authors' abstract)

NEDACHI, Munetomo, SHIN-YAMA, Tohru and UENO, Hirotomo, 1990, Electron probe microanalysis on fluid inclusions in quartz from the Ok Tedi mine: Science Reports, Kagoshima Univ., v. 39, p. 41-46 (in Japanese, English abstract).

Multiphase FI from the Ok Tedi porphyry Cu deposits were analyzed by electron probe microanalyzer. With increasing accelerating voltage, the accelerated electrons enter into the deeper portion and x-rays from the FI can be detected. The qualitative analysis show the existence of Na, S, Cl, K, Ca, Mn, Fe, Zn and Cu elements and is well compatible with the microscopic observations. (Authors' abstract)

NEELEY, J.M., POPE, R., GHAZI, A.M., VANKO, D.A. and BOWMAN, J.D., 1995, Elemental determination of aqueous magmatic fluid: a fluid inclusion study using flow injection ICPMS (abst.): Eos, v. 76, no. 46, p. F702.

The effectiveness of crush-leach analysis of FI was evaluated by using three different crushing media which included 18 MΩ water, a solution that contained 50 ppb Nb^{4+} in water, and a 5% HNO_3 solution. The trace elements including REE were determined by ICPMS using flow injection for sample introduction. Major cations, Na^+, K^+, Ca^{2+}, and Fe^{2+} were determined by using atomic absorption.

Samples included hydrothermal quartz, separated from altered quartz mozonites from the Bingham porphyry Cu deposit. Trace elements including REE were also determined for altered whole-rock samples. Without exception, 5% HNO_3 is the most effective leaching medium for liberating all cations, followed by the 50 ppb Nb^{4+}solution, followed by 18 MΩ water.

The REE contents normalized to chondrite values for the whole-rock samples form a narrow envelop of parallel patterns which are highly enriched in light REE $(La/Sm = 4.2)_{ave}$ and are characterized by a small negative Eu anomaly $(Eu/Eu^* = 0.8)_{ave}$. The results also show that in the F released from I, Na is the most abundant cation followed by K, Ca and Fe. The concentration of Na ranges from 10.51 ppm to 64.58 ppm, should be attributed to the presence of abundant halite dxls. The chondrite-normalized REE patterns for leachate solutions are also enriched in LREE (La/Sm = 3.17). The similarities between the REE patterns obtained for whole-rock samples and those from F released from I suggest that the F in the I is most likely magmatic in origin, exsolved from a granitic source. The less steep slope in REE patterns for F released from I suggests one or a combination of the following possibilities: (1) the chemical composition of I F represents a more primitive magmatic F exsolved prior to the solidification of the quartz monzonite host rocks, and (2) the F is a mixture, representing several generations of F. (Authors' abstract)

NESBITT, B.E., MENDOZA, C.A. and KERRICK, D.M., 1995, Surface fluid convection during Cordilleran extension and the generation of metamorphic CO_2 contributions to Cenozoic atmospheres: Geology, v. 23, no. 2, p. 99-101. First author at Dept. Geology, Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada.

Modeling of hydrogeological regimes associated with crustal extension indicate that flux values for deeply convected meteoric water are on the order of $10^{-3}\ m^3 \bullet m^{-2} \bullet yr^{-1}$. Calculated CO_2 fluxes produced by infiltration-driven, metamorphic decarbonation reactions along the circulation path are $2.4 \times 10^{-4}\ m^3 \bullet m^{-2} \bullet yr^{-1}$ or $3.8\ mol \bullet m^{-2} \bullet yr^{-1}$. Application of the model to Cenozoic extension in the North American Cordillera demonstrates that CO_2 generated in this manner may have been a major contributor to elevated CO_2 contents of Cenozoic atmospheres and the resulting global warming due to the CO_2 greenhouse effect. (Authors' abstract)

NESBITT, B.E. and MUEHLENBACHS, Karlis, 1995a, Geochemical studies of the origins and effects of synorogenic crustal fluids in the southern Omineca Belt of British Columbia, Canada: GSA Bull., v. 107, no. 9, p. 1033-1050. Author at Dept. Geology, Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada

FI and stable isotope investigations of 400+ samples of quartz ± carbonate veins and their zeolite to amphibolite grade host rocks from the southern Omineca Belt of the Canadian Cordillera have been used to determine origins, evolution, and effects of crustal F during and after orogenic activity. Correlations between FI characteristics and tectonic and lithologic features indicate that salinities and G compositions (CO_2/CH_4 ratios) are controlled by host rock lithology. High total G contents are linked to high I Th, which parallel increasing metamorphic grades.

Synthesis of the results yields a model for the hydrogeology of the brittle crust consisting of moderately high permeabilities in fractured brittle rocks with deep convection of surface, meteoric water. The maximum depth of penetration of the F is limited by the rheological brittle/ductile transition at 350 to 450°C and depths of 10 km or greater. The vast majority of veins found in greenschist and lower grades of metamorphic rocks are formed on the upflow limbs of the meteoric water convection cells. (From authors' abstract by E.R.)

NESBITT, B.E. and MUEHLENBACHS, Karlis, 1995b, Paleohydrogeology of the Canadian Rockies and origins of brines, Pb-Zn deposits and dolomitization in the Western Canada Sedimentary Basin: Reply: Geology, v. ___, p. 190.

A reply to Qing, Mountjoy, Nesbitt and Muehlenbachs, 1995, this volume. (E.R.)

NESBITT, B.E. and MUEHLENBACHS, Karlis, 1995c, Geochemistry of syntectonic, crustal fluid regimes along the Lithoprobe Southern Canadian Cordillera Transect: Can. J. Earth Sci., v. 32, no. 10, p. 1699-1719. Authors at Dept. Geology, Univ. Alberta, Edmonton AB T6G 2E3, Canada.

Research incorporated petrological, mineralogical, FI, $\delta^{18}O$, δD, $\delta^{13}C$, and Rb/Sr studies of samples of quartz ± carbonate veins and other rock types. The results of the study document a variety of pre-, syn-, and postorogenic, crustal F events. In the Rockies, a major pre-laramide hydrothermal event was identified, which was comprised of a west to east migration of warm, saline brines. This was followed by a major circulation of meteoric water in the Rockies during Laramide uplift. In the southern Omineca extensional zone, convecting surface F penetrated to the brittle-ductile transition at 350-450°C and locally into the underlying more ductile rocks. A principal conclusion of the study is that most quartz ± carbonate veins in metamorphic rocks in the southern Canadian Cordillera precipitated from deeply convected surface F. This conclusion supports a surface F convection model for the genesis of mesothermal Au-quartz veins, common in greenschist-facies rocks worldwide [see figure]. (From authors' abstract by E.R.)

Mainly literature FI data. (E.R.)

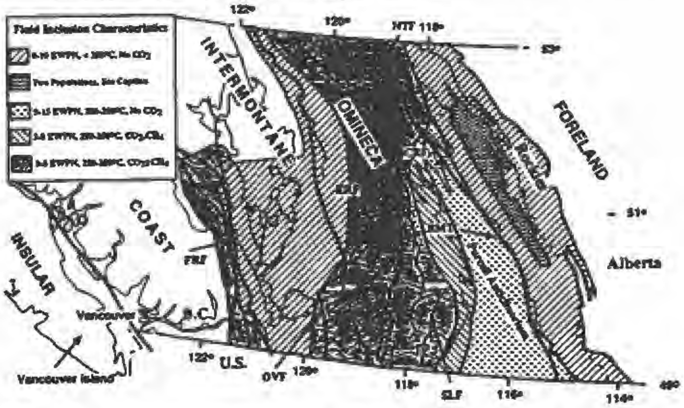


Figure 3. Regional variations in FI characteristics of quartz and carbonate veins from the southern Canadian Cordillera. EWPN denotes values are in eq. wt % NaCl. The region indicated by the pattern labeled "Two Populations" contains pre-Laramide dolomites hosting high-salinity I and syn- to post-Laramide veins with low-salinity I.

NESBITT, B.E., MUEHLENBACHS, K. and MENDOZA, C., 1995, Contrasts in paleo-hydrogeology between compressional and extensional orogens (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-313.

Studies of paleo-hydrogeological regimes in extensional (Omineca core complex) and compressional (Canadian Rockies) portions of southern British Columbia permit the comparison of pre-, syn- and post-tectonic F regimes in contrasting structural styles.

The Omineca core complex is composed of greenschist facies upper plates separated by detachment faults from amphibolite facies lower plates. Inclusion studies of veins in the upper plates indicate F T's of 300 to 400°C, salinities of 2 to 5 eq. wt % NaCl (EWPN), and $XCO_2 \pm CH_4 = 0.1$ to 0.2. Stable isotope studies indicate vein formation from F with $\delta D = -120$ to -140‰. In the lower plates, whole rock samples have been homogenized to $\delta^{18}O = 8$ to $\delta D = -120$ to -150‰. The results document widespread (100,000 km^2), homogeneous, deep (10 to 12 km) influx of meteoric F into the complex, reaching T's of 400°C. Rock permeabilities are estimated at 10^{-16} to 10^{-15} m^2 with fluxes of 10^{-3} $m^3 \cdot m^{-2} yr^{-1}$ and F P near hydrostatic. The existence of large scale circulation in extensional system can lead to concentration of metals, advection of heat, and contribution of CO_2 to the atmosphere.

In the fold and thrust belt of the Canadian Rockies, I results from synorogenic quartz-calcite veins indicate low F T's of 150 to 250°C, no CO_2 and salinities of 4 to 8 EWPN. Pre-orogenic F depositing dolomite had higher salinities of 20 to 25 EWPN. Stable isotopic results show distinct heterogeneities with δD values of -70 ± 9‰ for pre-orogenic F and -120 to -150‰ for the synorogenic F. $\delta^{18}O$ values vary from -3 to 7‰. Results from the Rockies indicate marked heterogeneities in F regimes from pre-orogenic dewatering of basinal brines to syn- to post-orogenic limited influx of meteoric F. The paleo-hydrogeology of compressional systems appears to have been dominated by spatial and temporal heterogeneities in F P (hydrostatic to lithostatic), and permeabilities, resulting in low F fluxes. Due to the heterogeneous nature of the F regimes and the lower F fluxes the economic potential and environmental impact of F systems in compressional orogens is limited. (Authors' abstract)

NEUMANN, E-R and WULFF-PEDERSEN, E., 1995, Melt inclusions in upper mantle xenoliths from the Canary Islands (abst.): Eos, v. 76, no. 17, p. S268. Authors at Mineralogisk-Geologisk Museum, Univ. Oslo, N-0562 Oslo, Norway.

Within each of the Canary Islands ultramafic xenoliths show a systematic relation between type of host rock and the composition of silicic glasses occurring as I and along grain boundaries. Glasses in xenoliths from La Palma show the following compositional ranges:

	Spinel harzburgite		Spinel dunite		Amph wehrlite
	dry	hydrous	dry	hydrous	
SiO_2	62.4-68.9	62.3-68.9	53.0-56.3	56.0-58.7	45.3-52.1
TiO_2	0.0-0.6	0.1-0.6	0.4-0.9	0.4-0.7	0.9-4.0
Al_2O_3	14.6-17.5	15.0-17.3	19.0-20.3	19.6-20.4	17.9-20.8
FeO	1.4-3.0	1.4-2.3	3.1-4.0	2.2-2.4	3.4-9.1
MgO	1.3-1.8	0.8-1.8	1.9-2.3	1.4-2.1	2.4-3.3
CaO	1.0-2.5	0.6-2.2	4.3-5.6	2.7-4.1	6.9-10.2
Na_2O	6.3-7.5	6.2-7.4	7.5-8.0	6.3-6.7	5.2-7.1
K_2O	4.4-5.0	4.4-4.9	4.6-5.1	6.7-7.2	2.5-4.1
P_2O_5	0.0-0.2	0.0-0.3	0.1-0.7	0.1-0.2	0.4-1.1

For each analyzed sample, glass I and host rock show similar TiO_2/Al_2O_3 ratios. Glasses in harzburgite and dunite xenoliths infiltrated by basaltic melts show a gradual shift from basaltic compositions (e.g., $SiO_2 \approx 40\%$, $TiO_2/Al_2O_3 \approx 0.33$) in broad veinlets, through intermediate compositions in narrow veinlets, to highly silicic ones typical of the host rock inside xenolith fragments (e.g., $SiO_2 \approx 63\%$, $TiO_2/Al_2O_3 \approx 0.03$). Experimental data show only weak fractionation of Ti relative to Al during partial melting in the upper mantle. Similar TiO_2/Al_2O_3 ratios thus strongly suggest equilibrium between glass and host rock. We interpret the observed glass-host rock correlations to reflect equilibria, and believe the silicic glasses to have formed by *in situ* partial melting. Small inter-island variations in ranges of glass compositions for the various rock types most likely reflect differences in modal relations, mineral chemistry, and/or conditions of formation. The high K_2O-contents in both dry and hydrous xenoliths from La Palma strongly suggest that phlogopite was present in all these xenoliths prior to partial melting. Glasses in spinel harzburgites and dunites from Lanzarote, where phlogopite has not been obseved, show much lower K_2O-concentrations (0.5-2.5%). (Authors' abstract)

NEUMANN, E.R., WULFF, P.E., JOHNSEN, K., ANDERSEN, T. and KROGH, E., 1995, Petrogenesis of spinel harzburgite and dunite suite xenoliths from Lanzarote, eastern Canary Islands: Implications for the upper mantle: Lithos, v. 35, p. 83-107.

We present data on petrography, mineral and whole rock major element relations and FI on ultramafic xenoliths from Quaternary to Recent alkaline basalts in Lanzarote, eastern Canary Islands. The xenoliths have been divided into two main suites: the spinel harzburgite suite (harzburgites and rare lherzolites) and the spinel dunite suite (spinel dunites and rare spinel plagioclase dunites). The spinel-harzburgite suite xenoliths from Lanzarote represent fragments of highly refractory, old suboceanic lithospheric mantle similar to that found beneath Hierro in the western part of the Canary Island chain. This mantle has been somewhat modified through a combination of melt extraction and metasomatism caused by infiltration of Fe-Ti-rich silicate melts and CO_2 F, probably in association with the formation of the Canary Islands. Also, the spinel-dunite suite xenoliths show oceanic affinities but are not directly related to the harzburgites through partial melting. T estimates combined with isochores representing the densest CO_2 I Th of -12°C in these nodules indicate a high geothermal gradient in the upper mantle under Lanzarote, 1100°C at > or = 26 km depth, and a correspondingly thinned lithosphere (> or = 27 km). This implies much hotter conditions than those expected in "normal" suboceanic lithospheric mantle of an age corresponding to that off West Africa, and hotter conditions under Lanzarote than under the western Canary Islands. A possible explanation for this is the presence of a mantle plume under the Canary Islands, which causes thermal erosion at the base of the lithosphere, whereas ascending plume melts are responsible for heating, partial melting and metasomatism in the overlying mantle. Edge effects such as small-scale convection caused by interaction between hot plume material flowing eastwards underneath the lithosphere and the continental margin of West Africa, may account for enhanced thermal erosion under the easternmost Canary Islands and recurrent volcanism. (Authors' abstract)

NEUMAYR, P., 1995, Metamorphic fluids in the Meatiq basement complex (Eastern Desert, Egypt): Evidence for a "clockwise" P-T path (abst.): Mitt. Österr. Miner. Ges., v. 140, p. 409-411 (in English). Author at Dept. Mineralogy-Crystallography and Petrology, Karl-Franzens Univ. Graz, Austria.

The structural and metamorphic evolution of the Meatiq basement complex has been a contentious issue for some time. FI have been investigated from various basement lithologies including gneisses and garnet-bearing quartz-rich schists at the structurally lowest parts, and metapelites at the structurally upper parts of the basement. Four types of FI are present in all lithologies investigated. The earliest, type 1 (H_2O-CO_2 + CH_4) occur in quartz I in peak metamorphic garnet. Type 2 (CO_2-H_2O + CH_4) and 3 (CO_2 + CH_4) I form subsequent metamorphic F with increasing CO_2 content with time. Trails of type 4 I crosscut trails of CO_2-bearing I as well as quartz grain boundaries and are interpreted to represent the last F generation.

Although type 1-3 I have distinctly different CO_2 content, microthermometric data of these I are very similar. Tm(ice) of CO_2 for type 1-3 I range typically from -56.6°C to -57.1°C in only one sample ≤-57.6°C which indicates that these I contain mainly CO_2 and only minor other G, probably CH_4. Clathrate Tm between 7°C and 10°C indicate a salt content between 0 and 6 eq. wt % NaCl for type 1 and 2 I. Th for the CO_2 phase for most type 1-3 I range from

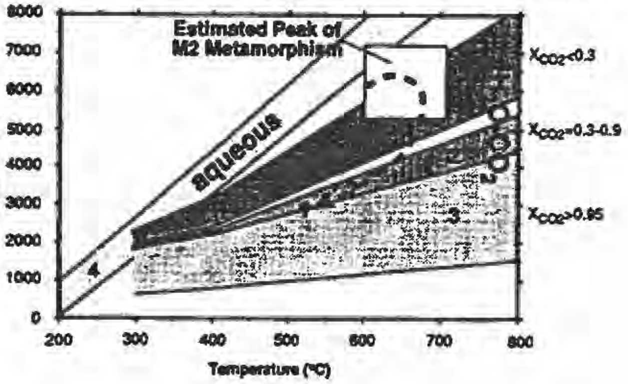


Figure 1. Isochores for the various F types in the Meatiq basement.

23°C to 31°C. Type 3 I show the lowest bulk densities between 0.5 and 0.75 g/cm^3. The highest bulk densities are recorded for type 1 I in the range 0.75 to 0.95 g/cm3. Type 2 I are intermediate with 0.65 to 0.85 g/cm^3. Tm of H_2O for type 4 aqueous I between -5°C and 0°C indicate only minor salt components of 0 to 10 eq. wt % NaCl. Th range from 150°C to 205°C.

Textural evidence suggests that type 1 I represent peak M2 metamorphic F. This is supported by isochores which pass through P-T conditions of 600-660°C and 4-7 kb which have been estimated from the M2 metamorphic peak (Fig. 1). Type 2 and 3 I represent retrograde M2 metamorphic F. The slope of the type 2 and 3 I relative to type 1 isochores indicates a clockwise P-T path for the M2 metamorphic event. Type 4 aqueous I may either represent late M2 or, more likely, M3 metamorphic F which is supported by steeper type 4 isochores compared to type 1-3 isochores. (From author's abstract by E.R.)

NEUMAYR, P., HOINKES, G. and PUHL, J., 1995, Constrains on the P-T-t evolution of a polymetamorphic Pan-African basement dome in the Central Eastern Desert (Egypt) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 316.

Three metamorphic events occurred in the polydeformed basement of the Meatiq dome. M1 is documented in migmatized amphibolite and metagabbro lenses within tonalitic gneisses in the structurally lowest parts of the dome.

Typical M2 mineral assemblages comprise Grt-Bio-Mu-Sill-Plag-Qtz + Zn-Spinel + Ilm in the metasedimentary cover sequences.

Microthermometric data of FI in quartz included in high-metamorphic grade garnets and in the quartz matrix suggest a combined low salinity H_2O-CO_2 F for the M2 metamorphic event with H_2O -rich F belonging to the peak of the M2 event. Retrograde M2 metamorphic F are increasingly CO_2-rich. The location of the isochores supports a clockwise P-T path during M2. (From authors' abstract by E.R.)

NEUROTH, G. and KLAPPER, H., 1995, The inclusions of particles during crystal growth in potassium alum and benzophenone and its effects on the growth process (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 68.

NEWMAN, Sally and STOLPER, Edward, 1995, H_2O and CO_2 in back-arc basin basalts from the Scotia Sea (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-75. Authors at Div. of Geological and Planetary Sciences, Caltech, Pasadena, CA 91125.

We have studied glass chips from ten lavas from five dredges from the East Scotia Sea in the South Atlantic Ocean. H_2O and CO_2 concentrations were analyzed by FTIR and major elements were determined by EPMA. Additional trace and major element data for Scotia Sea samples were obtained from the literature. H_2O contents range from 0.36 wt % to 2.24 wt % and CO_2 concentrations from 0 to 240 ppm. In addition, we have studied one glassy MI from each of two lavas from different dredges. One of the MI contains nearly the same amount of H_2O as its host lava, but almost four times as much CO_2 whereas the other contains no CO_2 and almost twice as much H_2O as the host. (From authors' abstract by H.E.B.)

NEWTON, R.C., 1995, Simple-system mineral reactions and high-grade metamorphic fluids: Eur. J. Mineral., v. 7, p. 861-881.

NIE, F.-J. and WU, C.-Y., 1995, Gold deposits related to alkaline igneous rocks in the North China Craton, People's Republic of China, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 173-176. Authors at Inst. Mineral Deposits, Chinese Acad. Geological Sciences, Beijing, PRC.

Recent discovery of the Dongping, Wulashan, Guilaizhuang and Shuangwang Au deposits brings a break-through of a new type of Au deposits in China. All these deposits are related in space and time to alkaline igneous complexes that formed during the Hercynian and Yanshanian orogenies. Au is confined mainly to quartz-K-feldspar veins and/or K-feldspar veins and albitite lenses. Results show a direct link between Au metallogeny and alkaline magma rich in volatile components. Alkaline igneous complexes are well developed within the North China Craton or along its marginal deep-seated faults. Consequently, these alkaline igneous rocks deserve particular attention during mineral exploration and metallogenic studies. (Authors' abstract)

FI and isotope (O, H and S) studies indicate that Au was deposited at 280° to 360°C and 1.5 to 3 kb from an ore F poor in CO_2 (<6 mol %) and of moderate salinity (~3 or 4% NaCl eq.). (From authors' text by E.R.)

NIEDERMAYR, Gerhard, 1995, Inclusion phenomena in quartz: Mineralien-Welt, v. 6, no. 4, p. 15-16 (in German).

NIELSEN, R.L., 1995, Estimating the volumetric proportions of parent magmas using information from melt inclusions (abst.): Eos, v. 76, no. 17, p. S267. Author at COAS, Oregon State Univ., Corvallis, OR 97331.

One of the basic questions regarding MORB petrogenesis is the identity, diversity and volumetric proportions of MORB parent magmas as a function of space and time. Most models of MORB genesis involve the production of diverse melts in a melting regime characterized by a wide range of T and % melting. Characterization of MORB parent magmas is complicated by the fact that many MORB magmas are products of fractionation and mixing. One method for approaching this problem is to investigate the composition of MI trapped in primitive phenocrysts. Our results, derived from re-homogenized MI from single samples dredged from the Gorda and Juan de Fuca Ridges, exhibit a range of composition greater than the entire ridge.

If we assume that M are trapped in proportion to their volume, we can use the frequency of MI to estimate the volumetric proportions of the primitive magmas in the lower crust. The relationship between the MI and the host can be determined using phase equilibria constraints. For all the samples studied to date, the shape and range of composition of the frequency distribution is related to the composition of the host. The distribution is skewed toward the depleted end of the range. The I from the more depleted hosts have depleted average compositions and the most skewed distribution. More enriched samples have higher average K/Ti and a slightly less skewed distribution. The incremental products of fractional melting will produce a somewhat skewed distribution of incompatible elements, but not to the extent exhibited in the observed patterns.

This information can be used to constrain the patterns of M production, flow and sampling by comparing the frequency distributions with predicted patterns. In addition, the effectiveness of mixing and order of mixing and fractionation in the crustal conduit system can be evaluated by comparison of the MI diversity with the observed range of erupted lava compositions. Our results indicate that Gorda ridge magmas represent preferential sampling of the central, depleted part of the melting regime. (Author's abstract)

NIELSEN, R.L., CHRISTIE, D.M. and SPRTEL, F.M., 1995, Anomalously low sodium MORB magmas: Evidence for depleted MORB or analytical artifact?: Geochim. Cosmochim. Acta, v. 59, p. 5023-5026. Authors at College of Oceanic and Atmospheric Sciences, Oregon State Univ., Corvallis, OR 97331.

One common characteristic of quenched natural basaltic glass is the presence microcrystalline halos surrounding many microphenocrysts (spherulites). From our investigations of the composition of' basaltic glasses in both quenched lavas and in plagioclase-hosted MI, we have discovered that quench halo portions of spherulites are >100 times as susceptible to Na loss during microprobe analysis than normal basaltic glass. This implies that there may be a significant negative bias in published MORB glass Na contents. This, in turn, would result in potential systematic errors in existing models of MORB petrogenesis that are dependent on those data. (Authors' abstract)

NIELSEN, R.L., CRUM, Jennifer, BOURGEOIS, Rene, HASCALL, Kaylea, FORSYTHE, L.M., IFSK, M.R. and CHRISTIE, D.M., 1995, Melt inclusions in high-An plagioclase from the Gorda Ridge: An example of the local diversity of MORB parent magmas: Contrib. Mineral. Petrol., v. 122, p. 34-50. First author at Dept. Geosciences, Oregon State Univ., Corvallis, OR 97331.

The use of ocean floor basalt chemistry as a tool to investigate mantle composition and processes requires that we work with basalts that have been modified little since leaving the mantle. One source of such basalts is MI trapped in primitive crystals. However, obtaining information from these MI is complicated by the fact that MI in natural basalts are essentially always altered by post-entrapment crystallization. This requires that we develop techniques for reconstructing the original trapped L compositions. We conducted a series of experiments to reverse the effects of post-entrapment crystallization by reheating the host crystals to their crystallization T. For these experiments we used plagioclase crystals separated from a single Gorda Ridge lava. The crystallization T for these crystals was determined by a set of incremental reheating experiments to be ~1240-1260°C. The I are primitive, high Ca-Al basaltic M, saturated with plagioclase, olivine and Al-rich chromite at low P. The I analyses can be linked to the host lava composition by low P fractionation. The major element composition of the rehomogenized MI within each crystal is relatively constant. However, the incompatible element analyses have extremely wide ranges. (From authors' abstract by E.R.)

NIIMI, N., TAMURA, H., AIKAWA, N. and SHINODA, K., 1995, The observation of the change of IR spectra of water in fluid inclusions at high temperature (abst.): Ann. Mtg. Min. Soc. Japan, 1995, *in* Mineral. J. (Japan), v. 17, no. 8, p. 386-386 (in English).

The change of the high-T infrared spectra of H_2O in FI has been investigated. As the T rises, infrared absorption spectra of H_2O shift to the high frequency side and rapidly reduce their absorbances. Though the highest frequency side of the spectra does not change ≤300°C, the new absorption spectra appear in the range 3700-3740 cm^{-1} at T above the critical conditions of H_2O. These results are due to the decrease of the degree of the H bonds between the H_2O molecules. The bulk H_2O at room T consists of H_2O multimers, whereas the supercritical H_2O mainly of monomer and dimer. (Authors' abstract)

NIKITINA, L.P., 1993, Co-ordinated system of thermometers and barometers for basic and ultrabasic rocks, and reconstruction of thermal regimes in the mantle according to xenoliths in kimberlites: Zapis. Vses. Mineral. Obsh., v. 72, no. 5, p. 6-x (in Russian, English abstract).

Equilibrium T and P for garnet lherzolite xenoliths from Yakutian and South African kimberlites are calculated on the basis of concordant system of geothermombarometers for ultramafic and mafic rocks. Thermal regimes of mantle beneath East Siberian and Kaapvaal kratons at the time of kimberlite formation were similar, and the thermodynamical gradients (dT/dP) increased from central part to marginal one of these structures. (Author's abstract)

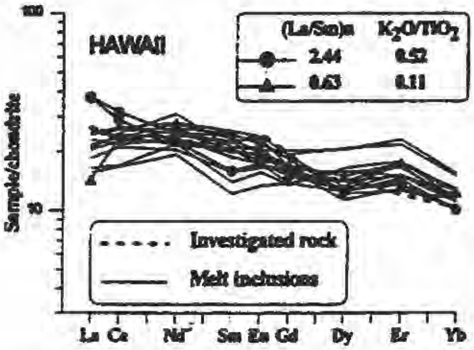
NIKOGOSYAN, I.K. and SOBOLEV, A.V., 1994, Liquid immiscibility phenomena in magmas from the islands of Hawaii (Pacific Ocean) and Réunion (Indian Ocean): Dokl. Ross. Akad. Nauk, v. 338, no. 2, p. 214-218 (in Russian).

Gives compositions of immiscible sulfide I (some high in Cu and Ni) and of high-Fe and low-Fe immiscible silicate L. (E.R.)

NIKOGOSIAN, I.K. and SOBOLEV, A.V., 1995, Significant geochemical variations and mixing of parental magmas within single volcanic suites of Mauna Loa (Hawaii) and Piton des Neiges (Reunion) (abst.): Eos, v. 76, no. 17, p. S269-S270. Authors at Vernadsky Inst. Geochemistry, Kosigin St. 19, Moscow 117975, Russia.

The data for MORBs show very significant variations in incompatible element concentrations in parental magmas found in the single samples as I in high-Mg olivine phenocrysts (Sobolev and Shimizu, Mineral. Mag., 85A, 1994). These variations and presence of ultra-depleted M suggest near fractional melting regime and common magma mixing under oceanic spreading centers. In this paper we report similar data for within plate environment from typical mantle plumes: Hawaii and Reunion.

MI in high-Mg olivine phenocrysts (Fo_{89-85}) from two picritic samples from Mauna Loa, prehistoric series (Hawaii) and from Piton des Neiges transitional series (Reunion) were studied in high T optical heating stage. The compositions of homogenized and quenched MI were analyzed by electron and ion microprobes. The observed ranges for highly to moderately incompatible elements ratios (K_2O/TiO_2, La/Sm, etc.) in MI significantly exceed typical variations of the same values for glasses and rocks from both Mauna Loa and Piton des Neiges. However, the majority of I fall within typical ranges. These data argue for abundant magma mixing and relatively efficient element fractionation during melting. However, compared to MORB samples studied with similar statistics (Sobolev and Shimizu, 1994), the observed variability for within plate primitive M was found to be significantly smaller. This may suggest that integration processes like M percolation or mixing are more abundant in plume related mantle than under mid-oceanic ridges. (From authors' abstract by E.R.)



NIU, Hecai and LIN, Chuanxian, 1995, Study of the fluid-melt inclusions in fluorite: Geol. Rev. (Dizhi Lunping): v. 41, no. 1, p. 28-33. Authors at Guangzhou Branch, Inst. Geochemistry, Acad. Sci., Guangzhou, PRC (in Chinese, English abstract).

Many F-MI have been found in fluorite formed in the early stage of the aegirine-augite-barite pegmatite veins in the Mianning REE ore deposit, Sichuan Province. The optical and laser-Raman spectral characteristics of minerals indicate that barite is the crystallized mineral in the F-MI. The Th of the F-MI in fluorite range from 493.7°C to 502.3°C and the capture [trapping] T is higher than that. This proves that the host mineral fluorite is formed by direct crystallization of the salt-melt which is dominated by $BaSO_4$ and CaF_2 and rich in volatiles, and that its Tf is very high. This kind of fluorite and its associated mineral-barite show the features of magmatic origin. (Authors' abstract)

NIVIN, V.A., DEVIRTS, A.L. and LAGUTINA, Ye.P., 1994, The origin of the gas phase in the Lovozero massif based on hydrogen-isotope data: Geokhimiya, no. 12, p. 1787-1793 (in Russian; translated in Geochem. Int'l, v. 32, no. 8, p. 65-71, 1995).

The best suggestion appears to be that the G phase was formed as such in the postmagmatic stage, e.g., during changes in the composition, structural state, and purity of the rock-forming minerals, which involved the mobilization of lattice-dissolved hydrocarbons in the micropores or else the splitting of the initial homogeneous F into two phases: an essentially aqueous (L) one and a reduced gaseous one <400°C. (From authors' abstract by E.R.)

NOGUEIRA, P. and NORONHA, F., 1995, "PLANIF" a computer program FIP [for?] the study of fluid inclusion planes (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 162-163. Authors at Centro de Geologia, Fac. Ciencias Univ. Porto, 4050 Porto, Portugal.

The equipment developed aims to characterise the features of FIP (fluid inclusion planes). The version of the software here presented can analyse most features, the exception being the dip of the planes.

The study of FIP is performed in oriented thick sections. A microscope with a video camera attached is required. This video camera produces images in the format NTSC or PAL, and the signal is read by a video frame grabber attached to the main board of the computer. This board transforms the analogic signal into a digital signal interpreted by the computer as an image (the same as the observed in the microscope field). The user also needs to have a computer (IBM PC type) with Windows Version 3.0 or later, and the program PLANIF. This computer program permits the user to acquire a more precise knowledge about the F circulation pathway at microscopic scale, obtaining reliable quantitative and qualitative data about it. (From authors' abstract by E.R.)

NOKOV, S.L. and CHRISTOVA, J.S., 1994, Microthermometric investigations on the adular-sericite type of ore mineralization in the Gaberovo deposit, Madjarovo ore field: Rev. Bulgarian Geol. Soc., v. 55, part 2, p. 29-36 (in Bulgarian, English abstract).

Microthermometric homogenization and cryometric investigations were carried out on FI in quartz, sphalerite and barite from the Gaberovo Ag ore deposit vein 6a, Madjerovo orefield. The results obtained show that the mineral deposition in the quartz-chalcedony-sulphosalt stage, which characterized the Gaberovo deposit, were achieved in system of NaCl-KCl-H_2O type with low total sal. (3.0-4.8 NaCl eq. NaCl) at 230-170°C. The physicochemical parameters of the mineralization determined and the widely displayed metasomatism define the ore formation at the Gaberovo deposit as typical for the adularia-sericite type of epithermal deposits. (Authors' abstract)

NOKOV, S.L. and MALINOV, O.K., 1993, Quartz-adularia metasomatites and molybdenum mineralization from the Madjarovo ore field (SE Bulgaria): Rev. Bulgarian Geol. Soc., v. 54, part 1, p. 1-12 (in Bulgarian, English abstract).

The Madjarovo ore field shows the characteristics of adularia-sericite type epithermal systems. Adularia occurs in strongly altered volcanic rocks close to the main faults. The special feature of the deposit is the occurrence of molybdenite and endogenetic wulfenite in these K-metasomatic zones. Th data from the quartz-adularia-barite zones are as follows: quartz 160-250°C (avg. 200°C); barite 150-240°C (avg. 195°C); sphalerite 160-210°C (avg. 190°C). (Abstract by F. Molnar)

NORONHA, F., VINDEL, E., LOPEZ, J.A., DORIA, A., BOIRON, M.C. and CATHELINEAU, M., 1995, Fluid evolution associated with W(Sn)-sulphide-quartz-vein in the Iberian peninsula (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 164-165. First author at Centro de Geologia, Fac. Ciencias, 4050 Porto, Portugal.

A comparative study of P-V-T-X F evolution in different Iberian W deposits has been carried out using previous and new microthermometric studies and Raman data on the following deposits: Panasqueira, Borralha, Mirandela and MurÇós (Portugal) and several deposits of Sierra del Guadarrama (SCS, Spain).

Three types of F have been distinguished:

(1) *Magmatic hypersaline aqueous fluids*: These F are represented by Lw (S) I (three-phase I including one or more solid phase (dominantly halite and/or sylvine, and unknown trapped minerals) with global homogenization to the L). ranges from 250°C to 450°C and salinity from 40 to 50 wt % eq. NaCl. These F are only present in the Guadarrama examples.

(2) *Metamorphic aquo-carbonic fluids*: This F is represented as different types of FI: (i) H_2O-NaCl-CO_2(CH_4) liquids (Lc-w or Vc-w, density 0.5/0.7) showing two-phase or three F phase at room T. CO_2 homogenizes to the V phase in the range of -4 to 30°C, TmCO_2 in the range of -64°C to -57°C, TmCl in the range of 6 to 12°C and Th in the range of 250 and 350°C (to the L phase); (ii) H_2O-NaCl-CO_2-(CH_4) V (Vc-w, density 0.2/0.3) with a dominant V phase; TmCO_2 is in the range of -62.0 to -60.0°C, Th in the range of 250 to 350°C (to V). They are only present when inmiscibility process occurred and may be found associated to the precedent type; (iii) H_2O-NaCl-CH_4-(CO_2) liquids (Lw-(c-m), density 0.7/0.8) occur as two-phase I, with a low density volatile phase displaying strong fluctuation of the CH_4/CO_2 ratio, that could be rather high, explaining the high TmCl (7/16°C) values. Global homogenization is in the range of 290-380°C.

(3) *Aqueous fluids*: This kinds of F is represented in different types of FI: (iv) Lw1 are two-phase aqueous I (Flw 0.7-0.9) and with Tm ice between -5.7 and -1.5°C corresponding to a salinity of 2.6 to 8.8 wt % eq. NaCl and moderate Th, ranging from 100-300°C; (v) Lw2 are small (<5-10 mm) biphase I (Flw = 0.9). They display higher Tm ice than Lw1, with a range -2.7 to -0.2°C corresponding to a low salinity of 0.3 to 4,7 wt % eq. NaCl. Th is in the range 90-210°C.

The reconstruction of the P-V-T-X evolution in each deposit using FI data and mineralogical constraints has been used to model the conditions of transport and deposition of the metals.The first stage of W deposition is always characterized by the presence of aquo-carbonic F, which are probably F equilibrated with metamorphic host-rocks. It is clear that the early hypersaline F observed locally are nor [not] related to the main stage of W deposition. Progressive dilution of early F yield to F compositions displaying rather low volatile contents which is dominated by CH_4 when the T is <350-400°C. The transport of W is probably related to aquo-carbonic F at P ranging from 130 to 50 MPa. Dilution and nearly isobaric T decrease, probably causing according to Dubessy et al (1987), an increase of the dielectric constant of the F, and correlatively the destabilization of neutral species may have caused the deposition of W.Presence of volatiles characterize the whole evolution until the main sulphide stage. The spatial relationships between CH_4-bearing I and the main sulphides, indicate a crystallization of these sulphides from CH_4-bearing F. (From authors' abstract by E.R.)

O'HARA, K.D., 1995, The effects of rupture and diffusion on the salinity of fault-related fluid inclusions: J. Struct. Geol., v. 17, p. 257-264. Author at Dept. Geological Sciences, Univ. Kentucky, Lexington, KY 40506.

The combined effects of fault rupture and diffusive transport on the salinity of fault-related F are addressed in the case of both an external solute source and that of rock buffered F compositions. The effects of injection of a dilute and a saline F into a fault zone, followed by diffusion, are examined in the case of both periodic and random fault rupture events. The models reproduce the large salinity variations characteristic of fault-related S FI, and suggest that correlation of salinity variations may allow reconstruction of rupture events.

These considerations suggest that large salinity variations and high F concentrations common in S FI associated with retrograde shear zones may be due to the combined effects of diffusion and rock buffering reactions in the fault zone. (From author's abstract by E.R.)

O'REILLY, C., GALLAGHER, V. and FEELY, M., 1995, Characterization of fluid inclusions in W-Sn-sulphide mineralization hosted by Caledonian microtonalites on the SE margin of the Leinster granite, Ireland (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 166-167. First author at Dept. Geology, Univ. College, Galway, Ireland.

Scheelite mineralized microtonalite dikes occur on the SE margin of the end-Caledonian Leinster Granite in SE Ireland. Scheelite, cassiterite and sulphides occur in veins in the microtonalites, disseminated throughout the greisened microtonalite dikes and in the adjacent wallrocks. Two major vein types occur in the microtonalite dikes:

(1) Scheelite ± arsenopyrite ± pyrrhotite occur in quartz-fluorite veins with no muscovite selvage

(2) Cassiterite ± sphalerite ± stannite ± chalcopyrite ± pyrite ± galena occur in quartz-fluorite veins with a coarse muscovite selvage and are often intergrown with the muscovite.

Quartz-hosted FI were examined from representative samples of both vein types using petrographic, microthermometric and Raman spectroscopic techniques. Three distinct types of FI have been recognized. Primary, V-rich Type 1 inclusions in quartz from the scheelite mineralized veins are of H_2O-CO_2-CH_4-N_2-NaCl composition. These I are noteworthy in that clathrate melting occurs after homogenization of the volatile-phase. All such I so far examined decrepitated between 300-400°C. Primary, L-rich Type 2 FI in the cassiterite ± sulphide mineralized veins are of H_2O-CH_4-N_2-H_2S-NaCl composition, homogenize to the L at ca. 260-350°C and occur as PS and SI in scheelite-mineralized veins. Secondary, dilute, low T, H_2O-NaCl FI occur in cross-cutting planes in both vein and microtonalite quartz and may be related to a regional, retrograde alteration of the microtonalites and of the Leinster Granite. (Authors' abstract; figures deleted)

OBERTHÜR, T., SCHMIDT MUMM, A., VETTER, U., WEISER, T., AMANOR, J.A. and BLENKINSOP, T.G., 1995, The Ashanti Goldfields mine at Obuasi in Ghana: A metallogenic model based on mineralogical, geochemical, fluid inclusion and structural data (abst.), *in* T.G. Blenkinsop and P.L. Tromp, eds., Sub-Saharan Economic Geology: Geol. Soc. Zimbabwe Spec. Pub. 3, p. 291-292.

OGRYZLO, P.L., 1995, Hearne Hill, British Columbia, Canada: Collapse brecciation in a continental volcano-plutonic arc: Unpub. Masters thesis, Univ. Regina, Regina, SK, Canada, 221 p.

The Hearne Hill breccia is a chalcopyrite- and dolomite-cemented breccia pipe contained within a low-grade classic porphyry Cu-Au deposit associated with a Tertiary continental magmatic igneous suite. FI geothermometry indicates that stockwork mineralization in the Hearne Hill porphyry Cu deposit formed at a minimum depth of 4 ± 1 km from highly saline hydrothermal brines. Th in complex FI in quartz grains range from 164.5°C to >600°C, with salinities of 40-60%. The Hearne Hill breccia pipe contained within the porphyry Cu deposit formed at a minimum depth of ~100 m from dilute epithermal F. Th average 172.5°C, with salinities of 2-10%. It is proposed that faulting occurred before the cessation of magmatic and hydrothermal activity on the exposed root of the deposit. The circulation of highly corrosive hydrothermal brines resulted in solution, withdrawal of support and subsequent collapse to form the Hearne Hill breccia pipe. (From author's abstract by E.R.)

OHBA, Takeshi, KAZAHAYA, Kohei and MATSUO, Sadao, 1995, Diffusional ^{18}O loss from inclusion water in a natural hydrothermal quartz from the Kaneuchi tungsten deposit, Japan: Geochim. Cosmochim. Acta, v. 59, p. 3039-3047. First author at Kasatsu-Shirane Volcano Observatory, Tokyo Inst. Technology, 641-36 Kasatsu, Gunma 377-17, Japan.

In hydrothermal quartz from the Kaneuchi tungsten deposit of Honsyu island, Japan, the smaller P FI have the lower $\delta^{18}O$ values. This correlation is well accounted for by a quantitative model based on (isotropic or anisotropic) ^{18}O diffusion through quartz. The model yields a room T ^{18}O diffusivity that is close to the extrapolated diffusivity of water molecules measured by Cordier et al. (1988) but much higher than the extrapolated diffusivity of structural O measured by Farver and Yund (1991). The observed correlation between the size of P FI in quartz and their $\delta^{18}O$(water) is thus well explained by relatively fast diffusion of O as water molecules. (Authors' abstract)

OHNENSTETTER, Daniel and BROWN, W.L., 1995, Compositional variation and water contents in interstitial and included glasses in boninites (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-77. Authors at CRPG-CNRS, BP 20, 54501 Vandœuvre-lès-Nancy Cedex, France.

Interstitial glasses and glasses included in phenocrysts in 14 boninites from New Caledonia, the Mariana Trench, Cape Vogel and Chichi-jima were analyzed by electron microprobe and the water contents measured by ion microprobe. The glasses are fresh and abundant (up to ~90 vol %), and phenocrysts are often skeletal with glass I. ~1000 broad-beam analyses of interstitial glasses and ~180 point analyses of glass I were carried out, as well as ~90 H analyses. Most glasses have low MgO and total iron, and are quartzofeldspatic in composition. The interstitial glasses from New Caledonia, the Marianas and most glasses from Chichi-jima are dacitic, those from Cape Vogel straddle dacitic and andesitic compositions, whereas the glasses in highly glassy sample from Chichi-jima are high-Mg andesitic or boninitic with ≤~9 wt % MgO, the most Mg-rich glasses so far described in boninites. Glasses included in orthopyroxene, olivine or clinoenstatite are boninitic or high-Mg andesitic in the highly glassy rock and dacitic to high-silica dacitic in the others. They are in general slightly more differentiated than the interstitial ones, because of crystallization on the walls of the host crystal in small I. The interstitial glass compositions show inverse relationships between silica and CaO, FeO and MgO, and a broad spread in values of the alkalis and TiO_2. Included glasses show similar compositional variations.

Water contents in interstitial glasses are ~1-1.5 wt % for the highly glassy high-Mg andesitic glasses from Chichi-jima, ~4-6 wt % for the more differentiated andesitic to dacitic glasses from Cape Vogel and the Marianas and in the more highly crystallized rock from Chichi-jima, and finally ~5-7 wt % in the most differentiated dacitic ones from New Caledonia. Water contents in glass I in clinoenstatite, orthopyroxene and olivine are in the range ~2-4 wt %. The interstitial glasses are not vesicular, showing that the liquids were not saturated on eruption on or near the sea floor, or insufficiently so to allow nucleation of water bubbles. The water is inferred to be primary and to increase from high-Ca through low-Ca type 3 to type 1 boninites, i.e., inversely with the CaO/Al_2O_3 ratio or directly with the solubility in the melts and with the refractory nature of the inferred mantle source. (Authors' abstract).

OHTANI, T., SASADA, M. and MATSUNAGA, I., 1995, Analysis of healed microcracks in granite from borehole HDR-3 in Hijiori area, Yamagata Prefecture (abst.): Abstracts (FIR) of 1995 Annual Mtg., Geothermal Research Soc. Japan (in Japanese).

The orientation analysis of healed microcracks in Cretaceous granite in Hijiori area was determined to estimate the stress orientation. We observed three preferred orientations of healed microcracks: (a) NE-SW, NW-shallow dipping; (b) NE-SW, SE-shallow to moderate dipping; (c) NW-SE, steeply dipping. As (c) is concordant with the present stress orientation deduced other methods (NEDO, 1992), (c) might be formed during present geothermal event. (a) and (b) might be formed past. (Authors' abstract, translated courtesy the author)

OJALA, V.J., 1995, Structural and depositional controls on gold mineralisation at the Granny Smith mine, Laverton, Western Australia: PhD thesis, Univ. Western Australia, 184 p.

The Granny Smith Au deposits (49 t contained Au) are situated 23 km south of Laverton within a greenstone sequence in the NE Goldfields Province of the Archaean Yilgarn Block. The deformation history of the area is similar to that elsewhere in the Province, with main Au mineralisation associated with D3, that is, mainly reactivation of earlier structures. The mine sequence consists of a steeply to moderately dipping sequence of turbiditic metasediments and banded Fe formations and the small, post D2, 2665 ± 4 Ma, elongate composite and zoned Granny Smith Granodiorite that crystallised at a P of ~1 kb. Au mineralisation is along a reactivated N-S striking, 45° dipping thrust which wraps the granitoid intrusion, along the faulted granitoid-sediment contact, and within the granitoid intrusion. In the granitoid, mineralisation is in conjugate carbonate-quartz veins and sericite-carbonate alteration haloes. In sedimentary rocks, it is along faults and veins that are subparallel to bedding. Breccias are common in the best mineralised areas adjacent to the contact. Pyrite is the main sulphide phase. In the granitoid, fracture orientations indicate a heterogeneous local stress field, with most marked variations where the contact is irregular. Three-dimensional stress modeling reproduces field stress observations well, and also models the most strongly mineralised areas as the most dilational.

Syn-Au mineralisation FI in quartz veins are low salinity CO_2-H_2O-NaCl ± CH_4 I with variable L/V ratio. Inclusions in the proximal alteration zones have higher XCO_2 and lower salinities than those from distal zones. Calculated trapping P range from 0.5 kb in distal parts of the deposit to 2-3 kb in the proximal parts. Nahcolite (Ts = 80-250°C) is a common dm, and indicates slightly alkaline conditions. The proximal high XCO_2 F is suggested to be a result of phase separation at depth. This F mixed with a cooler, relatively saline aqueous F at the deposit. H and C isotope compositions of alteration minerals and FI support models of mixing of deeply sourced and meteoric or connate waters. A small variation in O isotope values probably indicates a buffering effect of the wallrocks on the F. Pb isotope compositions estimated from K-feldspar, galena and Pb tellurides suggest that the ore F Pb was derived from a source similar to the granodiorite, 30 Ma after intrusion.

In the preferred model, ore F evolved from the same deep source region as the Granny Smith granodiorite and focused into a regional low mean stress zone created by the gross greenstone-granitoid geometry. On a local scale, highest grade Au mineralisation developed along the irregular granodiorite contact in zones of greatest dilation under the ENE-WSW far-field stress field operating at the time of mineralisation. (From authors' abstract by Dr. John Ridley)

OJALA, V.J., GROVES, D.I. and RIDLEY, J.R., 1995, Hydrogen isotope fractionation factors between hydrous minerals and ore fluids at low temperatures: Evidence from the Granny Smith gold deposit, Western Australia: Mineral. Deposita, v. 30, p. 328-331. Authors at Key Centre for Strategic Mineral Deposits, Dept. Geology and Geophysics, Univ. Western Australia, Nedlands WA 6009, Australia.

There are no reported experimental data on H isotope fractionation between muscovite and water at low T (<400°C). A fractionation curve derived from extrapolation of the high T calibration of Suzuoki and Epstein (1976) yields 20 to 40‰ higher δD values than the empirical graphical calibration of Bowers and Taylor (1985) at T of ~300°C. Data from natural hydrothermal systems formed at ~300°C, where δD analyses are available both from FI and alteration muscovite/sericite, support the Bowers and Taylor (1985) calibration, thus indicating smaller fractionation factors at these T than suggested by extrapolations from high-T experimental results. (Authors' abstract)

OLIVER, N.H.S., 1995, Hydrothermal history of the Mary Kathleen Fold Belt, Mt Isa Block, Queensland: Australian J. Earth Sci., v. 42, p. 267-279. Author at School of Applied Geology, Curtin Univ. Technology, GPI Box U 1987, Perth, WA 6001, Australia.

Intense metasomatism occurred during all four phases due to the involvement of highly saline F, with the apparent NaCl source being the evaporitic Corella Formation rocks. In all phases, the scale over which the hydrothermal systems operated was ≥1 km, with commensurate time integrated F fluxes of the order of 10^4 m^3/m^2 or more. F infiltrating the rocks were complex $NaCl-CaCl_2-KCl-H_2O-CO_2$ brines [FI data] that may have undergone phase separation. This F flow culminated in the formation of widespread calcite vein systems (with Cu) and the Mary Kathleen U-REE vein style orebody. If the high F salinities were due to evaporite dissolution from the Corella Formation, this requires selective or non-equilibrium evaporite dissolution during the early phases of hydrothermal activity. During the later stages, when all the salt was taken up in metamorphic scapolite, the high salinities may have been derived by equilibration of retrograde F with scapolitic rocks. (From author's abstract by E.R.)

OLSEN, S.N. and FERRY, J.M., 1995, A comparative fluid inclusion study of the Waterville and Sangerville (Vassalboro) Formations, south-central Maine: Contrib. Mineral. Petrol., v. 118, p. 396-413. Authors at Dept. Earth and Planetary Sciences, The Johns Hopkins Univ., Baltimore, MD 21218.

Petrologic and O isotope data indicate that H_2O-rich F infiltrated metasedimentary rocks of the Waterville and Sangerville (formally Vassalboro) Formations, south-central Maine, during peak metamorphism, and depleted Sangerville rocks in alkalis but not equivalent Waterville rocks.

Probable pre-peak or prograde I are preserved in metasediments as the texturally earliest carbonic I which contain CO_2, CH_4, $N_2 \pm H_2O$, as determined by microthermometry and Raman spectrometry. They may have formed by breakdown of organic matter. Isochores for many of the I in both metasediments and dikes are not consistent with the inferred P-T conditions of their trapping, but intersect at ~300° to 400°C and 1 to 2 kb. The intersections probably resulted because I densities continued to equilibrate during uplift and cooling until quartz became rigid. The present densities are those at the last equilibration, not the time of trapping. In contrast, the clear distinctions in I compositions between dikes and between dike and country rock show that the original compositional differences generally have been preserved. (From authors' abstract by E.R.)

ONASCH, C.M. and FARVER, J.R., 1995, Origin of cataclastic bands in Appalachian quartz arenites (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-73.

Cataclastic bands are a common microstructure in well cemented Appalachian quartz arenites in a wide variety of structural settings. They consist of tabular zones 10 μm to several mm wide consisting of microbreccia. Although shear displacements of ≤1-2 mm can be demonstrated in some bands, others show only dilation associated with extensional microfractures. Most bands are flanked by zones of intense band-parallel FI planes and microveins. Crosscutting relations show microfractures formed before, during, and after development of the microbreccia texture. Patches of variably deformed, euhedrally-terminated quartz indicates significant open space existed throughout the evolution of the bands. Two-phase, aqueous FI in the quartz yield Th of 250-230°C, considerably higher than the 180-220°C indicated by conodonts and illite.

This study demonstrates the importance of extensional microfracturing in the evolution of cataclastic bands, and that shear displacement is not a prerequisite for formation of the microbreccia texture. Despite the sub-greenschist conditions, recrystallization occurred in the cataclastic zones in response to the relatively hot F present during their formation +/- shear stress. (From authors' abstract by H.E.B.)

ONASCH, C.M. and VENNEMANN, T.W., 1995, Disequilibrium partitioning of oxygen isotopes associated with sector zoning in quartz: Geology, v. 23, no. 12, p. 1103-1106. First author at Dept. Geology, Bowling Green State Univ., Bowling Green, OH 43403.

Fractionation of O isotopes during crystal growth is commonly assumed to be an equilibrium process. We present evidence here that large variations in $\delta^{18}O$ values in a zoned vein quartz crystal are the result of disequilibrium partitioning between F and crystal. In contrast, FI Th and salinities are relatively constant and show no effect of growth or sector zoning. Differences in $\delta^{18}O$ values between sectors along the same growth zone cannot result from variations in the O isotope composition of the F and strongly suggest disequilibrium partitioning of O isotopes between F and the growing crystal. The cause of this disequilibrium is believed to be due to differences in surface structure and/or growth mechanisms between nonequivalent faces. (From authors' abstract by E.R.)

ONO, Shuji and SATO, Juichi, 1995a, Gold and silver ores from the Ezuri Kuroko ore deposits, Akita Prefecture, Japan: J. Mineral., Petrol. and Econ. Geol., v. 90, no. 8, p. 268-279 (in Japanese, English abstract). Authors at Dept. Mineral Resources Development Engineering, Fac. Engineering, Hokkaido Univ., Sapporo 060, Japan.

The Ezuri Kuroko deposits are stratiform Au-Ag black ores. The ranges of Th of FI in sphalerite are 236°-283°C (breccia-like black ore), 210°-279°C (massive black ore) and 165°-230°C (coarse-grained sphalerite filling cavities in massive black ore), respectively. The FeS content of sphalerite coexisting with electrum is <0.2 mol %. Taking account of the effect of P, it is deduced from these data that Au- and Ag-bearing ores were formed in a range of ca. 240°-290°C under the condition of a high activity of S. Furthermore, it appears that Au was precipitated from $Au(HS)_2^-$ complex mainly owing to cooling and a decrease in H_2S concentration of ore-forming F caused by mixing with seawater and/or by precipitation of metal sulfides. (From authors' abstract by E.R.)

ONO, Shuji and SATO, Juichi, 1995b, Fluid inclusions in gold-silver-quartz veins from the Koryu mine, Hokkaido, Japan: J. Mineral., Petrol. and Econ. Geol., v. 90, p. 215-224 (in Japanese, English abstract). Authors at Dept. Mineral Resources Development Engineering, Fac. Engineering, Hokkaido Univ., Sapporo 060, Japan.

The Koryu Au-Ag mine consists of seven epithermal Au-Ag-quartz veins, hosted by the Miocene black mudstone.

In this study, we have determined Th and Tm(ice) of FI in quartz, and chemical compositions of some ore minerals by microprobe analyses for the interpretation of mechanism of Au-Ag deposition in the two veins (No. 1 and No. 3).

Three stages of mineralization are discriminated on the basis of brecciation and crosscutting relations in the vein, and Au-Ag deposition occurred predominantly during the middle stage. The ores ordinarily exhibit banded structure composed of quartz, ± adularia, ± clay minerals, ± carbonates, and Au-Ag and other metallic minerals (*ginguro*).

FI observed in quartz of the middle stage are two-phase and L-rich type. Th for the No. 1 vein are mainly 220°-270°C with high frequency in the range 250°-260°C. The T for the No. 3 vein are about the same as those for the No. I vein, but show higher values (250°-280°C) at 30 mL. Tm(ice) of I F for the No. 1 and No. 3 veins are from -0.4°C to -1.3°C, and from -0.5°C to -1.4°C, respectively.

Spatial variations of these Th and Tm(ice), together with the data previously reported, would indicate that the relatively CO_2-rich ore F had boiled on the way to form ore shoots. (From authors' abstract by H.E.B.)

ONSTOTT, T.C., MILLER, M.L., EWING, R.C., ARNOLD, G.W. and WALSH, D.S., 1995, Recoil refinements: Implications for the $^{40}Ar/^{39}Ar$ dating technique: Geochim. Cosmochim. Acta, v. 59, p. 1821-1834. First author at Dept. Geological and Geophysical Sciences, Princeton Univ., Princeton, NJ 08544.

Integration of the neutron energy distribution for a water-moderated reactor with the most recent cross-section data yields mean recoil energies for ^{39}K (n, p) ^{39}Ar, ^{40}Ca (n, a) ^{37}Ar, and ^{37}Cl (n, γ) ^{38}Cl (β) ^{38}Ar. In principal, these data and calculations can be used to discriminate between different models for Ar diffusion in minerals. Finally, the 11 Å mean recoil distance calculated for ^{38}Ar indicates that it is not a proxy for anion-sited excess Ar. Instead, published correlations of ^{38}Ar with excess ^{40}Ar probably reflect the degassing of fine-grained, Cl-rich I. (From authors' abstract by E.R.)

ONSTOTT, T.C., TSENG, H.Y., PHELPS, T.J. and COLWELL, F.S., 1995, Entrapment of deep-subsurface bacteria over geological time interval mechanisms and occurrences (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 312.

Indexed under FI. (E.R.)

ORGEVAL, J.J., 1995, Peridiapiric metal concentration at Bou Grine (Tunisian Atlas): Some geochemical characteristics, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 299-302. Author at Bureau de Recherches Géologiques et Minières, Orlèans, France.

Association of organic matter and ore, FI, and investigations on radiogenic (Sr, Pb) isotopes have provided the final elements for understanding the peridiapiric Bou Grine deposit, which appears to reflect a remarkable metallogenic continuity from syndiagenesis to epigenesis. (Author's abstract)

P FI in sphalerites are mainly aqueous biphase xenomorphs with a high coefficient of infill (low G phase) and a high salinity (10-17 wt % NaCl eq.) reflecting Th of ~75-100°C. Those in calcite are monophase and triphase xenomorphic I that show a gaseous phase, an aqueous phase and hydrocarbons; these I have a low salinity (0.2-0.4 wt % NaCl eq.) with Th ~50-60°C. (From author's text by E.R.)

See also FIR, v. 27, p. 103. (E.R.)

ORPHANIDIS I., PASCAL M.L., RAMBOZ C., OUDIN E. and THISSE Y., 1995, Mechanism of barite and anhydrite coprecipitation at temperatures around 400°C in the subseafloor of SW basin, Atlantis II deep (central Red Sea) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 168-169. First author at CNRS-CRSCM, 1A, rue de la Ferollerie, F 45071 Orleans Cedex 2, France.

In the SW basin of Atlantis II deep, epigenetic sulfates (mostly anhydrite) are characteristic of geyser-type discharge areas. The barite subfacies is most remarkable by its base and precious metal-content, and it is considered as a modern analog of the Meggen deposit. FI and solubility measurements have been performed in order to ascertain the T and mechanism of sulfate coprecipitation in this subseafloor setting, and to measure the Ba-content of the hydrothermal F.

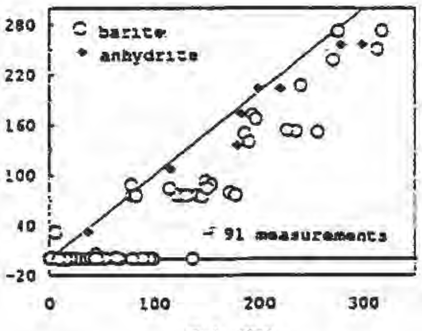


Figure 1

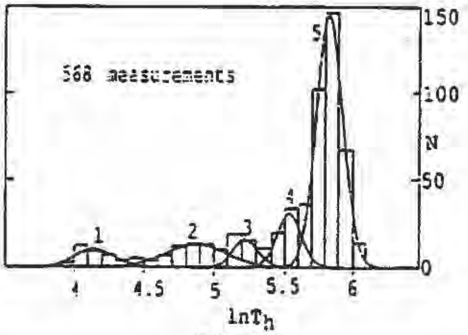


Figure2

FI data. Barite and anhydrite crystals, <2 mm-wide, from level 980, were studied without any previous preparation. FI in both sulfates were heated at a rate of 1.5°C/min and their Th was measured. These FI were then submitted to various degrees of overheating (T_{oh} = T-Th). Figure 1 shows that FI can be overheated ≤30°C, without any significant modification of Th.

Barite: Tm ice in P and PS FI range from -21.2°C to -7° and -13°C, respectively. Hydrohalite melts after ice only in P FI between -15.4° and -1.2°C (T_{mhy}). The Th to the L phase, of all FI measured in barite, vary from 53.7° to 425°C. Figure 2 shows that the Th histogram can be interpreted in terms of the addition of five populations with a log-normal distribution.

Anhydrite: All FI in anhydrite appear to be primary. Tm ice vary from -21.2° to -6.3°C. In 50% of the FI, hydrohalite melts after ice, between -5.2° and -0.3°C. All FI homogenize to the L phase between 55.7° and 393°C.

Low T processes probably correspond to F circulations in the heated sediment around the vents: High T processes mark the rapid cooling of the hydrothermal F. The Th of population 5 overlap the two-phase field boundary of the hydrothermal F at 220 bar (≈390°C). This, plus the lack of V homogenization and the absence of any oblique heterogeneous trapping trend in the Th-X plane, demonstrate that barite [repeatedly] trapped metastable superheated F with salinities increasing from 18 to 23 wt % NaCl. Anhydrite started to precipitate at and below ≈390°C, only when the F had reached a salinity of 23 wt % NaCl, by isothermal boiling in the deep reservoir. Level 980 anhydrite records neither superheating nor significant boiling.

^{18}O isotopic constraints suggest that the precipitated sulfate was not derived by oxydation of the hydrothermal F sulfide. Thus, the proposed mechanism of sulfate precipitation is the mixing of the hydrothermal end member with the interstitial brine.

Solubility data. The solubility of barite was measured by crystal weight loss at conditions relevant to those in level 980, and it was shown to be strongly prograde for salinities over 4 m NaCl. Available anhydrite solubility data in the same conditions show that its solubility is slightly retrograde. All these measurements fix the molar Ca/Ba ratio of the hydrothermal F when sulfates coprecipitate, at ≈30. Assuming that the Ca-content of the hydrothermal F is similar to that of the lower brine, the Ba-content of the hydrothermal F is calculated at ≈600 ppm. This, in turn, shows that mixing of 8 wt % of interstitial brine with this F is required to precipitate barite. Such a mixing ratio is indeed below the detection limit of microthermometry. (From authors' abstract by E.R.)

ORTEGA, L., OYARZUN, R. and GALLEGO, M., 1995, Metasediment-hosted epithermal Sb-(Au) mineralization in central Spain: Role of hidden Hercynian granitoids: Inst. Mining and Metallurgy, Trans., Sect. B, Appl. Earth Sci., v. 104, p. 80-86.

See following item. (E.R.)

ORTEGA, L., SIERRA, J., OYARZUN, R. and LUNAR, R., 1995, The epithermal Manto gold deposits from Andacollo (Chile) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 170-171. Authors at Dept. Cristalografía y Mineralogía, Fac. C.C. Geológicas, Univ. Complutense, 28040 Madrid, Spain.

The Andacollo district (northern Chile) comprises a variety of Au, Cu, and Hg deposits. FI studies were carried out in quartz and calcite from Toro, Chisperos, Churrumata and Tres Perlas. Composition of the F is mainly aqueous with dissolved salts. The absence of volatiles other than H_2O was checked by Raman analyses. Three main types of I can be distinguished in the area:

•*Type A:* low to moderate salinity, two-phase (L+V) inclusions. Th 150°-330°C and salinities of 3-11 % eq. NaCl. They are present in all the mantos.

•*Type B:* saline, two-phase (L+V) I, Th 110°-310°C and salinities of 12-17 % eq. NaCl. They are associated to quartz from manto Tres Perlas.

•*Type C:* very high salinity, both two-phase (L+V) and three-phase (S+L+V) halite-bearing inclusions. Total homogenization values occur between 110°- 250°C. Salinities range between 20-30 % eq. NaCl. They have only been found in calcite samples from the manto Toro.

Modeling the hydrothermal system

The Th show a generalized decreasing trend for all the deposits. However, higher Th values (>290°C) are restricted to mantos Toro and Chisperos which are the most distant deposits from the Andacollo porphyry. This is in open contradiction with the classic model for Andacollo, i.e., a porphyry-centered hydrothermal system. A major point to be considered is that mantos Toro and Chisperos are located within the lowest unit of Quebrada Marquesa Formation, thus suggesting a vertical rather than horizontal thermal gradient. Within such an scheme the actual heat source should be located stratigraphically beneath the manto zone. Structural and mineralogical data supports this model.

Mixing of F rather than boiling seems to be the most probable mechanism for ore deposition at Andacollo. The evolution trend (from low-, to high-salinity) may be indicating the sequential appearance of F with contrasting characteristics. It should be noted that meteoric waters circulating within the epithermal environment are expected to be very-low salinity (e.g., 1.6 % eq. NaCl in andesitic environments). A "typical" evolution trend for an epithermal system would imply progressive dilution of solutions due to increasing participation of meteoric waters. However, two facts must be considered in the Andacollo case: (1) the mantos formed within a relatively deep environment (≥2 km), and (2) the whole area was the site of massive intrusion of granitoids of batholithic dimensions from which a whole suite of shallow-seated intrusives was derived. Based on geologic and FI evidence the following working hypothesis can be proposed. F circulation would have be driven by a second porphyry or related intrusive type lying beneath the manto zone. FI population A would have formed from the initial mixing of low-salinity meteoric waters with hot brines originated within the intrusive. Even if higher degrees of mixing were attained during the process (as shown by the "hybrid" population B), as the system evolved, the brine partially displaced the descending meteoric waters. This eventually would have led to formation of population C. Under these conditions, Au and sulphide precipitation can be explained in terms of progressive cooling and oxidation of the system during the interaction of descending (meteoric) and ascending (saline) F. (From authors' abstract by E.R.)

ORTEGA, Lorena and VINDEL, Elena, 1995, Evolution of ore-forming fluids associated with late Hercynian antimony deposits in Central/Western Spain: Case study of Mari Rosa and El Juncalón: Eur. J. Mineral., v. 7, p. 655-673. Authors at Dpto. Cristalografía y Mineralogía, Univ. Complutense, 28040 Madrid, Spain.

Located in Central-Western Spain, the late Hercynian Mari Rosa and El Juncalón vein-type Sb deposits are spatially related to Late Carboniferous/Early Permian granitoids. At Mari Rosa, the following hydrothermal stages are recognized: (1) arsenopyrite-(pyrite), (2) stibnite-Au; and (3) pyrite-(pyrrhotite-galena-sphalerite-chalcopyrite-tetrahedrite-boulangerite-berthierite-stibnite-ullmannite-cobaltite). Only the second stage is of economic importance, containing massive stibnite. El Juncalón is characterized by a simple mineral paragenesis composed of stibnite with very minor pyrite. Au is associated with stibnite, which contains ≤30 ppm Au at Mari Rosa and ≤0.4 ppm Au at El Juncalón.

F associated with ore deposition lie in the H_2O-NaCl-CO_2-CH_4-N_2 system, but CO_2 is absent in the El Juncalón mineralized rocks. The F cooled progressively, from initial circulation T close T 400°C in the early stages to T of ~150°C in the late episodes. The F composition evolution is also characterized by a progressive increase in the overall water content of the F and by an increase in the relative proportions of N_2 with respect to CH_4 and CO_2 in the volatile fraction. At Mari Rosa, massive stibnite deposition resulted from a boiling process at 300°C and 0.9-1 kb. Unmixing of the F was induced by sudden P drops associated with dilational jogs during low-angle fault movements. Cooling of the F is recognized as the driving mechanism for stibnite deposition at 250°-270°C and 50-300 bars at El Juncalón. (Authors' abstract)

See previous item. (E.R.)

ORTOLEVA, P., AL-SHAIEB, Z. and PUCKETTE, J., 1995, Genesis and dynamics of basin compartments and seals: Am. J. Sci., v. 295, p. 345-427. First author at Dept. Chemistry and Geological Sciences, Indiana Univ., Bloomington, IN 47405.

Observations and geochemical modeling studies confirm and extend the proposition by Powley and Bradley that the deeper parts of a sedimentary basin can be divided into hydraulically isolated compartments. A host of compartmentation phenomena on [various scales] exist. These diverse phenomena have been observed in the Anadarko basin and analyzed using F P-depth data, well logs, petrologic analyses of cores, optical and photo-illuminescent petrography, and isotopic and FI data. (From authors' abstract by E.R.)

ORUZINSKY, V., KNESLOVA, A., JULENYOVA, E., ZLOCHA, M., RAJNOHA, R. and ANTAL, B., 1994, Indications of impregnation Au mineralization in Razdiel block of Tribec Mts., Western Carpathians: Mineralia Slovaca, v. 26, p. 29-29 (in Slovak, extended English abstract). First author at Dept. Economic Geology, Comenius Univ., 842 15 Bratislava, Slovakia.

Silicified rocks of jasperoid character are present at the tectonic contact of Triassic quartzites and dolomites in the Razdiel block of Tribec core mountain range. This complex study suggests unambiguously that this region could fulfill basic prospecting criteria of impregnation Au mineralization in carbonate rocks (Carlin type). Atmoaurometric measurements have shown anomalous Au concentrations (30-170 ng/m^3) at the tectonic line separating quartzites from dolomites. According to silicate and spectral analyses jasperoids have, in contrast to dolomites, increased contents of Au, Cr, Cu, Pb and also some Mo and V. On the basis of a detailed FI study in quartz, it can be concluded that the hydrothermal system at this tectonic contact had a considerably dynamic character and was boiling. F of low average salinity (2.6 wt % NaCl eq.) and low density (~0.87 to 0.9 g/cm^3) hydrothermal F caused mass silicification of carbonate rocks, the final products having been jasperoids. The low P (10 to $20 \cdot 10^5$ Pa) and T (170-240°C) indicate that the processes of silicification took place in near-surface epithermal conditions. (Authors' abstract)

OSBORNE, Mark and HASZELDINE, R.S., 1995a, Reply to a discussion of 'Evidence for resetting of fluid inclusion temperatures from quartz cements in oilfields' by Osborne and Haszeldine (1993): Marine and Petroleum Geol., v. 12, p. 561-565. Authors at Dept. Geology and Applied Geology, Glasgow Univ., Glasgow G12 8QQ, UK.

Walderhaug rejects the hypothesis that FI in authigenic quartz can be reset during burial, as advocated in Osborne and Haszeldine (1993). His arguments against resetting can be summarized as follows:

(1) The rate at which quartz cements precipitate in sandstones is controlled by a rise in T (Walderhaug, in press). Hence during rapid subsidence, low T I may not have time to form because the rate of quartz cementation at <120°C is very slow. In deeply buried samples which have the most rapid early subsidence histories, only high T I should be present. Shallow buried samples will have had slower subsidence histories and should contain lower T I. Hence an increase in Th with depth is a product of the differences in subsidence rate and is not evidence for the resetting of Th to present day T.

(2) Inclusions from quartz cements inside early diagenetic calcite concretions have slightly cooler Th than quartz cements from outside concretions, suggesting that the I have not been reset through time.

(3) If I are reset there should be a correlation between Th and I volume, but this has not been seen in samples from the Norwegian North Sea. In addition, the Th of very small I may be underestimated due to problems with optical resolution of the V bubble. (From authors' abstract by E.R.)

Each of these arguments is then critically examined. (E.R.)

See also Walderhaug (1995), this volume. (E.R.)

OSBORNE, Mark and HASZELDINE, R.S., 1995b, Reply to a discussion of 'Evidence for resetting of fluid inclusion temperatures from quartz cements in oilfields' by Osborne and Haszeldine (1993): Marine and Petroleum Geol., v. 12, p. 570-575. Authors at Dept. Geology and Applied Geology, Glasgow Univ., Glasgow G12 8QQ, UK.

Worden et al. have commented on fundamental aspects of our paper (Osborne and Haszeldine, 1993). In this, we proposed that FI T measured from diagenetic quartz in oilfields are probably spuriously hot as they have been reset to hotter values during burial. FI Th are widely used as palaeotemperature data in diagenetic studies on oilfield reservoirs and when reconstructing the thermal history of a sedimentary basin. These data commonly lead to inferences of hot palaeotemperatures and/or large quantities of F circulation through a basin. The palaeotemperature data from FI is critical to the "hot water" paradigm. One of the main objectives of Osborne and Haszeldine (1993) was to provide a way of testing the validity of FI data from authigenic quartz. The aim was not to discredit the whole FI technique, but to encourage workers to make their interpretations more rigorous. Although we suggest that, in many instances, FI are reset to spuriously hot T, we could also perhaps expect to find instances where FI in quartz cements are not reset. This is because resetting depends on a large number of variables, including subsidence history and I size, shape, composition and location. However, in Osborne and Haszeldine (1993) correlations were observed between Th and I size, shape, composition and present day depth of burial, which suggested that some, or possibly the majority, of FI occurring in authigenic Brent Group quartz had indeed been reset. Worden et al. Attempt to provide alternative explanations for the above observations. This reply critically examines each of their assertions. (Authors' abstract)

See also Walderhaug (1995), this volume. (E.R.)

OXTOBY, N.H., MITCHELL, A.W. and GLUYAS, J.G., 1995, The filling and emptying of the Ula Oilfield: Fluid inclusion constraints, *in* J.M. Cubitt and W.A. England, eds., The Geochemistry of Reservoirs: Geol. Society [London] Special Pub. No. 86, p. 141-157. First author at BP Exploration Operating Co. Ltd, BPX Technology Provision, Chertsey Road, Sunbury on Thames, Middlesex, TW16 7LN, UK.

The Norwegian sector Ula Field contains 430 million barrels of oil reserves trapped in a dip-closed Upper Jurassic sandstone reservoir and has multiple oil-water contacts (OWCs). Historically, the depth to the contacts has been the subject of some debate and development drilling has now proven the existence of at least six. The precise nature of some of these contacts remains uncertain because all were discovered after production start-up and determination of their origin is critical to future field development. The relationship of oil I abundances to OWCs and rock properties (porosity, permeability) has been evaluated (a) to gain an insight into the filling history and mechanisms, and (b) to attempt to define pre-production OWCS. Oil I abundances decrease with depth and towards present OWCs in Ula, but oil I also occur below them. They indicate that Ula filled from the crest down, and that the filling was synchronous with cementation to at least 3500 m subsea. Below this depth, cementation appears to have reduced permeability to such an extent prior to charge that the resulting filling geometry was irregular. Local abundance peaks within the oil column correlate with the tops of coarsening-upward cycles. Rare oil I below the oil legs may represent either migration pathways updip from the source or invasion downdip from the main oil leg along high permeability zones. Oil I persist to greater depths in the east and SE of the field which indicates that oil charged the field from these directions. A number of models explaining the variability of the OWCs have been ruled out by this work, thereby reducing the uncertainty in field development planning. (Authors' abstract)

PAGEL, M., BLANC, P., DEMARS, C. and SAVARY, V., 1995, Spectral analysis of the cathodoluminescence of detrital and authigenic quartz in sandstones (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 198-199.

Cathodoluminescence use was illustrated by several examples concerning sandstone oil-free (Ardéche margin, GPF program) and oil-bearing (Alwyn area, North Sea) reservoirs and U deposits (Oklo-Gabon)

The main points developed are:

(1) In the Alwyn area, the absence of the 330-340 nm peak is related to the low salinity of the silicification F. The healed microfractures containing hydrocarbon and aqueous I are observed in the detrital quartz grains. The migration time of hydrocarbons is deduced from the textural analyses and cathodoluminescence spectra. A hydrocarbon migration before silicification is evidenced.

(2) In the Ardéche margin, the FI indicate that the quartz overgrowth precipitates at T as low as 50°C ≤80°C. A peak at 330 nm is related to the evaporitic environment in the Triassic.

(3) Around natural fission zones in the Oklo area, the F circulation path is detected by past alpha irradiation without U presently observed. The luminescence in the U.V. range is enhanced in the irradiated zone.

The textural cathodoluminescence study of sandstone with the spectral analysis is a powerful approach in order to decipher the F pathway history in sedimentary formations. (From authors' abstract by E.R.)

PALAU, J., ARCOS, D., DELGADO, J. and SOLER, A., 1995, Gold-bearing metasomatic bodies related to the Hercynian plutonism in the Marimanya area (Central Pyrenees, Spain), *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 493-496. First author at Servi Geològic de Catalunya, Inst.. Cartogràfic de Catalunya, Spain.

Geothermometric and geobarometric data indicate that the Aurenere Au-bearing skarn mineralization took place at ~3 kb and 510 ± 40°C. FI data is not conclusive to clarify the origin of the metasomatic F. This could be related to an unmixing process from a single F or to the mixing of two F with different composition. C and O isotope data of calcites from skarn marbles range from $\delta^{18}O = 19.4$ to 13.1‰ and $\delta^{13}C = 1.6$ to -8.4‰. The variation has been modeled by an isotopic exchange process between Devonian limestones and a F of magmatic origin between 500-350°C. The ^{18}O and ^{13}C depletion around the skarn indicate that the metasomatic F circulated from the dike contact towards the country rocks, preferentially through interstratum porosity. S isotope data from $\delta^{34}S_{fluid} \approx 1‰$ suggest a S of magmatic origin or equilibrated with a magma. (From authors' abstract by E.R.)

PAN, Jiayong, ZHANG, Qian, ZHANG, Baogui, HONG, Duhao and LI, Shiyun, 1995, A geochemical study of fluid inclusions in minerals from the Chadong silver-gold deposit in western Guangdong Province: Acta Mineralogica Sinica, v. 15, no. 1, p. 47-54 (in Chinese, English abstract). First author at Inst. Geochemistry, Chinese Acad. Sci., Guiyang 550002, PR China.

The Chadong deposit is a typical polymetallic deposit in western Guangdong Province. FI studies of minerals show that the Th (160-341°C), ore-forming P (2.7×10^6 - 2.43×10^7 Pa), salinity (4.1-15.9 wt % NaCl), density (0.880-0.942 g/cm^3), fCO_2 ($10^{3.7}$ to $10^{4.3}$), = ($10^{-14.50}$ to $10^{-11.67}$) [sic] and fO_2 ($10^{-45.0}$ to $10^{-35.1}$) all decreased from the early stage to the late stage of ore deposition. pH (4.70-7.07) and Eh values (-0.65 to -1.15) show that the deposit was formed in a weakly acid-neutral and strongly reducing physicochemical environment. The ore-forming F is a mixture of meteoric water and juvenile water with the latter being largely involved at the early stage of ore deposition. (Authors' abstract)

PAN, Yuanming and FLEET, M.E., 1995, The late Archean Hemlo gold deposit, Ontario Canada: A review and synthesis: Ore Geol. Rev., v. 9, p. 455-488. First author at Dept. Sciences, Univ. Saskatchewan, Saskatoon, Sask. S7N 5E2, Canada.

The Hemlo Au deposit is characterized by intensive and extensive hydrothermal alteration, including potassic alteration, calc-silicate alteration, sulphidation, and, less significant silicification, tourmalinization, and carbonatization. Field occurrence, textural relationships, quantitative P-T-X-t data from mineral equilibria, O isotope geothermometry, FI microthermometry, and U-Pb and $^{40}Ar/^{39}Ar$ geochronology suggest a protracted history of hydrothermal activity. (From authors' abstract by E.R.)

Literature FI data are used. (E.R.)

PANIAGUA, A., LOREDO, J. and GARCIA-IGLESIAS, J., 1995, Epithermal carbonate-hosted Au-Cu-Ni-Co mineralization at the Villamanin area (Cantabrian Zone, N Spain): Fluid inclusion study versus paragenetic and sulfur isotopic data (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 172-173. First author at Dept. Geología. Univ. Oviedo. E-33005 Oviedo, Spain.

The Cantabrian Zone is the outermost part of the Variscan belt in the NW of the Iberian Peninsula. In the Cantabrian Zone the post-Variscan geodynamic processes have been of little effect on its tectonostratigraphic whole, allowing preservation of the Permian paleotopographic surface in certain areas. This fact has contributed to keep several types of hydrothermal deposits related to late-Variscan deep faults, from Au-bearing skarn deposits as the deeper ones, to epithermal Hg deposits as the shallower ones. A number of these deposits can be regarded as carbonate-hosted epithermal Au deposits (Paniagua, 1993; Paniagua et al., 1993). Among them, the Providencia and Profunda mines (Villamanin, NW Spain) display a remarkably high Ni, Co, Se and U contents. The Providencia mine is the type-locality of the mineral villamaninite, (Cu, Ni, Co, Fe)(S, $Se)_2$.

The deposits occur as veins in black, bituminous limestones with evaporitic levels. Dolomitization and silicification are the most important alteration processes. The ore is mainly composed of Cu-Ni-Co-Fe sulfides, sulfarsenides and selenides, hematite others.

FI in quartz, dolomite, calcite and sphalerite of barren and ore zones have been studied. Microthermometric measurements on P FI give a high variation of T along the deposit (100-275°C) and salinities (2.5-25.0 wt. % NaCl eq., with clear evidences of other ions, such as Ca and Mg, in the F). From a general point of view, salinity increases greatly in shallower, villamaninite-rich [(Cu,Ni,Co,Fe)S_2] zones, whereas T decreases.

Several geothermometers based on the mineral assemblages present at the ore agree with the FI Th. From these results a F-rock interaction between moderately saline hydrothermal F and the Namurian limestones (involving the hypersaline facies) can be inferred. (From authors' abstract by E.R.)

See also FIR, v. 26, p. 131. (E.R.)

PANINA, L.I., 1995, Differentiation and fractionation processes of melts during formation of layered plutons of high-potassic alkaline rocks (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 174-175. Author at Inst. Mineralogy and Petrography, Univ. pr. 3, 630090 Novosibirsk, Russia.

The known layered massifs of high-potassic alkaline rocks and associated deposits of synnyrites and apatites—Synnyr, Sakun, Murun and Yaksha Massifs are situated within Siberia and are confined to the Baikal-Stanovoi rifting zone. I of melts and melt-solutions were found in all rock-forming minerals. The errors in Th were estimated as 10-15°C. Crystalline phases and I glasses were analyzed by electron microprobe. The compositions of homogenized I and glassy I were taken as compositions of initial melts. Similar compositions of I in the margins of the minerals and all I in late minerals were identified with compositions of derivative I. The composition of unheated residual glasses in partially crystallized MI were taken as residual melts.Crystallization T of minerals during formation of all rock varieties were high and corresponded to crystallization T of similar minerals in alkaline basalts. The crystallization sequence of minerals was the same and corresponded to the scheme: Ol -> cPx (1320-1190°C) <=> Mgnt -> Lc (1250-1200°C) -> Ap (1200-1180°C) <=> Bt -> K-Fsp (1180-1020°C) -> Ne, Ks (1100-850°C). Transformation of leucite into pseudoleucite aggregate occurred at 1100-900°C. A relatively high H_2O content in the melt promoted Al accumulation in magma and concentration of alkali silicates in gaseous phase and provided the transition of FeO in Fe_2O_3 and crystallization of magnetite. The derivative melt was similar to pulaskite, while deeply differentiated residual melts corresponded to nepheline and pseudoleucite syenites. They contained: 58-60 SiO_2, 21-24 Al_2O_3, 12-14 K_2O and 3 wt % Na_2O. The total content of MgO, CaO and FeO did not exceed 2-3 wt %.Accumulation of leucite crystals in the apical parts of the chamber and their further transformation into a pseudoleucite aggregate by solid-phase decay and melting provided a possibility for the formation of synnyrite deposits. The resources of apatite and synnyrite deposits directly depend on the size of magmatic chamber, its tightness, period and degree of manifestation of processes of crystal differentiation and fractionation. (From author's abstract by E.R.)

See also FIR, v. 26, p. 131, and next item. (E.R.)

PANINA, L.I. and KONEV, A.A., 1995, On the origin of lamproites of the Molbo River (western Aldan): Geokhimiya, 1995, no. 3, p. 366-376 (in Russian, English abstract).

In mineralogical studies of diopside and phlogopite phenocrysts of olivine-leucitic rocks of Molbo river the crystallites of fresh leucite with 3.5 wt % FeO were described. Thermobarometric studies of MI in minerals showed that the pyroxene crystallisation is corresponding to 1210 ± 30°C whereas the apatite within 1150°-1030°C T range. It was found that the initial M were low alumina bearing (6-8 wt % Al_2O_3), high Mg (4-8 wt % MgO), enriched in Ba and Sr. M were regarded as agpaitic rock. The M studied are greatly enriched in SO_3 and Cl correspondingly up to 0.37 and 0.47 wt % resulting in the barite-celestine crystallisation at the magmatic stage of rock formation. The study shows that the olivine-leucitic rocks of Molbo river should be related to the low Ti species of lamproite rock family. These rocks are mostly similar to diopside-leucitic lamproites of Nunkabach (Western Australia) as well as wyomingites and orendites of Leucite-Hills in USA. (From authors' abstract by E.R.)

PANINA, L.I. and VLADYKIN, N.V., 1994, Lamproitic rocks of the Murun Massif and their genesis: Geology and Geophysics, 1994, no. 12, p. 100-113 (in Russian, English abstract).

This paper deals with the lamproitic rocks of the Murun Massif. They are characterized in the context of their geological setting, mineralogy, and petrochemistry. Chemical compositions of minerals and I of solidified M in them are considered as well as mineral crystallization T. The mineral chemistry has some features typical of classical Al-poor lamproites: clinopyroxene is mainly represented by diopside and diopside-salite; phlogopite is enriched by Ti and depleted in Al; K-feldspar contains an isomorphous impurity of Fe and Ba; olivine has extremely low Ca content; leucite phenocrysts are transformed into K-feldspar and K-feldspar-kalsilite aggregations. Some similarities are also established between the Murun rocks and Al-rich K-basaltoids. The latter were best expressed during the transformation of initial mineral-forming media conserved in minerals: In the course of crystallization they predominantly evolved toward miaskitic M as Fe/(Fe+Mn) and Al/(Al+Ca) increased. The data obtained support that the Murun rocks belong to the lamproite family, being identical to the Spanish lamproites and well different from the Western Australian lamproites. The specific character of the Murun rocks either is due to mixing of an Al-poor lamproitic magma with an Al-enriched K-basaltoid magma, or is a result of melting of initial M of specific composition at a higher level, not typical of ordinary deep-seated lamproitic magmas. (Authors' abstract)

PAQUETTE, Jeanne and REEDER, R.J., 1995, Relationship between surface structure, growth mechanism, and trace element incorporation in calcite: Geochim. Cosmochim. Acta, v. 59, p. 735-749.

Pertinent to the use of cathodoluminescence during I studies. (E.R.)

PARNELL, John, 1995, Sulphide vein mineralization in Northern Ireland: Constraints on fluid sources, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 373-376. Author at School of Geosciences, Queen's Univ., Belfast, UK.

Quartz in the Conlig deposit shows two distinct populations of FI; a set of crystallographically-controlled PI, and crosscutting trails of SI. The PI yield Th of 225-250°C, while the SI yield lower T in the range 145-200°C. The higher T represent quartz veining during Caledonian deformation; the SI T represent mineralizing F during later ore deposition. This is consistent with the observed vein paragenesis. (From author's text by E.R.)

PARNELL, J. and MONSON, B., 1995, Paragenesis of hydrocarbon, metalliferous and other fluids in the Newark Group basins, eastern U.S.A.: Inst. Mining and Metallurgy, Trans., Sect. B: Appl. Earth Sci., v. 104, p. 136-144.

Bitumen shows occur in the Newark, Hartford and Deerfield Basins, eastern U.S.A., in reservoir sandstones, veinlets in the vicinity of hydrocarbon source rocks, veins through lava beds and in sulphide-mineralized veins. The bitumen shows occur late in the diagenetic history of the sandstones, occupying dissolution porosity. The parent hydrocarbons entered the sandstones from crosscutting fractures. In sulphide-mineralized veins bitumens are closely associated with, but predate, the sulphides. The role of organic matter was probably in enhancing metal reduction by creating a low-Eh environment rather than in metal transport. In several cases bitumens contain euhedral quartz crystals that were precipitated coevally with the bitumen, indicating a significant aqueous component to the hydrocarbon F. Inclusions in the quartz crystals variably contain hydrocarbon or aqueous F. PI contain hydrocarbons, whereas SI contain aqueous F, which is consistent with the sequence of bitumen precipitation before sulphide precipitation in veins. Th for aqueous I in south-central Connecticut are in the range 110-120°C.

Bitumen-bearing carbonate veinlets in the Newark Basin occur in carbonate-rich sequences. Study of the veinlets under cathodoluminescence shows that there were two or more distinct episodes of carbonate veining. Sulphides were deposited in the first carbonate phase, and bitumens were deposited in the second. Albite was deposited coevally with the bitumen, providing further evidence of an aqueous component to the hydrocarbon F. (Authors' abstract)

PARSONS, M.B. and MUECKE, G.K., 1995, Geochemistry and petrogenesis of late Cretaceous bentonites from the Kanguk Formation, Alex Heiberg and Ellesmere Island, Canadian High Arctic (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-81. First author at Dept. Geological and Environmental Sciences, Stanford Univ., Stanford, California, 94305-2115.

Petrographic and geochemical analyses of bulk bentonites volcanic minerals, and unaltered glass I in quartz phenocrysts reveal the composition and tectonic setting of Late Cretaceous explosive volcanism in the Canadian High Arctic. Microprobe analyses of glass I within quartz phenocrysts confirm oversaturated, marginally peralkaline parent melt compositions, and permit evaluations of element mobilities during bentonite formation. Appropriate modeling of elemental fluxes allows recalculation of original ash composition from bulk bentonite analyses, and indicated a potential for geochemical correlation between individual units or groups of units. Detailed major and trace element geochemistry on both primary phenocrysts and bulk bentonites, in conjunction with discriminant diagrams, reveals a within-plate tectonic setting for the parent volcanism, and a dominance of peralkaline rhyolite compositions. (From authors' abstract by H.E.B.)

PASAVA, Jan, KŘÍBEK, Bohdan and ZÁK, Karel, editors, 1995, Mineral Deposits: From Their Origin to Their Environmental Impacts: Proc. 3rd Biennial SGA Mtg., Prague, Czech Republic, 28-31 August 1995, 240 p.

Includes, among the 254 contributions, numerous extended abstracts on I studies, individually entered in this volume. (E.R.)

PASTERIS, J.D., FREEMAN, J.J. and CHOU, I-M., 1995, Fluid-deposited graphitic inclusions in quartz: comparison between KTB (German continental deep-drilling) core samples and artificially re-equilibrated natural inclusions (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-262.

Analysis of graphitic precipitates along grain boundaries and within fractures in rocks provides a means of tracing the patterns of flow and the P-T-fO2 conditions of C-bearing deep crustal F. Such graphitic precipitates can occur as (areally extensive) thin films or as thick deposits in localized fracture/cataclastic zones. This study focuses on graphite-bearing FI in quartz as a means of better understanding how C moves in crustal F and how graphite is brought to saturation. By use of Raman microsampling spectroscopy (RMS), the degree of crystallinity of graphitic I associated with microfractures was investigated in quartz-rich samples of Gt-Bio gneiss from cataclastic zones of the KTB Pilot Drill Hole in SE Germany. Among the five textural types of graphitic I in the KTB samples, there is much overlap in the degree of crystallinity. Most graphites are structurally equivalent to those from carbonaceous metapelites from the chlorite-biotite to andalusite zones. However, (1) extremely disordered graphite occurs as bimineralic intergrowths with chlorite, and (2) small blades and hexagons of granulite-grade graphite occur in the same sample. To infer the mechanism and conditions of graphite precipitation in these rocks, specifically the importance of H diffusion, a natural quartz sample containing initially pure CO_2 I (Olsen, 1987, 1988) was run at $T = 720°C$, $P_{tot} = 2$ kb, $fH_2 = 73$ bar for 9-13 days (run 1). Then half of the wafer was run at the same T and P, but at $fH_2 = 0.06$ bar (run 2). Changes occurred in the gas speciation in the I after run 1 (Morgan et al., 1993), and graphite precipitated. After run 2, gas compositions had reverted to pure CO_2, but the graphite remained. The experimental graphites show a wider range in crystallinity than the KTB samples. As in the KTB samples, however, the experimental graphites show a correlation between textural type and degree of crystallinity. This comparison suggests (1) specifically, that the KTB graphites may have precipitated at T>700°C or by a mechanism other than H diffusion, and (2) generally, that F-deposited graphite may be poorly ordered even when it is precipitated at T >700°C and that the degree of crystallinity may be affected by fO_2 and fH_2 as well as T (cf. D. Ziegenbein, pers. comm.). (Authors' abstract)

PASTERIS, J.D., HARRIS, T.N. and SASSANI, D.C., 1995, Interactions of mixed volatile-brine fluids in rocks of the southwestern footwall of the Duluth Complex, Minnesota: Evidence from aqueous fluid inclusions: Am. J. Sci., v. 295, p. 125-172. Authors at Dept. Earth and Planetary Sciences, Washington Univ., St. Louis, MO 63130.

The goal of the study was to investigate the nature of the aqueous F that interacted with the igneous rocks and possibly affected the concentration and distribution of ore minerals. Microthermometric and Raman microprobe analyses were done on FI hosted by quartz and apatite in hydrously altered mafic rocks. The aqueous F range from 0 to 48 wt % total dissolved salt (assuming NaCl + $CaCl_2$) with $CaCl_2$/(NaCl + $CaCl_2$) weight ratios up to 0.9. Th range from ~100° to >400°C. The I data suggest that the Complex experienced significant interactions with mixed aqueous (NaCl + $CaCl_2$ + KCl)-volatile ($CH_4 + N_2 \pm CO_2$) F over a T range from >700° to <200°C at ~2 kb P. The aqueous components were derived from metasediments of the Thompson Formation and from the mafic igneous M, whereas organic components of the metasediments are the major source of the C-O-H-N volatiles in the F. The high salinities of some of these brines were achieved by separation of a magmatic F component, reaction of F with igneous and metasedimentary rocks, development of brine-brine immiscibility at high T and brine-G immiscibility at lower T, removal of a G phase by effervescence through surface-penetrating fractures, and removal of water into hydrous alteration phases. The hot, highly saline F were capable of transporting ore components such as Cu, Fe, Ni, and PGE. In principle, the development of brine-brine and brine-G immiscibility in these F has strong ore-forming potential. However, the sporadic PGE concentrations at Duluth may be due to: (1) the insufficient concentration of PGE in the original magmas; (2) the repeated intrusion of mafic M, which caused ore components to be dispersed by overlapping hydrothermal cells; and (3) the reduced nature of the F, making them less capable of transporting ore components. (From authors' abstract by E.R.)

PATRIER, Patricia, BEAUFORT, Daniel, BRIL, Hubert, AUMAÎTRE, Roland and BONHOMME, Michel, 1995, Argillic alteration, a guide for uranium deposits emplacement in episyenitic granitoids, French Massif Central: The case study of 'Le Bernardan mining district', *in* Pasava, Kříbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 377-380.

A study of late hydrothermal parageneses in Le Bernardan Hercynian U-district points out the role of Jurassic, low T argillic alteration episodes for present-day distribution and size of the mineralized bodies. (Authors' abstract)

Scarce I in dolomite showed Tm ice -22°C, Th 190-400°C. (E.R.)

PATTERSON, D.B., HONDA, Masahiko and McDOUGALL, Ian, 1994a, Atmospheric, MORB-like, and crustal-derived noble gas components in subduction-related samples, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 147-158.

PATTERSON, D.B., HONDA, Masahiko and McDOUGALL, Ian, 1994b, Deconvolution of multiple components of neon and helium in mantle-derived samples, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 179-189.

PAUER, Frank, KIPFSTUHL, Josef and KUHS, W.F., 1995, Raman spectroscopic study on the nitrogen/oxygen ratio in natural ice clathrates in the GRIP ice core: Geophys. Res. Lett., v. 22, no. 8, p. 969-971. First author at Alfred-Wegener-Inst. Polar- und Meeresforschung, D-27568 Bremerhaven, Germany.

We have carried out Raman spectroscopic experiments on air clathrates in the GReenland Ice Core Project (GRIP) deep ice core. We present new N_2/O_2 measurements that markedly differ from previous measurements of the Dye-3 ice core: the N_2/O_2 ratio we observe is much closer to atmospheric. This has new implications for the interpretation of G distributions in ice sheets and the reconstruction of past atmospheric conditions. (Authors' abstract)

PAVLISHIN, V., VOZNYAK, D. and KUZNETSOV, G., 1995, Marmaros diamantes: Geol. Soc. Greece, Sp. Publ., No. 4, p.465-466. Authors at Inst. Geochemistry, Mineralogy and Ore Formation, Nat'l Acad. Sci. Ukraine, Kiev, Ukraine.

Marmaros diamantes grown in the medium with a high hydrocarbon content (from thermobarogeochemistry data) are featured by skeleton structure, high transparency and lustre, intensive luminescence within 280°C, weak or no absorption within hydroxyl variation, presence of primary concretions [sic] of hydrocarbon composition, etc. Analysis of these and some other data permits a conclusion that availability of H defects in quartz is a typomorphic character of its formation from water-containing media and their absence from hydrocarbon silicon-containing solutions. (Authors' abstract)

PAVLOV, D.I. and KHITAROV, D.N., 1994, Participation of highly alkaline solutions in forming stratiform Pb-Zn mineralization at the Sardana deposit, southeast Yakutia: Dokl. Ross. Akad. Nauk, v. 339, no. 4, p. 525-527 (in Russian).

Four water leachates (from sphalerite and pyrite) were analyzed for Na, K, Ca, Mg, HCO_3, Cl, SO_4^{2-}, and S^{2-}. (E.R.)

PEDERSEN, L.E., HEAMAN, L.M. and HOLM, P.M., 1995, Further constraints on the temporal evolution of the Oslo Rift from precise U-Pb zircon dating in the Siljan-Skrim area: Lithos, v. 34, no. 4, p. 301-315.

The common Pb data indicate that U has been present in the feldspars since the time of crystallisation, probably in a late magmatic volatile phase in FI. (E.R.)

PENROD, B.E., 1995, Decrepitation of glass grade carbonates from western Virginia: West Virginia Geological and Economic Survey Circular, 222 p.

PETERS, M.T. and WICKHAM, S.M., 1995, On the causes of ^{18}O-depletion and $^{18}O/^{16}O$ homogenization during regional metamorphism; the East Humboldt Range core complex, Nevada: Contrib. Mineral. Petrol., v. 119, p. 68-82.

PETFORD, N., MILLER, J.A. and RANKIN, A.H., 1995, Three dimensional morphology of fracture sets in quartz: the application of confocal microscopy to fluid flow (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 190.

Investigation of a single crystal of quartz revealed large (>10 µm) diameter I surrounded by numerous small (<1 µm) highly reflective I. CSLM, allied to image processing has show that the arrangement of I is not random. The small I are arranged in planes oriented in two directions at least. The planes are not readily visible in transmitted light. The technique allows measurements of the angle of intersection between planes and their orientation in three dimensions.

Results suggest that larger I (>10 µm) occur where two planes of small I intersect, and that the shape of each large I is controlled by the angular relationship between intersecting planes. The unique ability of CSLM to resolve the 3D morphology of individual planes or fracture sets, combined with the allied investigation of F trapped at these intersections provides a new way of investigating F flow in rocks. (From authors' abstract by E.R.)

PETRACHENKO, E.D., 1995, Molybdenum in recent hydrothermal systems of the Kuril Islands, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 533-535. Author at Far Eastern Geological Inst., Vladivostok, Russia.

Fe, Zn, Cu, Sn sulfides are often present among altered rocks of recent hydrothermal systems (Pleistocene-Quaternary) in Kuril Islands. Molybdenite and jordisite have been recognized also. They were precipitated from thermal chloride-sulphate solutions, gases and V-L emanations. T of mineral formation was 390-120°C [FI data]. Associations of molybdenite and jordisite with native S, marcasite, troilite, hydromicas, kaolinite, opal, sulphates are typical for recent hydrothermal systems. (Author's abstract)

PETRAKAKIS, Konstantin and JAWECKI, Christine, 1995, High-grade metamorphism and retrogression of Moldanubian granulites, Austria: Eur. J. Mineral., v. 7, no. 5, p. 1183-1203. Authors at Inst. Petrology, Univ. Vienna, Dr. Karl Lueger-Ring 1, A-1010 Vienna, Austria.

Charnockitic granulites from the Dunkelsteiner Wald, Moldanubian zone in Austria, bear the assemblage Grt + Opx + Bt + Kfs + Plg + Qz + Rt + Ilm. Textural and compositional relations suggest a near-equilibrium state among these minerals, thus allowing the application of thermobarometry. Estimated conditions for the latest high-T overprint are 770°C, 10.7 kb and $aH_2O \approx 0.1$.

Breakdown of garnet and I of corundum and plagioclase therein was initiated by infiltrating F; their composition ($XH_2O \approx 0.7$) was estimated from early FI in quartz. The studied rocks show a clockwise PT-path characterized by (a) isothermal decompression during and after attainment of peak metamorphic conditions, (b) nearly isobaric cooling in the range 500-600°C and 5-6 kb, and (c) further decompression that may be related to thrusting of Moldanubia over Moravia. (From authors' abstract by E.R.)

PETRICHENKO, O.I. (see also PETRYCZENKO)

PETRICHENKO, O.Y. and KOVALEVICH, V.M., 1995, Hydrocarbon inclusions in halite of evaporite deposits of east Europe (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 176-177. Authors at Inst. Geology and Geochemistry of Combustible Minerals, Naukova st. 3a, 290053, L'viv, Ukraine.

Hydrocarbon I are [surprisingly] rare. I aggregate composition is very different. They consist of dispersed organic [solid] matter and hydrocarbons that migrated in. The bulk composition is exceedingly variable, from essentially G (CH_4) to very [complex], consisting of several solid, L and G phases. The I trapping took place during salt recrystallization in postsedimentary stages. FI contain CH_4, naphtenic and aromatic hydrocarbons, sometimes with impurities of sulphurous compounds. Among the solid hydrocarbons there were determined the ozokerite, anthraxolite, wax-like matter composed, probably, from several independent compounds.

Hydrocarbon I are most characteristic for halite of diagenetic and katagenetic stages; if metamorphosed at >200-250°C, G I of heavy hydrocarbons were found. (From authors' abstract by E.R.)

PETROV, P.P. and RANKIN, A.H., 1995, Distribution of sectorial primary fluid inclusions and sulphide ore minerals in epithermal quartz crystals from Bulgaria: A manifestation of gravitional [sic] crystallisation processes? (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 178. First author at Fac. Geography and Geology, Sofia Univ., 1000 Sofia, Bulgaria.

Individual quartz crystals from a number of epithermal Pb Zn Cu Au deposits of Oligocene to Miocene age commonly contain myriads of small, elongate and dendritic FI which are demonstrably primary in origin.

Inclusions with characteristics similar to those above are not uncommon in the epithermal environment. However, the remarkable feature reported here, with special reference to quartz from the Kruchev dol Pb-Zn mine in the Madan district, is their distinctive, asymmetrical zonal distribution patterns which clearly reflect some directional crystallisation process. These I are found only in great numbers in sections or sectors of the pyramid faces of the host crystal and are hence termed Sectorial Primary Fluid Inclusions (SPFI).

The SPFI inclusions (Th 270°C to 290°C) are typically elongate perpendicular to rhombohedral crystallographic directions and collectively impart a characteristic cloudiness to the quartz sectors in which they appear. Single quartz crystals which have grown with their C-axes perpendicular to the gravitational force direction illustrate preferential distribution of these I which, at face value, appear to be related to this force. An additional noteworthy feature is the asymmetrical distribution of ore minerals which occur almost exclusively in the clear (i.e., SPFI-free) areas of individual quartz crystals. Whilst it is tempting to speculate that these combined observations reflect gravitational (and therefore hydrodynamic) forces other possible controls cannot, at present, be excluded from consideration. (Authors' abstract)

PETRYCZENKO, O.I., PERYT, T.M., POBEREZSKI, A.W. and KASPRZYK, Alicja, 1995, Inclusions of microorganisms in the Middle Miocene Badenian gypsum crystals of the Carpathian Foredeep: Przeglad Geologiczny, v. 43, no. 10, p. 859-862.

Crystalline gypsum characteristic of the Middle Miocene of southern Poland and West Ukraine shows rhythmic zonality caused by occurrence of mineral, F, and microorganic I. Study of FI and analyses of water extracts showed that brines during deposition had sulphate composition. Solutions in I are saturated in respect to gases related to degradation of organic matter. Besides common algae, higher organisms were found. Good state of preservation of the microorganism tissues indicates anaerobic conditions during gypsum precipitation. The microorganic I contain organic F in addition to water solutions.

It is clear that brines in the Badenian basin at the time of gypsum deposition were saturated in respect to calcium sulfate; however, it was found that the total mineralization during deposition of skeletal and sabre-like gypsum did not exceed 0.5%. Earlier mineralization ranging from 1 to 9% was recorded in different parts of the Badenian basin. The conclusion is that the total mineralization of the Badenian basin was a few times lower than that characteristic of the stage of gypsum precipitation from marine-derived brines (i.e., 11-12%). An alternative may be that the studied I are not primary but according to [authors] OIP and AWP, there are no features indicating such a possibility. (From authors' abstract by E.R.)

Note: Authors given in Polish spellings; thus first author is same as O.I. Petrichenko. (E.R.)

PETTKE, Th. and DIAMOND, L.W., 1995a, Rb-Sr dating of sphalerite based on fluid inclusion–host mineral isochrons: Systematics and age significance (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 179-180. Authors at Univ. Bern, Min. Pet. Inst., Isotopengeologie, Erlachstr. 9a, CH-3012 BERN, Switzerland.

Recent publications have presented Rb-Sr isochrons obtained on sphalerites by separating the FI fraction, termed leachate, from the residual sphalerite, termed residue. The ages were used to date MVT ore deposits in the U.S.A. with the main conclusion that at least two distinct tectonic episodes were responsible for the mineralisation. They could not explain why this dating approach yields isochrons at all. Herein we draw on [our recent] results of Rb-Sr isotopic analyses of synthetic FI in quartz to explain the systematics of the published isochrons and to evaluate their age significance.

Rb-Sr leachate-residue pairs for sphalerite from the West Hayden ore body fall on an isochron, whereby the leachates cluster around one point and the residues show a range of ^{87}Rb/^{86}Sr ratios. Rb and Sr are ~200 and 12,000 times less concentrated in the residue, respectively, than in the F.

The spread of earlier data resulted from incomplete FI extraction from the host. The residue analyses are highly sensitive to small quantities of unopened Rb- and Sr-rich FI, hence they define a mixing-line. In contrast, the leachates are single-phase extracts, hence they define a point.

The variability in the residue ^{87}Rb/^{86}Sr could also result from evolving partition coefficients during sphalerite growth, e.g., as a function of variable F T. (1993) require mixing of F with different Rb/Sr elemental ratios.

We conclude that leachate–residue isochrons for sphalerite only carry the significance of two-point ages, regardless of how many samples are used to define the isochron. In particular, agreement between isochrons fitted through only the residues on the one hand, and through the F-residue pairs on the other, lends no additional support to the calculated age. Since the isochrons are simply binary mixing-lines, agreement between two such isochrons is to be expected. It is well known that two-point ages may be geologically meaningless because there is no straightforward way to prove that the two points have the same initial ^{87}Sr/^{86}Sr ratio and have not been disturbed later. Therefore, normal petrographic examinations and, where possible, microthermometric studies must be performed on FI samples prior to isotopic analysis in order to interpret the results. The crux of the age interpretation lies in whether all the FI analysed in a bulk sample are identifiable as being exclusively primary. (From authors' abstract by E.R.)

See also next item. (E.R.)

PETTKE, Thomas and DIAMOND, L.W., 1995b, Rb-Sr isotopic analysis of fluid inclusions in quartz: Evaluation of bulk extraction procedures and geochronometer systematics using synthetic fluid inclusions: Geochim. Cosmochim. Acta, v. 59, p. 4009-4027.

This is full paper for previous item. (E.R.)

PETTKE, Thomas, DIAMOND, L.W., FREI, Robert and VILLA, I.M., 1995b, He, Ar, U-Pb and Rb-Sr isotope systematics of fluid inclusions in quartz, associated vein minerals and native gold from epigenetic late Alpine Au-veins in NW Italy (abst.): Schweiz. Mineral. Petrogr. Mitt., v. 75, p. 308-309.

See previous item. (E.R.)

PETTKE, Th., FREI, R., KAMENSKY, I.L., KRAMERS, J.D., TOLSTIKHIN, I. N. and VILLA, I.M., 1995, U, He and Ar isotope systematics in fluid inclusions of vein-gold, quartz and carbonates from Brusson, Val d'Ayas (NW Italy): (U+Th)/He dating of gold and isotopic tracing (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 181-182. First author at Univ. Bern, Min. Pet. Inst., Isotopengeologie, Erlachstr. 9a, CH-3012 BERN, Switzerland.

This paper addresses U/He and Ar isotope systematics in vein Au [and associated quartz] crystallised from an aqueous hydrothermal solution ~30 Ma ago (Monte Rosa Gold District, NW Italy) in order to (i) test the direct (U+Th)/He datability of metallic Au and (ii) to assess the potential use of rare gases trapped in Au as geochemical tracers.

Evaluation of the U-He systematics with the known age of the sample (~30 Ma) showed that ≥98% of the He is trapped which alone makes precise (U+Th)/He dating impossible. An isochron with the two free Au samples gave an apparent age of 434 ±56 Ma; this failure can easily be explained by the assumption that the two observed trapped He components are heterogeneously distributed.

The isotope signatures of the two trapped gas components cannot be related by fractionation alone, and a two-stage process is required; thus the F which precipitated final stage Au at Fenilia had a different history or rare gas source from that which crystallised main stage quartz. Hence, rare gas isotope systematics on vein Au and possibly other native metals are poor as a dating tool but very promising as a F-geochemical tracer. (From authors' abstract by E.R.)

PHILIPPOT, Pascal, 1995, Fluid composition and evolution in the coesite-bearing rocks of the Dora-Maira massif, Western Alps: Bochumer Geol. U. Geotech. Arb., v. 44, p. 144-145 (English). Author at CNRS, Laboratoire de Petrologie, Univ. Paris 7, 4 place Jussieu, 75005 Paris, France.

FI and F-, Cl-concentration of hydrous minerals were analysed in the coesite-pyrope quartzite, the interlayered jadeite quartzite and their country-rock gneiss from the Dora-Maira massif using a combination of microthermometry, Raman spectrometry, synchrotron X-ray microfluorescence and electron microprobe analysis. Three populations of FI were recognized texturally and can be related to distinct metamorphic stages. A low-salinity aqueous F occurs in the retrogressed country gneiss and as late SI in jadeite quartzite and chloritized pyrope. An earlier secondary population is found in matrix quartz of the jadeite- and pyrope-quartzites. This population can be related to the early decompression and so to incipient breakdown of garnet into phlogopite-bearing assemblages. The I F is highly saline (≤84 wt % eq. NaCl) and contains Na, Ca, Fe, Cu and Zn as major cations. In pyrope quartzite, additional K was found in these brines, which locally coexist with CO_2-rich I. The oldest FI are preserved in kyanite grains included in fresh pyrope and in pyrope itself. In pyrope, all I have decrepitated and contain magnesite, an Mg-phosphate, sheet-silicate(s), a chloride and an opaque phase, with no F preserved. In contrast, the kyanite I in pyrope preserve primary H_2O-CO_2 low-salinity FI, probably owing to the low compressibility of the kyanite I and host garnet. In spite of *in situ* reequilibration, these I can be interpreted as relics of the dehydration F that attended pyrope growth. These correlations between textural and chemical FI data and metamorphic stages are consistent with the F composition calculated from the halogen content of different generations of (Na-) phlogopite and biotite. The preservation of different F compositions, both in time and space, is evidence for local control and possibly origin of the F. Recognition of 3‰ variation in $\delta^{18}O$ between the pyrope-quartzite and surrounding gneiss (Sharp, 1993) and of grain-scale heterogeneities in ^{40}Ar/^{36}Ar and ^{39}Ar/^{40}Ar isotopic ratios in phengite from the same outcrop (Scaillet et al., 1990) argues for limited F mobility during high-P metamorphism as significant infiltration of homogeneous F should have eradicated such isotopic variations. (From author's abstract by H.E.B.)

PHILIPPOT, Pascal, CHEVALLIER, Pierre, CHOPIN, Christian and DUBESSY, Jean, 1995, Fluid composition and evolution in coesite-bearing rocks (Dora-Maira massif, Western Alps): Implications for element recycling during subduction: Contrib. Mineral. Petrol., v. 121, p. 29-44. First author at CNRS, Laboratoire de Pétrologie, Univ. Paris 7, 4 place Jussieu, F-75005 Paris, France.

FI and F, Cl concentration of hydrous minerals were analysed using a combination of microthermometry, Raman spectrometry, synchrotron X-ray microfluorescence and electron microprobe analysis. Three populations of FI were recognized texturally and can be related to distinct metamorphic stages. A low-salinity aqueous F occurs in the retrogressed country gneiss. An earlier secondary population is related to the early decompression and so to incipient breakdown of garnet into phlogopite-bearing assemblages. It is highly saline (≤84 wt % eq. NaCl) and contains Na, Ca, Fe, Cu and Zn as major cations. The oldest FI are preserved in kyanite grains included in fresh pyrope and in pyrope itself. In pyrope, all I have decrepitated and contain magnesite, an Mg-phosphate, sheet-silicate(s), a chloride and an opaque phase, with no F preserved. In contrast, the kyanite I in pyrope preserve P H_2O-CO_2 low-salinity FI, probably owing to the low compressibility of the kyanite I and host garnet. In spite of *in situ* reequilibration, these I can be interpreted as relics of the dehydration F that attended pyrope growth. The preservation of different F compositions, both in time and space, is evidence for local control and possibly origin of the F, in agreement with isotopic data. These results, in particular the absence of CO_2 in the jadeite quartzite, are best interpreted in terms of a F-M system evolution. The process of F-M interaction envisioned here coupled with models of M extraction in subduction zones provides an attractive opportunity for the instantaneous (<1 Ma) and selective transport of elements between a downgoing slab and the overlying mantle wedge. (From authors' abstract by E.R.)

PHILIPPOT, P., CHEVALLIER, P. and GIBERT, F., 1995a, Synchrotron X-ray fluorescence analysis of individual fluid inclusion: $(K\alpha/K\beta)_i$ used as a correction term for concentration estimates (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 183. First author at CNRS-URA736, Laboratoire de Pétrologie, Univ. Paris 7, 4 place Jussieu, 75252 Paris cedex 05, France.

Experiments designed to obtain a quantitative estimates of the concentration of trace elements in individual FI were performed using the LURE synchrotron radiation laboratory (Orsay) and the European Synchrotron Radiation Facilities (ESRF; Grenoble). An elliptical Bragg-Fresnel multilayer lens is used to image a 100 µm diameter pinhole set 6.3 m upstream from the lens and acting as a primary source on a 2 µm diameter focal spot. The lens also acts as a monochromator and ~10^5 (LURE) and ~10^9 (ESRF) 12.4 Kev photons.sec^{-1} passes through the focal spot. The sample can be positioned with an accuracy of 0.1 µm through a remote-controlled Microcontrôle three axis stage and is observed with a video microscope (×700 magnification). The beam passes at an angle of 45° to the surface of the host mineral (quartz). The X-ray fluorescence spectrum is recorded with a PGT Si(Li) detector of 150 eV energy resolution set at 90° from the incident beam.

Synchrotron-XRF analysis were performed on natural and synthetic aqueous I (800°C-0.7 GPa) containing known concentrations of (1) $NiCl_2 + ZnCl_2$ (526-1876 ppm), (2) $CuCl_2 + SrCl_2$ (95-120, 952-1200 and 9510-11990 ppm), and (3) $FeCl_2$ (970 ppm). Results show that within the same FI, the precision of the analysis is poor, reflecting differences in the pathlength of the incident beam in the host mineral (irregularly-shaped I). Since sensitivity is primarily dependent on absorption, $(K\alpha/K\beta)_i$, which is proportional to the thickness of material traversed, can be used as a correction term for concentration estimates. Calculations performed for Fe and using the simplified FI geometry indicate that $(K\alpha/K\beta)_{Fe}$ is primarily dependent on the thickness of host quartz. Although absorption in pure water can be considered as negligible, $(K\alpha/K\beta)_{Fe}$ is strongly dependent on the salinity of the I F. Experimental procedures designed to quantify the effects of quartz thickness and F salinity on $K\alpha/K\beta$ for different chemical elements are currently underway. (From authors' abstract by E.R.)

PHILIPPOT, P., CHEVALLIER, P., GIBERT, F. and LEGRAND, F., 1995b, Synchrotron X-Ray Fluorescence Analysis of individual fluid inclusion (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 344.

Experiments designed to obtain a quantitative estimate of the concentration of trace elements in individual FI were performed using the LURE synchrotron radiation laboratory (Orsay) and the European Synchrotron Radiation Facilities (ESRF; Grenoble). An elliptical Bragg-Fresnel multilayer lens is used to image a 100 µm diameter pinhole set 6.3 meters upstream from the lens. The lens also acts as a monochromator and ~10^5 (LURE) and 10^9 (ESRF) 12.4 Kev photons.sec^{-1} passes through the focal spot. The beam passes at an angle of 45° to the surface of the host mineral (quartz). The XFR spectrum is recorded with a Si(Li) detector set at 90° from the incident beam.

Synchrotron-XRF analysis were performed on natural and synthetic aqueous I (800°C-0.7 GPa) containing known concentrations of (1) $NiCl_2 + ZnCl_2$ (526-1876 ppm), (2) $CuCl_2 + SrCl_2$ (95-120, 952-1200 and 9510-11,990 ppm), and (3) $FeCl_2$ (970 ppm). Preliminary results show that within a [given] FI, the precision of the analysis is poor, reflecting differences in the path length of the incident beam in the host mineral (irregularly-shaped I). Although improved correction procedures are necessary for high-precision quantitative analysis, the available data indicate that the detection limit for heavy metals should be at least on the tens of ppm level. (From authors' abstract by E.R.)

PHILLIPS, G.N., WILLIAMS, P.J. and DE JONG, Geoffrey, 1994, The nature of metamorphic fluids and significance for metal exploration, *in* J. Parnell, ed., Geofluids: Origin, Migration and Evolution of Fluids in Sedimentary Basins: Geol. Soc. (London) Spec. Publ. No. 78, p. 55-68. Authors at Nat'l Key Centre in Economic Geology, James Cook Univ., 4811, Townsville, Australia.

F are active at all levels in the crust during metamorphism. Devolatilization of many rock packages leads to the evolution of H_2O, CO_2 and/or S as a F phase that is commonly of low salinity. The composition of the F phase released during devolatilization is controlled by the dominant mineral assemblage in the source region, and the evolution of such F is most dramatic where major changes in modal mineralogy occur, e.g., across metamorphic facies boundaries. Evidence for this loss of volatiles during metamorphism is provided by metamorphic assemblages that typically contain less volatile components as grade increases.

The metamorphism of mafic rock successions can yield a metamorphic F rich in H_2O, CO_2 and S, and close in composition to F inferred in the formation of many Au-only deposits. The close affinity between Au and these F arises from the stability of the Au-S complexing.

Where evaporites are present in the succession, the F released during devolatilization can be quite saline. A further potential source of saline F in these environments is from crystallization of certain magmas. Saline F have a composition favourable for transporting Au *and* base metals, which is likely to explain the occurrence of Au as a co-product in many products where saline F are inferred.

The contrast between saline and low salinity F during metamorphism is not only reflected in ore metals, but also in the associated alteration and element mobility. Only a few elements are mobile in the low salinity F, and the alteration mineralogy is strongly influenced by the nature of the host rocks. Saline F readily transport many elements, and a similar alteration assemblage can be superimposed on many different precursors. (Authors' abstract)

PICCOLI, P.M., CANDELA, P.A. and WILLIAMS, T.J., 1995, Iron and copper partitioning from magmas into vapor and vapor/brine mixtures in shallow granitic systems (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-379.

The algorithm, Magmatic Volatile Phases (MVP), can be used to estimate the composition of the magmatic V or V + brine (b), exsolved isobarically from granitic (*s.l.*) magmas. Rather than perform simple mass-balance calculations for each element individually, MVP considers the *simultaneous* equilibria among melt (m), crystals (xl), and volatile phases that must be accounted for to model the efficiencies with which ore-metals are removed from magmas into aqueous "ore fluids." The algorithm calculates the partitioning of elements between m and volatile phase(s) accounting for xl/m partitioning both before and after volatile saturation. Crystallization is modelled *implicitly* through the use of bulk xl/m partition coefficients (D) for each element. Once the composition of the melt is calculated at volatile saturation, the composition of successive aliquots of v, or v+b, can be calculated, until the volatile-saturated melt has crystallized. Existing data on the composition of coexisting b+v+m are limited. However, our data on HCl and CuCl partitioning in b+v+m mixtures, together with the assumptions that: (1) exchange constants (not partition coefficients) for v/m and b/m are the same (that this is reasonable is demonstrated by our experiments for CuCl); and that (2) the solubility of magnetite (mt) in the brine is given by the $f(O_2)$ and m_{HCl}-dependent solubility as tabulated in Frantz et al. (1981; Geochim. Cosmochim. Acta, v. 45, p. 69), allow an estimation of brine composition.

Results of this model suggest: (1) brine can form at relatively low magmatic Cl/H_2O (e.g., ~0.05 by weight at 1 kb and 800°C), indicating that the presence of brine ± V-rich I *alone* is not a good indicator of high Cl/H_2O of the initial melt; (2) because magmatic HCl/total Cl is controlled by the ASI (molar $Al_2O_3/(Na_2O + K_2O + CaO)$) of the melt, and because aqueous $FeCl_2$ increases proportional to the square of the HCl concentration, the $FeCl_2$ concentration in magmatic brine can be shown to be a strong function of the ASI of the melt (at 800°C, 1 kb, and NNO, a brine in equilibrium with a mt-saturated melt will contain on the order of 10^4 ppm Fe at ASI = 1.03, and on the order of 10^3 ppm Fe at ASI = 1.01. These agree qualitatively with published analyses of FI); and (3) Cu concentrations in v and b under similar conditions, with Cu behaving as an incompatible element (after volatile saturation) and with only a few tens of ppm of Cu in the melt are predicted to be on the order of 10^2 and 10^3 ppm respectively. Although some Cu concentration data on natural V-rich I are problematic, analyses of Cu in brines are consistent with concentrations predicted by MVP. (Authors' abstract)

PIELOW, H.-U. and BEHR, H.-J., 1995, Hydrothermal corrosion processes in the upper crust: Evidence from mineral surface textures from the Continental Deep Drilling Project KTB (Germany) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII). Note: This one-page abstract was distributed unofficially at the ECROFI XIII meeting; it did not appear in the Abstracts volume.

The KTB deep-drilling cuts a series of steeply inclined gneisses and amphibolites at the western margin of the Bohemian Massif. With a final depth of 9101 m, a T of 250°C and a minimum P of 1 kb, the KTB offers possibilities for *in situ* studies of interactions between (sub)recently migrating F and the rock pile. Cuttings from depths between 400 and 9016 m from the KTB have been studied by SEM and EDX analysis. About 90% of the mineral surfaces are recent products of the drilling process, but natural surfaces of rock-forming quartz and feldspar along microcracks and beneath removed grains show textures generated by recent to subrecent aqueous saline solutions. Three types of corrosional textures have been distinguished.

•The fresh broken and highly reactive surfaces of the samples are free of dissolution textures, hence a corrosive influence of the drilling F on the material can be ruled out.

•Corrison in the upper 2000 m is generated by HCO_3^- weathering solutions. Corrosive textures are indicative for high permeability, associated with faults and cataclasis zones.

•The horizon between 2000 and 8000 m is influenced by mixture and diluting of ascending Ca-Na-Cl basement brines with descending Na-Cl-formation water and residual brines. Mineral textures show both dissolution and precipitation in close neighbourhood.

•The dominating feature <8000 m is chemical etching and dissolution of quartz. These phenomena show evidence for an intensive penetration of the rock pile by saline solutions that started under the P-T conditions of the laumontite-prehnite-quartz facies but is still active under recent P-T conditions.

•A widespread high-saline solution system developed in the Variscan basement under the postvarsician extensional regime. Original Na-K-Mg-Ca-Cl solutions from the sedimentary cover descended gravitationally down to depths of ~10 km. The interaction of $CaCl_2$ water with the rock pile in an extensional regime produces zones of secondary porosity and permeability. The penetrative occurrence of corrosional features in the deep drilling indicates continuous activity of F flow under non-equilibrium conditions. (From authors' abstract by E.R.)

PILI, Eric and MEVEL, Catherine, 1994, Interactions between deep ocean crust/seawater: Pyroxene veins from ODP site 735B (Indian Ocean) (abst.): 15th Reunion Sci. de la Terre, p. 109 (in French). First author at URA 726, ENS Lyon I, Univ. Paris 6, UCB Lyon I, France.

Drilling from ODP leg 118, site 735B, revealed the presence of hydrothermal veins of clinopyroxenes, previously not recorded from an oceanic situation. Petrological studies have provided characterization of the P-T-X conditions and the temporal evolution of the water/rock interactions.

Our study shows that the veins developed with the start of differentiated magmatic intrusions (plagiogranites) which remobilized F after a first hydrothermal circulation, using seawater and responsible for extensive amphibolitization (Stakes et al., 1991, *in* R.P. Van Herzen et al., Proc. ODP Sci. results 118, College Station, Texas). The new F circulation, associated with an important hydraulic fracturing, initially formed breccias—magmatic and then hydrothermal—and finally veins of Cpx-amphibole-Pl (T ≥500°C), then only amphibole-Pl [plagioclase?] when the T decreased. Chlorite, epidote, sphene, calcite are the accessory minerals. The F was initially rich in Ca and accessory minerals. The F was initially rich in Ca and Na. The hydrothermal diopside developed with the loss of magmatic augite (3% Al_2O_3) or with the loss of green hornblende (amphibolitized magmatic pyroxene). Two generations of hydrothermal pyroxenes followed: those richest in Ca (+3 then +4% CaO) and more depleted in Al (-2.5 then -1.5% Al_2O_3) than the magmatic pyroxenes.

The microthermometric studies of the secondary pyroxene FI indicate an aqueous F of salinity 5 then 3.5 wt % NaCl eq. The Tt determined for the coprecipitation of amphibole/Pl (+ Cpx) were <580°C. The P estimate for the F trapping is much less than 800 bars. This indicates either an abnormally low thickness for the basalts and vein complex and/or the water column, or a lower F P than currently acknowledged for the lithostatic P (1 kb).

The study of these pyroxene veins provides essential information on the nature, evolution, and circulation mechanisms in the deep oceanic crust. (Authors' abstract; translation courtesy of Dr. A.P. Gize)

PINTEA, I., 1995a, Fluid inclusions evidence for liquid magmatic immiscibility between hydrous salt melt and silicate melt as primary source of ore metals in porphyry copper systems from Apuseni Mountains (Romania) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 184-185. Author at Geological Inst. Romania, Bucharest, Romania.

The quartz veinlets associated with the potassic zone in neogene porphyry Cu deposits from Metalliferous Mountains (western Romania) contain three main FI types: silicate M, hydrous salt melt and V rich. These were trapped together as coeval I, suggesting immiscibility at the trapping conditions.

Silicate melt inclusions were found abundantly in the quartz crystals associated with bornite, molybdenite, magnetite, chalcopyrite and pyrite of the potassic zone of Deva porphyry Cu deposit. This kind of I consists of a silicate glass ground mass including chlorides and silicate phases as dms, in various volume ratios. They are primarily distributed in the growth zones of the quartz crystals as a result of primary origin. Electron microprobe analyses of the silicate glass fall within a granitic composition with Cl 0.1-0.36%.

Two kinds of Th were recorded during the microthermometric experiments: the disappearance of the V bubble in the silicate melt (Tv = 1050-1250°C) and/or the partial homogenization by V dissolution in the salt melt (Thp = 1100-1300°C). [This] should be seen as a continuous volume ratio variation between two end members: hydrous silicate melt and hydrous salt melt, trapped as immiscible F.

Hydrous salt melt inclusions. These are representative for the salt melt separated by immiscibility during the transition from magmatic to high hydrothermal conditions when the potassic zone was generated. At room T, they contain more than three solid dms, a V bubble and frequently a L phase. The solid phases identified by optical microscopy, microthermometry, SEM/EDS, PIXE and electron microprobe include: halite, sylvite, other chloride complexes like hydrous Fe chloride, K,Fe-chloride and other metal chloride complexes, K,Al-silicate, anhydrite, hematite, chalcopyrite, magnetite, pyrite, and unidentified transparent and opaque microcrystalline species. A variety of homogenization behaviors were recorded for these many phases.

These data combined with some recent preliminary experimental runs [on] the $KAlSi_3O_8$-NaCl-KCl system lead to these conclusions:

(1) The first stage is porphyry Cu genesis (i.e., potassic zone) is generated at the end of crystallizing shallow intrusion as a result of the immiscibility among a hydrous silicate melt and salt melt. All processes obey the theoretical model developed by Burham in 1979.

(2) The immiscibility hydrous silicate melt-salt melt seems to be a function of the initial magmatic Cl content, T (>1000-1100°C) and variable P conditions.

(3) The aqueous V phase and ore elements were partitioned at the end of magmatic evolution between the hydrous silicate melt and salt melt F. (From authors' abstract by E.R.)

See also FIR, v. 26, p. 138. (E.R.)

PINTEA, Ioan, 1995b, First national symposium on mineralogy: Romanian J. Mineral., v. 76, p. 25-36.

PINTO-COELHO, C. and CHAROY, B., 1994, Probable primary carbonic inclusions in alkaline feldspars of the Serra Branca massif (Goiás, Central Brazil) (abst.): 15th Mtg. of Earth Sciences [15^{e} Réunion des Sciences de la Terre], 26-28 April 1994, Nancy, France, p. 53.

The Serra Branca massif is one of the about 20 granitic massifs which make Goiás a tin province. The Serra Branca massif is composed of two major granites: a western porphyroid granite with only biotite or with minor muscovite, and an eastern granite with only muscovite or with accessory biotite. Deformation and hydrothermal activity are the rule, and the eastern granite is completely greisened. This greisen is polyphase and it is always mineralized with cassiterite, topaz, fluorite and beryl. The primary paragenesis of the two granites is relatively simple, but is characterized by the development of a late non-perthitic microcline. The early alkali feldspar, in majority perthitic (veins and spots), is also a microcline, but it contains abundant carbonic I, triphase at room T. They are generally rectangular with a size of 5 to 10 µm, and they obscure by their multitude the core of the feldspar crystals (phenocrysts or matrix). The I are crystallographically oriented along [001] of the host crystal, and they are typically absent in the margins, especially in parts where the Ab-pericline trellis is optically well visible. The I also disappear near the borders with the broad perthitic veins. The I homogenize to the L, indicating high density. All these features imply a primary origin for these I, earlier than the processes of exsolution and monoclinic-triclinic inversion of the host feldspar. This allows the assumption that the solubility of CO_2, the dominant F phase, in magmas is not negligible, in accordance with experimental results obtained on such systems. The presence of FI in the alkali feldspars contrasts with the presence of numerous mineral I in the plagioclase (An_5-An_{15}). (Authors' abstract, translation courtesy Dr. E.A.J. Burke)

PINTO-COELHO, C., CHAROY, B. and RONCHI, L.H., 1995, Primary aquo-carbonic fluid inclusions in alkali feldspars from the Serra Branca granite (Goiás state-central Brazil) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 186-187. First author at CNPq, Brazil.

Feldspars generally have only SMI, if any. Here, the granite rocks (biotite granite and muscovite granite) are characterized by the occurrence of two contrasting generations of alkali feldspars: (1) the first, supposed to be magmatic, is strongly perthitic and typically crowded by countless FI; (2) the second is metasomatically superimposed (even on the greisen paragenesis) and devoid of any perthite exsolution and FI.

Several lines of evidence indicate that these FI are primary: (a) they are quasi-euhedral (rectangular) and mainly oriented along the [001] axis of the feldspar host which is well shown in appropriate sections; (b) if very abundant in cores of feldspars, they are systematically absent from rims, along the large perthite veins/patches and from zones where the cross-hatched twinning is optically well expressed; (c) they are not represented in all the other major minerals: plagioclase which in turn is crowded by solid I (so great is the contrast that an unambiguous distinction between alkali feldspar and plagioclase can be easily made with uncrossed polars) or quartz which is always recrystallized.

All these features suggest that these FI which are crystallographically controlled were prior to the main stages of exsolution and ordering and were obliterated during the subsequent structural re-equilibration of the feldspar host.

These FI are small (5-10 µm), phase changes are very difficult to observe; the uncertainty can be large (± 1°C). Results are roughly similar for both types of granite:

•Tm CO_2 is in the range -56.7 to -58.2°C, proving the occurrence of CH_4;

•Tm ice occurs ~-0.6°C (very dilute solution);

•Tm of the "likely" clathrates was never really observed (only some sudden convulsive movement of the bubble);

•Th LV(L) (suggesting a high density) occurs between 24.6 and 26.3°C;

•Th total was rarely observed ~240°C, because of the frequent decrepitation.

A micro Raman investigation confirms the coexistence of the CO_2-CH_4 species (3 to 5 mol % CH_4) in the volatile phase. The bulk density of the system is ~0.86 while that of the volatile phase is 0.35. (From authors' abstract by E.R.)

PIPEROV, N.B. and ZIDAROVA, B.P., 1995, Fluid inclusions in synthetic fluorite crystals—Checking of analytical procedures and thermal investigations. *A priori* stretched inclusions?: N. Jb. Miner. Mh. 1995, v. 5, p. 224-240.

FI in synthetic fluorites, crystallized in an autoclave at P = 100-120 MPa and T = 340-464°C in NH_4Cl and LiCl solutions (7-44.6%) were studied. The Th for 32 FI in 32 specimens were determined. The values obtained are considered too high: 100-130° above the expected Th. A version of EGA-MS analysis was tested as a method for analyzing molecular species in the I; water was the only substance identified. The Td are either equal to or higher than the T of synthesis (Tf). Cryometric measurements proved possible with only two specimens. In one Tm represents very well the salinity of the I. The I under investigations seem to be substantially modified even during the short time of synthesis: Some alterations of shape as well as changes in volume are suggested. The I are assumed to be anomalous - partly *a priori* stretched. The intentional T gradient in the autoclave is assumed to be responsible for a difference in F densities, causing a positive difference between internal (in I) and confining P on cooling and, probably, I stretching. (Authors' abstract)

PIRONON, J., DEREPPE, J.-M. and MOREAUX, C., 1994, Characterization of intracrystalline fluid inclusions with proton nuclear magnetic resonance (abst.): 15th Mtg. of Earth Sciences [15^{e} Réunion des Sciences de la Terre], 26-28 April 1994, Nancy, France, p. 44 (in French).

Proton nuclear magnetic resonance (NMR ^1H) has been applied to the study of natural and synthetic FI rich in aqueous solutions and hydrocarbons. The specimens have been analyzed for NMR with magic-angle rotation on a Bruker CXP 90 MHz spectrometer. Spectra obtained from synthetic I containing toluene and isobutylbenzene in KCl show the separated contributions from protons bonded to H_2O and to the hydrocarbons. The integrated intensities of each type of proton of the organic fraction are in good agreement with theoretical data. Synthetic sylvite crystals with a natural oil have a NMR spectrum similar to the spectrum of the pure oil. Different peak ratios (H_{ali}/H_{aro}, CH_2/CH_3, $CH/\Sigma C_{ali}$, hydrocarbon/H_2O) can be calculated. The volume ratio hydrocarbon/H_2O ranges from 3 to 10%, close to the optically measured ratio of 4%.

After this calibration, NMR ^1H has been applied to natural FI of the North Sea Basin. Peaks from CH_4 and aliphatic fractions have been observed, but not a single contribution from aromatic fractions is present. CH_4 concentrations of 3.6 and 1.7 mol/l have been estimated, based on an average alkane composition of *n*-nonane, as determined by infrared microspectrometry.

This study shows that the detection and differentiation of organic fractions of an oil trapped with H_2O in intracrystalline I are now possible with an *in situ* NMR ^1H study. Quantification of the I contents is possible with this non-destructive method. This type of analysis has the following limitations: (1) the specimens should not contain paramagnetic impurities; (2) a volume of 1 cm^3 consisting of millimeter-sized crystals (in order to avoid anisotropy effects) must be analyzed; (3) internal standards cannot be used (precise location of peaks is therefore impossible); (4) different generations of I cannot be separated. (Authors' abstract, translation courtesy Dr. E.A.J. Burke)

PIRONON, J., GRISHINA, S. and MAZUROV, M., 1995, On the origin of molecular nitrogen in salt deposits: the example of Lena-Tungusska oil-bearing region (Siberia) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 188-189. First author at CNRS-CREGU, BP 23, 54500 Vandœuvre-lès-Nancy (France).

Carbonate-evaporite Cambrian deposits of Lena-Tungusska oil-bearing region of Siberian platform are convenient to study the interactions in the system evaporite-brine-oil under influence of basalt intrusions. The objective of present work is the genetic interpretation of nitrogen I from Lena-Tungusska oil-bearing region, and the comparison with other salt environments.

Numerous I filled with variable nitrogen concentrations have been found in Siberian salt rocks. Compositions of pure nitrogen, pure CO_2 and pure CH_4, and various mixtures were found, and H_2S made up to 3% of the total, deduced from Raman analyses. These gaseous I occur in halite in close association with carnallite, sylvite and hematite. FT-IR microanalyses have shown that no NH_4/K substitution occurs in potassium chlorides. Some associations between molecular nitrogen and hydrocarbon have been observed. Hydrocarbon I in planes fluoresce in blue and yellow under UV. Gaseous I have been separated from oil I by necking-down phenomena. Gaseous phases are surrounded by a blue fluorescent film, and the FT-IR analysis has shown the presence of CH_4 and light hydrocarbon (propane). Raman analyses, which have been obtained on gaseous I with very low level of fluorescence, has confirmed the presence of molecular nitrogen. Th of nitrogen-bearing I occurred in L phase at -147°C. Sometimes, critical phenomena have been observed. FT-IR spectra of yellow fluorescent oil I have shown the presence of alkanes (with an average C number of 6 to 7) and CH_4. No CO_2 contamination has been found in such I. From I-mineral associations, Raman analysis of gaseous I and FT-IR data, it can be concluded that molecular nitrogen occurs in KCl zones, rich in hematite, and [is] slightly to strongly affected by dolerite intrusions. Oil and CH_4 I are observed far from the sills, whereas CO_2 I and carbonaceous materials are located near the sills. The N_2-rich I area is also marked by the presence of ammonium-free potassium chlorides.

These results are in good agreement with data from Germany, Ukraine, Russian platform, France and Gabon.

Comparisons between Siberian salt series and other salt environments clarify the origin of molecular nitrogen concentrations in I. N_2 is present in potash zones affected by magmatism. During early diagenesis, ammonium ions are produced by deamination of organic compounds and are stored in potassium chlorides (sylvite and carnallite). If magmatic intrusions take place in salt series, the redox conditions can be modified: carbonate destruction can produce CO_2 and an oxidizing F. Consequently, ammonium ions in chloride minerals are oxidized to produce molecular nitrogen which can be trapped in I during salt recrystallization. (From authors' abstract by E.R.)

PIRONON, Jacques, PAGEL, Maurice, LÉVEQUE, Marie-Hèléne and MOGÉ, Michel, 1995, Organic inclusions in salt. Part I: Solid and liquid organic matter, carbon dioxide and nitrogen species in fluid inclusions from the Bresse basin (France): Org. Geochem., v. 23, no. 5, p. 391-402. First author at GDR CNRS-CREDU no. 077, BP 23, 54501 Vandoeuvre-lès-Nancy, France.

Organic I from the Etrez and Cormoz areas of the Paleogene Bresse salt basin (France) have been studied. Different organic fractions are trapped with brine solutions in FI in halite. Isolated I from both areas are brine-bearing, and organic matter is sometimes associated with dps (carbonate, sulfate, clay). Structured and unstructured solid organic matter is observed both in the Etrez area (central basin) and in the Cormoz area (Northern ridge), while L organic droplets are only observed in FI from the Cormoz area. FT-IR microspectroscopic measurements show a low aliphatic contribution, and the presence of aromatic and O double bonds for the solid organic matter. Low to high aliphatic contents (C5 and C7+, deduced from CH_2/CH_3 ratio measurements), low to high C=C and C=O contributions, and the presence of characteristic C-N functions of amino-acids are detected in L droplets by FT-IR spectroscopy. CO_2, originating from the thermal degradation of solid organic matter, is generally detected. Organic two-phase I (brine + L organic matter) in planes are located in clear halite crystals from the Cormoz area. High aliphatic contributions, and variable aromatic and O contents are observed. Ammonium ions (NH_4^+) are detected in the brine solution, and no CO_2 contribution is recorded. Organic matter trapped in the halite of the Bresse basin is immature to early mature. In the deeper part of the basin (Etrez, 800-1000 m), the organic matter in the I is slightly thermally degraded, with little or no generation of L organic compounds. This agrees with the data on organic matter previously published from this area. In the Northern ridge (Cormoz, 500-800 m), L heteroatomic compounds (C, H, O, N) were produced, migrated through the salt and were trapped without G phases. This implies a slightly lower T in the deeper part (Etrez) of the Bresse basin. Differences in thermal gradients between the Northern ridge, and the deeper part of the Bresse basin, must be invoked to explain differences in organic matter maturation. The analysis of organic I is a contribution to understanding the thermal and biochemical history of the Bresse basin by the in situ observation of organic evolution products which are preserved by entrapment in salt. (Authors' abstract)

PIRONON, Jacques, PAGEL, Maurice, WALGENWITZ, Frédéric and BARRÈS, Odile, 1995, Organic inclusions in salt. Part 2: Oil, gas and ammonium in inclusions from the Gabon margin: Org. Geochem., v. 23, no. 8, p. 739-750. First author at GDR CNRS-CREDU no. 077, BP 23, 54501 Vandoeuvre-lès-Nancy, France.

Organic I have been found in a salt diapir south of Port-Gentil in the North Subbasin of the Gabon margin. Two main types of organic I are described. Type I G-rich (CH_4 and CO_2) oil I located in recrystallized halite, associated with a complex mineral daughter paragenesis: anhydrite, quartz, K-feldspar, dolomite, ammonium sylvite and carnallite (1 and 2.5% molar NH_4Cl, respectively). The oil is essentially aliphatic with some aromatic content, the composition being characteristic of mature oil. The different CH_4/C_2 + ratios in the G and oil phases indicate an internal P ~200 bars, which is compatible with hydrostatic P at sampling depth. Th of two-phase hydrocarbon I inside dolomite dxls have been measured (Th = 113°C). Type 2 organic I are located in healed fracture planes in recrystallized halite and contain aliphatic oil; the brine content is high, and no G have been detected. Different alkane compositions occur in different fracture planes. Type 2 I correspond to injections of mature oil into halite fracture systems at low T (≈60°C). Comparisons between FI in halite occurring in the Bresse area (France), and in the North Subbasin of the Gabon margin, help one to follow C and N cycles from diagenesis to catagenesis. The organic inclusions hosted in salt rocks reflect the geochemical reactions that have occurred in the salt over time. (Authors' abstract)

PLESHAKOV, A.M. and SHUKOLYUKOV, Y.A., 1994, Isotopic variations of helium in the diamonds of the Kokchetav massif's metamorphic rocks, Kazakhstan, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 229-243. Authors at Vernadsky Inst. Geochemistry and Analytical Chemistry, Russian Acad. Sci., 117975 Moscow, Russia.

Isotopic composition and concentration of He was studied in microdiamonds (14, 28 and 60 µm size) from metasomatites of the Kokchetav massif, Northern Kazakhstan. Isotope abundances of this diamonds are higher than all measured values to date. The diamonds do not possess the properties of the classical "mantle" juvenile He. On the contrary, all the data obtained show that the diamonds have emerged in the environment typical of the crust substance. We have not found out convincing properties of the ion-implantation mechanism of the penetration of ^{3}He into the Kokchetav diamonds. On the contrary, the available data favours the view that the crust F and noble G might were brought to the structure of the growing diamonds under the changing physicochemical conditions at the metasomatosis of the rocks. On the available data grounds, as difficult validate or disprove to the hypothesis that together with diamonds contaminants carriers of anomalous ^{3}He (Verchovsky et al., 1993). [sic] (From authors' abstract by E.R.)

PLIMER, I.R., LU, J., FOSTER, D. and KLEEMAN, J.D., 1995, Ar-Ar dating of multiphase mineralisation associated with the Mole

Granite, Australia, *in* Pasava, Kribek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 497-500. First author at The Univ. Melbourne, Vic., Australia.

The Late Permian Mole Granite is a sill-like high-level mass of highly specialised granite which has been the source of 30,000 tons of Sn in cassiterite, wolframite, topaz and base metals from five phases of mineralisation. The mineralisation exhibits thermal resurgence associated with intrusion of the latest phase of granite emplacement. An evolving magmatic F-dominated hydrothermal history over a 4-5 m.y. period was punctuated by the ingress of meteoric F. (Authors' abstract)

FI in pegmatite had Th 510-580°C, indicating boiling. Mo-W-Bi stockworks gave Th 280-400° and 4-14% NaCl. Topaz from greisen gave Th 520-620°. Simple veins gave lower values. (E.R.)

PLUMLEE, G.S., GOLDHABER, M.B. and ROWAN, E.L., 1995, The potential role of magmatic gases in the genesis of Illinois-Kentucky fluorspar deposits: Implications from chemical reaction path modeling: Econ. Geol., v. 90, p. 999-1011. First author at U.S. Geol. Surv., MS 999, 345 Middlefield Road, Menlo Park, CA 94025.

In this paper, we present results of reaction path calculations using the chemical speciation and reaction path programs SOLVEQ and CHILLER to model possible fluorite deposition mechanisms in the Illinois-Kentucky fluorspar district. Input to the reaction path calculations were the T, salinities, and concentrations of major cation and anions (Na, K, Cl, SO_4, etc.) and dissolved gases (H_2S, CO_2, etc.) in the hydrothermal F, based on published FI data and unpublished FI G compositions.

These results indicate that the F responsible for Illinois-Kentucky fluorspar mineralization were most likely quite acidic (pH <4) and rich in fluorine in order to produce the fluorite-rich, dolomite-poor mineral assemblages and extensive dissolution of host limestones. A possible source for the acid and fluorine may have been HF-rich gases which were expelled from alkalic magmas and then incorporated by migrating basinal brines. (From authors' abstract by E.R.)

PLUSCHEV, E.E., DIMITROV, D.L. and MLADENOVA, Vasilka, 1995, Characteristics and environments of epithermal deposits in the Eastern Rhodopes (Bulgaria): Geol. Soc. Greece, Sp. Publ., No. 4, p. 823-828.

FI data on Au-polymetallic deposits is integrated in the description of deposit characteristics. (H.E.B.)

PLUTA, Irena and ZUBER, Andrzej, 1995, Origin of brines in the Upper Silesian Coal Basin (Poland) inferred from stable isotope and chemical data: Appl. Geochem., v. 10, p. 447-460.

PLYUSNINA, L.P., NEKRASOV, I.Ya. and SHCHEKA, Zh.A., 1995, Experimental investigation of platinum solubility in aqueous chloride solutions at 300° to 500°C and 1 kb: Dokl. Ross. Akad. Nauk, v. 340, no. 4, p. 525-527 (in Russian).

POBEREGSKY, A.V. and PERYT, T.M., 1995, Physico-chemical conditions of gypsum crystallization in the Middle Miocene Badenian basin of the Carpathian foredeep in light of fluid inclusion study (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1. Note: Late(?) one-page abstract, unpaginated and not bound in Abstracts volume. First author at Inst. Geology and Geochemistry of Combustible Minerals, Nat'l Acad. Sci. Ukraine, Naukova 3a, 290053, L'viv, Ukraine.

Rather large P FI (40-300 μm) were found in sedimentary coarse-crystalline gypsum varieties. Some are related to the growth zones of crystals and formed due to preservation of different fossil microorganisms, mostly cyanobacteria, during gypsum crystallization at the basin bottom. The shapes of such I are aligned, ellipsoidal and spherical, the sizes range from a few to 200-300 μm. Altogether 10 representatives of different organisms were recorded.

Chemical analyses of solutions contained in these I showed that the basin brines were of the sodium sulphate type. The total mineralization of waters in the Badenian basin—5-7%, and in some cases even <1%—appeared to be much lower than the concentration of marine waters at the stage of gypsum precipitation. These solutions contain mainly NaCl as well as Mg, Ca and K salts. The solutions are gas-saturated; the origin of gas is in many cases related to degradation of organic matter. The composition of the G (CO_2, N, CH_4, rare hydrogen and H_2S) indicates anaerobic conditions at the bottom of the sedimentary basin in which gypsum precipitated. (From authors' abstract by E.R.)

POMARLEANU, Vasile and GATTER, István, 1992, Cryometric determinations of the fluid inclusions in the vein quartz associated with the Marca-Malcoci barite mineralization (Northern Dobrogea): Rom. J. Mineral Deposits, v. 75, p. 93-95 (in Romanian, English abstract).

The vein quartz from barite occurrences in the Triassic limestones of the Marca-Malcoci district (Northern Dobrogea) formed at T between 139° and 165°C, from hydrothermal solutions of low concentration (2.49-2.48% NaCl) and with density ranging from 0.919 to 0.949 g/cm^3. (Authors' abstract)

POMARLEANU, Vasile and IMREH, Iosef, 1993, Celestine occurrence at Ivancauli (north of the Moldavian Platform): Rom. J. Mineral Deposits, v. 76, p. 47-51 (in French, English abstract).

The chemistry of the celestiniferous limestones, crystallography, chemistry and certain growth particularities of celestine and Th FI of this mineral are presented. Sr redistribution and celestine formation have taken place subsequently to the diagenetic process. (Authors' abstract)

POPP, R.K., VIRGO, David, YODER, H.S., Jr., HOERING, T.C. and PHILLIPS, M.W., 1995, An experimental study of phase equilibria and Fe oxy-component in kaersutitic amphibole: Implications for the fH_2 and aH_2O in the upper mantle: Am. Mineral., v. 80, p. 534-548.

PORCELLI, D. and WASSERBURG, G.J., 1995, Mass transfer of helium, neon, argon, and xenon through a steady-state upper mantle: Geochim. Cosmochim. Acta, v. 59, p. 4921-4937.

PORTNYAGIN, M.V. and SOBOLEV, A.V., 1995, Melting beneath immature island arc: Evidence from melt inclusions study of Cyprus volcanics (abst.): Eos, v. 76, no. 17, p. S267. Authors at Vernadsky Inst. Geochemistry and Analytical Chemistry, Kosigin St. 19, Moscow, Russia.

The processes governing geochemical features of island arc basalts are not well understood yet. Here we present data on MI that allowed [us] to evaluate the contribution from both subarc mantle and subduction related components. The study was carried out on the sample of primitive arc tholeiite from the lower section of the Troodos lava complex that is thought to be formed at the earliest stage of the Cyprus arc formation (Shmincke et al., Geology, 11, 405, 1983). Inclusions in high-Mg olivines (Fo_{84-92}) were homogenized with optical control and, after quenching, analyzed by electron and ion probes for major, trace elements and H_2O. The compositions of I display [a] broad range of incompatible elements and their ratios ($[La/Sm]_N = 0.1$-2, Ti/Zr = 40-860). the most LREE depleted M suggest the origin by near fractional melting (Sobolev and Shimizu, EOS, 74, no. 43, 660, 1993). However, the majority of studied M show clear signature of slab-derived components which strongly affect some element ratios predicted from mantle melting models (e.g., $[K/Nb]_N$ is increased up to 10). We suggest [the existence of] at least two of such subduction-related components. One, largely supplying water (H_2O ~1.5 wt % in the melts), appears to be F, taking into account high H_2O/K_2O ratio (≤200) recorded in some M. The other is likely silicate M and characterized by enriched REE pattern ($[La/Sm]_N$ ~2), high K and strong negative Nb (and Ti?) anomalies. This component was locally added into the source region and caused LREE and K enrichment versus HFSE. Positive Sr anomaly, commonly found in arc basalts, is not an universal feature of the Cyprus melts ($[Sr/Ce]_N = 0.6$-40). Furthermore, Sr does not correlate either with water or LREE and K. Such behavior of Sr is explained by independent enriching process which is not necessarily subduction related. More likely, this may be [the result of] melting of the mantle locally enriched in plagioclase or interaction of some M with plagioclase cumulates in the lower crust or magma chamber. (Authors' abstract)

POULSEN, T., 1995, Fluid evolution during formation of the Ivigtut cryolite deposit, South Greenland: Evidence from fluid inclusions (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 190-191. Author at Dept. Geology and Mineral Resources

Engineering, Norwegian Inst. Technology (NTH), Høgskoleringen 6, 7034 Trondheim, Norway.

FI (mostly PS to S) in siderite, quartz, cryolite and fluorite from different parts of the deposit have been analyzed. The I are of three types: (1) H_2O - CO_2 ± H_2S ± Solids, (2) H_2O ± H_2S ± Solids and (3) CO_2 - H_2O. The salinity of the I vary with relative age from 0-22 wt % NaCl eq., the earliest (i.e., type 1) generally being the most saline. Te in aqueous I at -50.7°C to -30.2°C and occurrence of solid I of fluorite and carbonates indicate presence of solutes other than Na (e.g., Ca, Fe and K). CO_2-content of type 1 I is relatively low, whereas type 3 I in all the investigated minerals are quite CO_2-rich (80-95 vol %). The CO_2-phase in both type 1 and type 3 is very pure. H_2S (immiscible) and solid I are found almost exclusively in I in cryolite, and both result from late secondary processes. Th tot L of the I occur at 325-340°C for early saline H_2O-CO_2 I, at 142-295°C for slightly younger, moderately saline H_2O-I, at 176-268°C for late low-salinity CO_2-H_2O and H_2O-I and at 124-173°C for very late saline H_2O- and CO_2-H_2O I.

General geological information, combined with the spatial relations and F compositions of the analyzed I, suggest an early separation of the F precursors of the quartz-siderite unit and the cryolite body (melt-melt immiscibility?). Early crystallization of siderite (+ fluorite and quartz) from an aqueous F enriched in CO_2 (~10 mol %), H_2S and dissolved halogens drastically changed the pH and Eh of the remaining F, causing supersaturation with respect to H_2S which led to deposition of basemetal sulphides. FI evidence of the following intermediate stage is scanty, but I in siderite and early fluorite suggest a drop in salinity (from 20 to 10-15 wt % NaCl eq.) and CO_2 (from 10 to 0 mol %). During the later stages of crystallization the CO_2-content of the F phase became higher, probably due to decrepitation of earlier H_2O-CO_2-I. These low-salinity F were trapped more or less at the H_2O-CO_2 solvus, leading to immiscible separation of CO_2-rich and H_2O-rich F. In the closing stage of formation of the deposit early saline (~20 wt % NaCl eq.) H_2O-CO_2 I in cryolite and fluorite re-equilibrated within the immiscibility field of the H_2O-CO_2 system. This phase separation probably led to small sulphosalt mineralizations in the fluorite unit (through re-use of earlier trapped H_2S?).

T and P of formation for the initial stages are not easily obtained, because of difficulties in homogenizing the H_2O-CO_2 I, but Th_{tot} = 325-340°C for early siderite set the initial conditions at at least 340°C and 1.5 kb. Likewise, the late immiscible entrapment of CO_2-, H_2O- and H_2O-CO_2 F set the conditions of the final stages at 225-270°C (depending on CO_2-content) and 1 kb. Intense brecciation in early and late stages of the formation of the deposit suggest periods of overpressuring/de-pressuring, probably due to high CO_2-levels in the F. (From authors' abstract by E.R.)

POUTIAINEN, M., 1995a, Magmatic versus metamorphic fluids in the Siilinjärvi carbonatite complex, eastern Finland: A fluid inclusion study of zircon and apatite (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 192-193. Author at Dept. Geology, Univ. Helsinki, PO Box 11, FIN-00014, Finland.

In the studied zircon and apatite crystals two types of FI occur: Type 1 CO_2-H_2O low salinity (XCO_2 = 0.42 to 0.87; XNaCl = 0.001 to 0.005) with bulk densities of 0.73 to 0.87 g/cm^3, and Type 2 H_2O moderate salinity (XNaCl = 0.03 to 0.06) with densities of 0.83 to 1.02 g/cm^3. Type 1 is present only in zircon, where the observed types occur in separate domains: around (Type 1) and outside (Type 2) the apparent core. FI are further subdivided into PS (Type 1a and 2a) and S (Type 1b, 2b and 2c) I. Using a combination of SEM-EDS, optical characteristics and crushing-stage, various daughter and captive minerals were identified (calcite, apatite, phlogopite, baryte, Na-K chlorides, magnetite).

The data suggest that the PS Type 1a and Type 2a I in zircon and apatite were trapped during the pre-emplacement evolution of the carbonatite at mid-crustal conditions. The Type 1 F was obviously involved in fenitization. During emplacement of the carbonatite to the present level, zircon phenocrysts were intensively fractured, some Type 1a I were re-equilibrated (Type 1b), and multiphase Type 2b I were trapped. It is assumed that all these I in zircon and the PS Type 2a I in apatite have a magmatic origin.

Mineral geothermometers suggest a crystallization T range of c. 300 to 420°C for the apatite. This low T range may be attributed to the postcrystallization re-equilibration processes during the regional metamorphism c. 1.9 Ga ago. Late-stage fluorine and hydroxyl exchange may have occurred at low T with an aqueous F. In apatite, calcite I occur side-by-side with the S Type 2c aqueous I. These calcites coexisted with the aqueous F during fracturing and metamorphic re-crystallization of apatites. Probably, this F also is responsible for the transport and deposition of at least some of the calcite at low T (200-350°C). (From authors' abstract by E.R.)

See also next item. (E.R.)

POUTIAINEN, Matti, 1995b, Fluid inclusion evidence for the formation conditions of zircon and apatite: Bull. Geol. Soc. Finland, no. 67, part 1, p. 3-18.

Full paper for previous item. (E.R.)

PRESNELL, Ricardo and PARRY, W.T., 1995, Evidence of Jurassic tectonism from the Barneys Canyon gold deposit, Oquirrh Mountains, Utah: Geol. Soc. Am. Spec. Paper 299, p. 313-326. First author at Kennecott Exploration Co., PO Box 11248, Salt Lake City, UT 84147.

Detailed geologic mapping, clay mineralogy, and FI analyses together with Jurassic K/Ar age determinations indicate that deformation at Barneys Canyon was contemporaneous with regional Jurassic metamorphism recognized in the southern Oquirrh Mountains by Wilson and Parry (1990b).

FI analyses from quartz and barite show a range of Th from 130-400°C with two weak modes at 225°C and 345°C. Kaolinite and quartz are unstable with respect to pyrophyllite at the higher T. No pyrophyllite has been observed at Barneys Canyon restricting the kaolinitic alteration to the lower-T range. The Tf of illite is not constrained. (From authors' abstract by E.R.)

PRICE, P.B., 1995, Kinetics of conversion of air bubbles to air hydrate crystals in Antarctic ice: Science, v. 267, p. 1802-1804. Author at Physics Dept., Univ. California, Berkeley, CA 94720.

The depth dependence of bubble concentration at pressures above the transition to the air hydrate phase and the optical scattering length due to bubbles in deep ice at the South Pole are modeled with diffusion-growth data from the laboratory, taking into account the dependence of age and T on depth in the ice. The model fits the available data on bubbles in cores from Vostok and Byrd and on scattering length in deep ice at the South Pole. It explains why bubbles and air hydrate crystals coexist in deep ice over a range of depths as great as 800 m and predicts that at depths <-1400 m the AMANDA neutrino observatory at the South Pole will operate unimpaired by light scattering from bubbles. (Author's abstract)

PRIETO, M., PANIAGUA, A. and MARCOS, C., 1995, Formation of primary fluid inclusions by influence of the hydrodynamic environment (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 194-195. Authors at Dpto. Geología, Univ. Oviedo. Spain.

The most common causes of trapping of F during the crystal growth lead to a random and sparse distribution within the host. However, trapping of F may also occur under certain hydrodynamic conditions which promote an uneven distribution of inclusions. Formation of inclusions, downstream, in the rear side of the crystal, has been observed in crystal growth from solutions under poor stirring. In this work, the influence of the hydrodynamics on the trapping of F is studied for different configurations and experimental observations are compared with natural occurrences.

With this aim, crystals of KH_2PO_4 and $NH_4H_2PO_4$ were grown from solutions in a controlled convection system. The interrelations of the parameters growth rate, surface roughness, solution velocity, Reynolds number, supersaturation, and boundary layer formation are explored, to explain "starvation" effects, formation of macrosteps, and subsequent formation of FI in the rear zone of the crystal, beyond a critical point on the surface. The number of I increases as the bulk supersaturation increases and the solution velocity decreases.

Behind the crystal, at low Reynolds numbers, a large stable eddy is found. Since the eddy is closed, exhaustion of its solution can occur, which give rise to the formation of I along the backside of the crystal. At high supersaturations the starvation effect may even lead to formation of open holes. (From authors' abstract by E.R.)

PROCHASKA, W., HAFELLNER, M., BANKS, D.A. and

YARDLEY, B.W.D., 1995, Relation between metamorphism and mineralization in the Eastern Alps of Austria, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 901-904. First author at Dept. Geosciences, Univ. Mining and Metallurgy, Leoben, Austria.

According to the structure and on the basis of stable isotope analyses and crush-leach analyses of mineralizing F different groups of alpine mineralizations in the Eastern Alps can be distinguished. Quartz-siderite mineralizations were formed in the early Jurassic by formation water, possibly influenced by evaporitic sediments. In the Cretaceous syntectonic (synmetamorphic) ductile shearzones in deep crustal segments were formed. The corresponding F still show some similarities to seawater and are interpreted as F expelled from sedimentary series of deeper tectonic units. The rocks in the shear are leached phyllonites and possibly the sourcerocks of mineralizations in tectonically higher positions. After the peak of the Cretaceous metamorphism mineralized quartz veins were formed (meteoric water signature) in an extensional phase due to the uplift and exhumation of metamorphosed crustal segments. Vein type mineralizations in the Tertiary are rare in the Austroalpine units and are possibly related to devolatilization F of the "late Alpine metamorphism" of the underlying Penninic Unit. (Authors' abstract)

PROCHASKA, W., POHL, W., BELOCKY, R. and KUCHA, H., 1995, Tertiary metallogenesis in the Eastern Alps: The Waldenstein hematite deposit (Austria): Geol. Runds., v. 84, no. 4, p. 831-842.

Indexed under FI. (E.R.)

PROKOF'YEV, V.Yu., AFANAS'YEVA, Z.B., IVANOVA, G.F., BOIRON, M.C. and MARIGNAC, Ch., 1994, Fluid inclusions in minerals at the Olimpiada Au-(Sb-W) deposit, Yeisey Ridge: Geokhimiya, no. 7, p. 1012-1029 (in Russian; translated in Geochem. Int'l, v. 32, no. 2, p. 104-121, 1995).

Abstract in FIR, v. 27, p. 115. (E.R.)

PROKOF'YEV, V.Yu., SPIRIDONOV, A.M., GNILUSHA, V.A. and KOVALEVA, V.F., 1992, Genesis of alkalic granite in the Kari ore cluster in Siberia, as inferred from a study of melt and fluid inclusions: Dokl. Ross. Akad. Nauk, v. 326, no. 3, p. 521-523 (in Russian; translated in Trans. (Dokl.) of Russ. Acad. Sci. (Earth Sci. Sect.), v. 328, p. 113-xxx, 1994). Authors at Vinogradov Inst. Geochemistry, Siberian Dept., Russian Acad. Sci., Irkutsk, Russia.

Alkalic vein granite, locally called "grorudite," occupies a special place in the geologic history of the Kari magmatic ore structures, since it contains the Au ore. However, there is no agreement as to its origin or role in the hydrothermal process. It usually occurs as complex stockwork systems of veins and veinlets, ranging in thickness from 0.01 to 0.3 m. Their rock-forming minerals are quartz, microcline, albite and aegirine, the most characteristic accessory mineral being sphene. We investigated the FI in the quartz of grorudite rock. (From authors' abstract by E.R.)

PROSPERT, C. and BIINO, G.G., 1995a, Fluid-rock interactions in the polymetamorphic metasedimentary rocks of the Silvretta thrust sheet (eastern Alps) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 196-197. Authors at Inst. Mineralogy and Petrography, Perolles, CH-1700 Fribourg, Switzerland.

The Silvretta thrust sheet metasediments contain quartz-andalusite veins. In order to understand the formation of the veins and the related F circulation, field study was carried out in a 4 km^2 area near Davos (Pishahorn). FI study has been performed on the quartz from the first generation of veins. No unambiguous P FI have been recognised, and we have paid special attention on large horizontal planes which contain CH_4-N_2 FI. Reequilibrated FI and particularly annular FI have been identified. Microthermometric data display a large variation of the Th which ranges from -90°C to -170°C. According to Raman analysis, this variation is due to a variation of density. That result and textural relationships involve from the initial P condition to the later recorded by reequilibrated FI an increase of 3 kb. That result and textural observation provide constraints on the P-T-t path. (From authors' abstract by E.R.)

PROSPERT, C. and BIINO, G.G., 1995b, Late Variscan fluid infiltration in the polymetamorphic metasediments of the Silvretta thrust sheet (Switzerland) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 312.

We investigated the structural and petrologic evolution of polymetamorphic metasedimentary rocks and Qtz-And veins in the Silvretta thrust sheet (Austroalpine basement). Theoretical calculation of F-rock interaction, advective transport and FI study have been performed in order to better constrain the late Variscan event. (From authors' abstract by H.E.B.)

See adjacent items. (E.R.)

PROSPERT, C. and BIINO, G.G., 1995c, Genetic mechanism of quartz-andalusite veins in the Silvretta nappe as suggested by field, microscopic and fluid inclusion data (abst.): Schweiz. Mineral. Petrogr. Mitt., v. 75, p. 312-313.

See previous item. (E.R.)

PITTSYN, A.C., 1995, Calculating freezing points for aqueous electrolyte solutions: Geokhimiya, no. 3, p. 456-561 (in Russian; translated in Geochem. Int'l, v. 32, no. 11, p. 149-154, 1995).

QIN, Jianxiong, XU, Xinhuang and LI, Baohua, 1995, A study of the geochemical characteristic of inclusions in the Wuxu polymetallic ore field: J. Chengdu Inst. Technology, v. 22, no. 1, p. 69-77 (in Chinese).

QIN, Jianxiong, ZHANG, Changjun, LI, Tiansheng and LI, Yungang, 1995, Fluid inclusions in the Xichang Basin and their applications in oil-gas exploration: Chinese J. Geochem., v. 14, no. 3, p. 264-275 (in English). First author at Inst. Sedimentology, Chengdu Inst. Technology, Chengdu 610059, PRC.

FI are commonly observed in various stages during the diagenetic evolution and the generation, migration and accumulation of hydrocarbons in Lower Permian carbonate rocks in the Xichang Basin, providing direct physico-chemical evidence for the process. Altogether seven stages can be recognized, i.e., the penecontemporaneous, early and mid-late diagenetic stages, the epidiagenetic stage and the early, middle and late reburying stages. Karst and dissolution pores and structural fissures developed during the epidiagenetic and reburying stages constitute the major reservoirs for hydrocarbon accumulation. Oil generation and migration began in the early reburying stage in Late Permian time and developed to its climax in the middle reburying stage in the Triassic period, followed by extensive, generation and migration of natural gases during the late stage of reburying in the Jurassic and later periods. The generation, migration and accumulation of hydrocarbons are closely related to Hercynian basalt eruption and Indosinian and Yenshanian tecto-magmatism. (Authors' abstract)

QIN, Ming, BAI, Wachen and REN, Lingzi, 1995, Fluid inclusion factors of gold elevation on vein gold deposits in Xiaoqinling: Gold Geol., v. 3, p. 54-60 (in Chinese).

QING, Hairuo and MOUNTJOY, E.W., 1995, Paleohydrogeology of the Canadian Rockies and origins of brines, Pb-Zn deposits and dolomitization in the Western Canada sedimentary basin: Comment: Geology, v. 23, p. 189-190.

A discussion of Nesbitt and Muehlenbachs (1994) (FIR, v. 27, p. 98). For reply see Nesbitt and Muehlenbachs, this volume. (E.R.)

QIU, Zhili, QIN, Shecai and PANG, Xuebin, 1995, The genesis of corundum megacrysts related to alkali basalt in Hainan: Acta Scientiarum Naturalium Univ. Sunyatseni (Zhongshan Daxue Xuebao): v. 34, no. 3, p. 95-101 (in Chinese, English abstract).

Penglai of Hainan province is one of the important localities of sapphire in China. The corundum megacrysts are related to Cenozoic alkali basalt and have the following features: having clear surface melted structure and containing zircon and tiniobite [sic] and CO_2-bearing F MI with Th 1125-1265°C, being rich in light REE and having the REE distribution pattern similar to that of hypersthene granite, mother rock of pegmatite-type corundum, but different from those alkali basalts. (From authors' abstract by H.E.B.)

QUÍLEZ, E., MORALES, S., BOIRON, M.C. and CATHELINEAU, M., 1995, P-V-T-X-fO_2-fS2-pH conditions of the W-sulphide deposition in a hydrothermal vein system: El Estepar (Spanish Central System), *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 381-383. First author at Centro de CC, Experimentales y Técnicas, Univ. San Pablo-CEU, Boadilla del Monte, Madrid, Spain.

El Estepar ore deposit provides good evidences of hydrothermal transport and deposition of W, followed by sulphides in the Spanish Central System and serves to highlight the important role of the complex carbonic-aqueous F in this process. FI data, mineral chemistry and mineral assemblages, made possible to estimate fO_2-fS_2-pH at the P-T conditions of ore deposition. (Authors' abstract)

QUILEZ, E., MORALES, S., BOIRON, M.C., CATHELINEAU, M., VINDEL, E. and LOPEZ-GARCIA, J.A., 1995a, Fluid inclusion studies and geochemical features of the formation of W-Mo-sulphides from Cabeza Lijar ore deposits (Spanish Central System) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 198-199. First author at Centro de CC. Experimentales y Técnicas, Univ. San Pablo-CEU. 28668 Boadilla del Monte. Madrid. Spain.

The W-Mo-sulphide ore deposit from Cabeza Lijar is closely associated with a shallow, highly differentiated late Hercynian porphyritic leucogranite intrusion.

The multistage W-Mo-sulphide veins show a complex F evolution with clearly definite F stages which are structurally controlled.

Stage I corresponds to an early high salinity, high density and high T F. It is represented by trapping of isolated Lw-s I containing halite and $CaCl_2$ and $MgCl_2$ as dms. This brine (53-43 % wt. eq. NaCl) trapped at high T (475°-350°C) is probably of magmatic origin, and it has circulated during an early faulting episode causing subsequent greisen alteration.

Stage II is characterized by complex carbonic-aqueous solutions represented in the ore deposits by Lc-w I trapped in quartz intergrowth with wolframite and later wolframite-bearing quartz. This solution with salinities between 7 to 4% wt eq. NaCl and density ranging from 0.9 to 0.8 $g.cm^{-3}$ circulated at minimum T in the range of 385° to 350°C. The P-T conditions of trapping estimated from isochores are >300°C and 3 Kb. This P is higher than the hydrostatic P, and is likely lithostatic, indicative of a relative deep structural level. Neither Raman spectrometry nor microthermometric data revealed intermediate compositions between Lw-s and Lc-w I.

Stage III is represented by trapping of Lw-(c-m) I from NaCl-CO_2-CH_4-N_2 system as a result of F mixing. Circulation of F during this stage is represented by a wide range of Th (340°-150°C), salinities (8-1% wt. eq. NaCl) and densities (0.9-0.6 $g.cm^{-3}$). The P-T conditions of trapping correspond to T >250°C and P >100 bars

The Lc-w (stage II) and Lw-(c-m) (stage III) are considered associated with deposition of the minerals from W-Mo stage.

Stage IV corresponds to the circulation and trapping of isolated Lw-m I in the quartz intergrowth with sulphide phases. These FI display F composition from the H_2O-NaCl-CH_4 system, with low to moderate salinities (8-1 wt % eq. NaCl), moderate densities (0.9-0.7 $g.cm^{-3}$) and Th ranging between 210° to 180°C. The minimum P-T trapping conditions is 200°C and 100 bars. The circulation of this F is considerated associated with the Cu-Zn-Fe-Sn sulphides-chlorites.

Stage V to the circulation and trapping of low salinity (3-1 wt % eq. NaCl) aqueous solutions represented by Lw I, homogenizing at low T (190°-130°C).

FI data, mineral chemistry and mineral assemblages enable us to characterize the physical and chemical conditions of the ore deposition at Cabeza Lijar. In general, decrease of T associated with a decrease of the fO_2, an increase of the fS_2 and a change of the pH through the two stages can be observed.

Deposition of wolframite is related to the loss of CO_2 in the system which provokes the variations in the pH and an increase the dielectric constant of the F. Furthermore, the decrease of T and salinity in the hydrothermal evolution has a decisive influence in the decrease of the ionic strength of the solutions and in the increase of Fe^{2+}, Mn^{2+} and WO_4^{2-} activities.

Sulphide precipitation is related to a decrease of the T and salinity of the F mainly from mixing of hydrothermal solutions with cooler meteoric waters. (From authors' abstract by E.R.)

QUILET, E., MORALES, S., BOIRON, M.C., CATHELINEAU, M., VINDEL, E. and LOPEZ-GARCIA, J., 1995b, Physical and chemical conditions (P-V-T-X-fO2-fS2-pH) of ore formation from Cabeza Lijar (Spanish Central System) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 290.

The Cabeza Ljiar ore deposit provides good evidence of hydrothermal transport of W-Mo-(Cu-Zn-Pb-Sn) and deposition of tungsten and sulphides in the Spanish Central System and serves to highlight the important role of the complex carbonic-aqueous F behaviour in this process. FI, mineral chemistry and mineral assemblages, made possible the calculation of fO_2-pH, fO_2-fS_2 and fO_2-T evolutions and the characterization of the physical and chemical environment of ore deposition from W-Mo to Cu-Zn-Fe-Sn sulphides stages at Cabeza Lijar. In the W-Mo stage, molybdenite, rutile, magnetite, muscovite and garnet appear associated with wolframite. In the sulphide stage, chalcopyrite, sphalerite, pyrite, stannite, Pb-Bi-Ag sulphides and sulphosalts are deposited together with chlorite. Textural relationships and FI data indicate W-Mo and sulfides were formed from two different F. W-Mo deposition is related to a moderate salinity H_2O-NaCl- CO_2-CH_4-N_2 F at high T-P. During the evolution exists a drop in the trapping conditions of complex carbonic-aqueous solutions, T ranging from 380° to 250°C, a change of P from lithostatic to hydrostatic conditions (3 kb to 100 bars) and CO_2 dilution until disappears in the system [sic]. Later sulphides were deposited from a low salinity H_2O-NaCl-CH_4 F at lower P-T (200°C, 100 bars) These changes have associated a decrease of the fO_2, a increase of fS2 and a change of the pH across the two stages. (Authors' abstract.)

RAFIKOVA, F.Z., 1995, Scapolite mineralization of the Kukurt gemstone complex (East Pamir): Vestnik Moskovskogo Univ., Geologiya, 1994 (in Russian; translated in Moscow Univ. Geology Bull., v. 49, no. 6, p. 46-50).

Th, decrepitation, FI fluid chemistry and petrography is described for a variety of scapolites found in the Kukurt Complex. (H.E.B.)

RAHN, Meinert, MULLIS, Josef, ERDELBROCK, Kersten and FREY, Martin, 1995, Alpine metamorphism in the North Helvetic flysch of the Glarus Alps, Switzerland: Eclogae Geol. Helvetiae, v. 88, p. 157-178.

Indexed under FI. (E.R.)

RAITH, J.G., GRUM, W., PROCHASKA, W. and FRANK, W., 1995, Polymetamorphism and polyphase deformation of the strata-bound magnesite-scheelite deposit, Tux-Lanersbach, Eastern Alps, Austria: Econ. Geol., v. 90, p. 763-781. First author at Inst. Geowissenschaften, Montanuniversität Leoben, A-8700 Leoben, Austria.

The Tux-Lanersbach magnesite-scheelite deposit is a strata-bound scheelite deposit in low-grade metamorphic quartz phyllites. The scheelite mineralization was affected by both Alpine metamorphic and deformational events and the youngest scheelite (scheelite 3) generation crystallized late to post-D_3. Corresponding F (type 2 FI) have a low salinity (H_2O-NaCl system, 1-7 wt % NaCl eq.), an average Th (156° ± 16°C), and show a meteoric F signature with a $\delta^{18}O_{fluid}$ value of ca. 2 ‰ and a δD_{fluid} value of -80 to -90‰ SMOW. Scheelite 2 quartz veins formed syn-D_3 between 270° and 295°C. Corresponding H_2O-NaCl-$CaCl_2$-($MgCl_2$) F (type 1a and b FI) are moderately saline (10-22 wt % NaCl eq., NaCl/$CaCl_2$ = 0.4), have a higher Th (150°-240°C), and exhibit metamorphic F characteristics ($\delta^{18}O_{fluid}$ = 8-9.5 ‰; δD_{fluid} = ca. -45 ‰ SMOW). A dilution trend in type 1 FI is best explained by F mixing, which is regarded as an important process for precipitation of W in syn-D_3 metamorphic veins. O isotopes indicate disequilibrium between magnesites and dolomitic host rocks and support an epigenetic model of spar magnesite formation. The present data do not support either a syn- or epigenetic concentration for the primary W. (From authors' abstract by E.R.)

RAKOVAN, John, MITCHELTREE, D.B., BENTON, L.D. and AVELLA, Sal, 1995, Amethyst on milky quartz from Hopkinton, Rhode Island: The Mineralogical Record, v. 26, p. 83-89.

Indexed under FI. (E.R.)

RAMAMBAZAFY, A., RAKOTONDRAZAFY, M., MOINE, B. and CUNEY, M., 1995, CO_2-rich fluids, granulite facies metamorphism and metasomatism in south-east Madagascar (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 200-201. First author at Lab. Minéralogie, URA 67 CNRS, Toulouse Univ., France.

The significance of CO_2-rich FI characteristic of the granulite facies is greatly debated.

P FI in garnet consist of high density (0.88 to 0.91 g/cm^3) pure CO_2 (invisible water). In quartz, similar CO_2 I predominate over H_2O-CO_2-NaCl ones (XCO_2 = 0.4-0.5; 5-6 wt % NaCl) which are probably later while H_2O-NaCl FI are clearly secondary. Similar FI are present in quartz from the granitic rocks.

Only CO_2-rich FI have been observed in the minerals from the skarns. P FI in corundum and spinel belonging to the stage I paragenesis were trapped in the P-T conditions of the regional metamorphism. Fluor(phlogopite, pargasite)- and REE(hibonite)-rich minerals as well as anorthite are characteristic of the stage II paragenesis at 750-800°C. Carbonic FI in hibonite and anorthite are of lower density, and the corresponding P is ~3 kb. Wollastonite which occurs only near the contact with granitic rocks, i.e., in zones of high values of $aSiO_2$ also contains this type of FI, in agreement with its conditions of stability at 800°C. Also the stability of hibonite with respect to corundum + calcite in zones of very low values of $aSiO_2$ is satisfactorily explained.

These results demonstrate that CO_2-rich F were synchronous with the granulite facies metamorphism and were at the origin of the formation of extensive metasomatic rocks requiring large scale transport of various elements such as Si, Mg, Th, U, Zr, REE, etc. (From authors' abstract by E.R.)

RAMBOZ, C. and ORPHANIDIS, I., 1995, Fluid inclusions in sulfates (anhydrite, barite) in passive margin or oceanic rift settings: Potentially reliable indicators of ancient pressure regimes and thermal disequilibrium. Examples: The Cevennes margin and the Red Sea rift (Atlantis II Deep) (abst.): Soc. Geol. de France Mtg., November 1995, Abstracts, p. 157 (in French). Authors at CRSCM/CNRS, 1A Rue de la Ferollerie, Orleans-la-Source, Cedex 2, France.

The middle Jurassic Les Malines deposit at the Cevennes margin consists of polymetallic sulfides as veins and stratiform karst fillings, partly of MVT, in Cambrian dolomite. The final paragenetic stages, B1 and B2, are barite highly enriched in ^{34}S. H_2O-CO_2 FI, P in B2 and S in B1, have CO_2 partial P ~40 bars at 25°C. Good agreement between observed and experimental PVTX properties indicate no significant modification since trapping. Implied trapping P are 365 ± 45 and 285 ± 45 bars, and T ~115 and 175°C in B1 and B2, respectively. Mineralization occurred before uplift of the Cevennes margin, under 2300 m (B1) and 1800 m (B2) of cover. Geopressures were due to injection of F into an isolated structural block. Emplacement at great depth distinguishes this mineralization from MVT.

FI in anhydrite at 1085 cm in drill hole 268 in the SW basin of the Atlantis II Deep trapped V and L, indicating a boiling emergent F at 390°C, 21 wt % NaCl, and confirming that the lower brine reservoir of the Deep is fed by a submarine geyser. A salinity increase from 19 to 32 wt % NaCl between the centers and edges of crystals indicates vaporization of 50% of the F mass of the lower reservoir. Solutions were in strong thermal disequilibrium with enclosing sediments, and cooled rapidly at constant salinity. FI in barite from 980 cm show no boiling, and trapped only L superheated ≤20°C above its boiling point. The paradoxical mass and heat balance of the Atlantis II Deep from 1965 to 1980 can be explained by superheating. Superheated L retains its metal-depositing potential as far as the sea floor, while boiling F deposits its metals at depth. (Abridged from authors' abstract and translated by C.J. Eastoe)

RANKIN, A.H., 1995a, Hydrothermal orefields and ore fluids, *in* M.J. Le Bas, ed., Milestones in Geology: Geol. Soc., London, Memoir No. 16, p. 237-247.

A review, emphasizing the Cornish and North Pennine ore field. (E.R.)

RANKIN, A.H., 1995b, Fluid inclusion evidence for mineral transport and accumulation by bubble flotation in natural fluid systems (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 202. Author at School of Geological Sciences, Kingston Univ., Kingston upon Thames. Surrey KT1 2EE, UK.

Bubble or froth flotation [of solids in L] is a common ore beneficiation process, but little attention has been given by earth scientists to the possibility that bubble flotation may be significant in natural, heterogeneous, F systems.

This contribution reviews existing data on contact angles (a measure of hydrophobicity and wettability) in brine-air-mineral systems and presents the following lines of FI evidence to suggest that such processes are feasible under certain geological conditions:

(1) Observation of bubble-particle attachments in three-phase FI.

Small solid particles are commonly observed attached to the V bubble in many different types of FI. These include native Ag(Au) and sulphides. These particles can remain firmly attached to the V bubble even at high T and during rapid movement of the bubble.

(2) Simulation of the process in natural Na-K-Cl-brine using bubbles and *particles expelled from F* and *solid I on dissolution of evaporite minerals.*

Na-K-Cl-brines containing dispersed bubbles of $N_2/CH_4/L$ hydrocarbons and small grains of hematite, gypsum and quartz (10 to 100 microns) were produced from the I by dissolving natural halite and sylvite (from the Boulby potash mine, UK) in water under the microscope.

Results, captured on film and on video, showed that bubble-solid attachments were ubiquitous. Organic compounds released from hydrocarbon-bearing I probably act in much the same way as "collectors" in industrial froth flotation cells.

Examples where bubble flotation may play a significant role in mineral transport and accumulation include:

- Concentration of S and Au-Ag in boiling epithermal systems (CO2-H2O).
- Cementation processes in hydrocarbon reservoirs accompanying gas and petroleum migration in oilfield brines (CH4/HC's-brine). (From author's abstract by E.R.)

RANSOM, Barbara, SPIVACK, A.J. and KASTNER, Miriam, 1995, Stable Cl isotopes in subduction-zone pore waters: Implications for fluid-rock reactions and the cycling of chlorine: Geology, v. 23, p. 715-718. Authors at Scripps Inst. Oceanography, Univ. California at San Diego, La Jolla, CA 92093.

Recent laboratory data strongly suggest that the isotopic composition of Cl in pore waters from subduction zones reflects diagenetic and metamorphic dehydration and transformation reactions. Cl therefore cannot be considered geochemically conservative in these systems. The uptake of Cl by hydrous phases provides a mechanism by which Cl can be cycled into the mantle through subduction zones. Thus, stable Cl isotopes should help in determining the extent to which Cl and companion excess volatiles like H_2O and CO_2 cycle between the crust and mantle. (From authors' abstract by E.R.)

RAWAT, R.S. and SHARMA, Rajesh, 1995, Field and petrological evidences for the origin of polymetallic sulphide mineralisation near Rithanth, District Nainital, Kumaun Lesser Himalaya (abst), *in* Symp. on Recent Advances in Geological Studies of Northwest Himalaya and the Foredeep: Geol. Surv. India, p. 172-173.

Indexed under FI. (E.R.)

REED, A.R., VEARNCOMBE, J.R. and GROVES, D.I., 1995, Timing of copper mineralisation at Maroochydore, Paterson Province, Western Australia: Implications for the genesis of sediment-hosted copper deposits, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 311-314. Authors at Key Centre for Strategic Mineral Deposits, Dept. Geology and Geophysics, Univ. Western Australia, Nedlands, W.A., Australia.

A stratabound sediment-hosted Cu prospect in the Paterson Province of Western Australia is demonstrated to be multigenetic, with Cu introduced during regional metamorphism, but reliant on, and adopting, many of the characteristics of diagenetically evolved sulphides. Chalcopyrite and, to a lesser extent sphalerite and galena, mineralisation at the Maroochydore Cu prospect preferentially formed in D2 P shadows to pre-existing sulphides and in the hinges of D2 folds, and is interpreted to be of syntectonic origin. Mineralising T were at least 205°C, but, with corrections for P, may have been as much as 100°C to 200°C hotter, consistent with their coincidence with peak greenschist-facies metamorphism. Chalcopyrite precipitated on reduction of the ore-fluids via interaction with carbonaceous and carbonate-rich country rock, with framboidal pyrite providing the main S reservoir. (Authors' abstract)

All analysed FI from quartz veins associated with chalcopyrite mineralisation are two-phase L plus V, demonstrating consistent phase proportions indicative of formation from a F that has not undergone boiling (Shepherd et al., 1985). Data range between 9 wt % NaCl and 25 wt % NaCl and between 190°C and 450°C, with a mean T and salinity of 259 ± 59°C (1σ), respectively. Higher T, but lower salinity F prevail in discordant, coarse-grained silica-dolomite veins and breccias oriented axial planar to D2 folds, whilst the lower T, but more saline, F are more common in bedding-parallel sulphide layers, and veins less than a few millimetres wide. It is interpreted that replacement of diagenetic sulphate, which occurred during early metamorphism, resulted in initially hypersaline connate F that became less saline as higher-T metamorphic F evolved. Corrections for P, based on a minimum 8000 m thickness of overlying sedimentary rocks, could raise Tf by 100°C to 200°C, compatible with their formation during greenschist facies metamorphism. (From authors' text by E.R.)

REN, Qijang, FU, Bing, HU, Wenxuan, XU, Wenyi, DUAN, Zhenhao, MØLLER, Nancy and WEARE, J.H., 1995, Characteristics of the hydrothermal system of the porphyry copper (gold) deposit at Shaxi, Eastern China, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 683-685. First author at Dept. Earth Sciences, Nanjing Univ., PRC.

The porphyry Cu (Au) deposit at Shaxi is a special and large size deposit in eastern China. In the ore-forming process, the water and ore-forming materials in ore solution were magmatic in origin. Systematic studies of fluid inclusions reveal that the ore-forming system was characterized by relatively high T and low P as well as high contents of CO_2 and NaCl. Great amounts of evidence support that fluid immiscibility played an important part in the formation of Shaxi porphyry Cu (Au) deposits. (Authors' abstract)

The analytical results show that $\delta^{18}O$ and δD values of water in ore-solution are from 5.52 to 3.51 and -48.1 to -78.6‰, respectively. The $\delta^{18}O$ value of altered rocks is between 6.82 and 8.93‰, which indicates relatively low water/rock ratios during water-rock interaction process. The $\delta^{34}S$ value of sulfides was derived from a magma system. The $\delta^{13}C$ value from CO_2 from FI is -3.0 to -6.5‰, approaching the $\delta^{13}C$ value of CO_2 from deep level of crust and upper mantle. During the main mineralization period, the water in ore-solution was magmatic in origin and ore-forming materials were from a magma system.

The FI in this deposit can be divided into three types as follows: Type I, high salinity inclusions containing dms NaCl ± KCl ± $CaSO_4$ ± hematite ± sulfides; Type II, V-L inclusions containing a L percentage <50%, which homogenize to a V [sic; i.e., no type III described].

The microthermometric Th (Linkam 600 stage) can be divided into three groups, i.e., >440-340°C, 250-170°C, 170-100°C; the first group is predominant. Using T-salinity-P diagram at equilibrium state (Roedder and Bodnar, 1980), the homogenization P for high salinity FI have been calculated.

Salinities of FI vary substantially. The I can be divided into two groups: a high salinity (>50 eq. wt % NaCl on average) group and a low to moderate salinity (~15 eq. wt % NaCl). The mineralization intensity is closely connected with the distribution of high salinity FI.

The density of high salinity FI is from 1.073 to 1.215 g/cm^3; for the low to moderate salinity I, density is from 0.78 to 1.11 g/cm^3.

The data indicate that the water in ore solution was magmatic in origin, at relatively high T and low P, with considerable evidence of F immiscibility. (From authors' text by E.R.)

REN, Qijiang, SUN, Xiaoming, XU, Zhaowen, YANG, Rongyong and LIU, Hongyin, 1995, Evolution of hydrothermal system of a huge porphyry molybdenum deposit in Jingduicheng, Central China, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 651-652. Authors at Dept. Earth Sciences, Nanjing Univ., PRC.

Systematic study of FI in quartz from the porphyry Mo deposit in Jingduicheng has shown that the ore-metal mostly came from magmatic F. In late stage a great deal of meteoric water mixed into the hydrothermal solution, leading to decreases in T, salinity and $\delta^{18}O$ values, and causing precipitation of molybdenite. (Authors' abstract)

In the early pre-mineralization stage, the K-Na-Ca equilibrium T is 500°C. (The Leitz 1350 and the LGHS-1 heating stages were used.) During the late pre-mineralization and mineralization period, the Th of FI ranges between 99°C and 412°C. The Th of the FI in the quartz associated with molybdenite range mostly between 120°C and 280°C, with salinities of 1.9 wt % to 17.5 wt %, and the predominant range between 5 and 10 wt % (all salinities are reported as eq. wt % NaCl). The salinities of FI containing dms are from 28 to 41 wt %. The bimodal distribution pattern of salinity and the existence of high salinity of ore-forming solution, indicate that a magmatic F played an important part in the formation of the Jingduicheng porphyry Mo deposit, as demonstrated by 22 analyses of the isotope composition of O (from quartz) and H (from I F, from quartz). From early stage to the late stage the $\delta^{18}O$ values decreased, from the values of typical magmatic water to the values of mixing of magmatic and meteoric water. In the mineralization stage $\delta^{18}O$ values were relatively low; this could result from mixing large amounts of meteoric water in the hydrothermal solution, causing decreased T and salinity (δD ranged from -57 to -121). Because all the samples were collected in an open pit that was located in the upper part of the hydrothermal system, the action of meteoric water was more important than those in the deep part.

From the measured results by Raman, the composition of FI is characterized by a very high CO_2 content, which implies a high fCO_2 in the magma system. One sample showed 24 mol % H_2S in the L phase. (From authors' text by E.R.)

REN, Shengli, 1995, An origin of Laowangzhai-Donggualin gold deposit, Zhengyuan county, Yunnan province: Earth Science (Digiu Kexue), J. China Univ. Geosciences, v. 20, no. 1, p. 47-52 (in Chinese, English abstract). First author at Inst. Geology, Chinese Acad. Sci., Beijing 100029, PRC.

Laowangzhai-Donggualin Au deposit is located in the north part of Ailaoshan epimetamorphic belt. It can be concluded that the ore formation is polyphase and that Au is originated from the widespread basic-ultrabasic rocks in this area. H and O isotopic data for I F in quartz is given. (H.E.B.)

REN, S.K., WALSHE, J.L., PATERSON, R.G., BOTH, R.A. and ANDREW, Anita, 1995, Magmatic and hydrothermal history of the porphyry-style deposits of the Ardlethan tin field, New South Wales, Australia: Econ. Geol., v. 90, no. 6, p. 1620-1645. First author at Dept. Geology, Australian Nat'l Univ., Canberra, ACT 0200, Australia.

The continuum of salinity and T conditions from high-T and high-salinity F in the Ardlethan Granite to lower T and less saline F in the breccia pipes in the Mine granite; and the isotopic character of the ore F which is consistent with a magmatic F source characterized by primitive isotopic signatures for C and S. Tourmaline nodules occur within the Ardlethan Granite and halite-bearing FI found in quartz from the nodules homogenized between 250° and 485°C. FI data from vug-filling quartz show that the deposition of milky quartz and cassiterite occurred between 300° and 370°C, sulfide and clear quartz between 210° and 280°C, and toothy quartz, fluorite, and cookeite between 105° and 245°C. F salinities ranged between ~13 and 18 wt % NaCl eq. For the main stages of mineralization. Coexisting CO_2- and H_2O-rich FI permit a minimum P estimate of ~500 bars. T calculated from the compositions of hydrothermal biotite, muscovite, and chlorite are in good agreement with the results of FI microthermometry and indicate a paleotemperature gradient in the Mine granite breccia pipe. Cooling of the hydrothermal F contributed to the deposition of cassiterite together with increases in pH and fO_2 resulting from boiling of reduced F and wall-rock reactions. (From authors' abstract by E.R.)

RENAC, C., BRIL, H. and RAMBOZ, C., 1994, Polyphase fluid circulation at the margin of the Cevennes: Data from the Balazuc-1 drilling (GPF programme) (abst.): 15th Mtg. of Earth Sciences [15^e Réunion des Sciences de la Terre], 26-28 April 1994, Nancy, France, p. 45 (in French).

The Balazuc-1 drilling has cut, starting from level 1669, through 1730 m of sediments, from the Kimmeridgian to the Stephanian. The whole lower part of the drilling until the Rhaetian (level 1350) is crosscut by mm- and cm-sized veins and geodes of anhydrite-quartz or dolomite with a zonally variable Fe content. The microthermometric study of FI in anhydrite in fractures or geodes at nine levels between 1683 and 1459 m shows the following facts:) (1) At all levels, P FI in anhydrite are monophase, which would imply that anhydrite in veins has crystallized at ~60°C. (2) Above the NaCl level ~1612 m (Edon et al., in preparation and this work), white anhydrite contains 90-100% of monophase FI with high salinities (on avg. ~21 eq. % NaCl). (3) Under this halite level, monophase FI in white or pink anhydrite have variable salinities, but always lower than the monophase FI of the higher levels (two principal maxima at ~4 and ~15 eq. % NaCl). (4) Two-phase (5 to 50%) PS and S I have salinities between 12 and 25 eq. % NaCl, and Th between 113 and 235°C [sic]. Measurements in the Fe-bearing dolomite of the levels 1729 (vein) and 1708 (subhorizontal crack-seal fissures) only show two-phase FI (Th = 130 to 150°C) with high salinities (21 to 23 eq. % NaCl).

This study makes clear that the top of the Carboniferous underwent the same Mesozoic history as the sediments above it. Three diachronic phases of F circulation have been documented. (1) Low-T F accompanied the intense Triassic tectonic activity in the synsedimentary stage (Martin and Bergerat, 1993) and deposited the anhydrite. Diluted F (interstitial water?) probably percolated this complex partially along fractures. They could be enriched with NaCl while percolating through evaporitic levels, washing out particularly the halite during ascending stretches. (2) The ubiquitous deposition of Fe-bearing dolomite corresponds with a hydrothermal phase of higher T (120 to 150°C), with high salinities under elevated F P (Pf about $\sigma 3$, with $\sigma 1$ varying from horizontal to vertical). (3) Finally, some S FI in anhydrite of level 1630 contain hotter (≤230°C) and more saline F, which possibly ascended from halite levels in the deep basin. (Authors' abstract, translation courtesy Dr. E.A.J. Burke)

RENAC, C., BRIL, H. and RAMBOZ, C., 1995, Structural development and evolution of the Ardeche margin perpendicular to a listric fault: Triassic and Paleozoic record of the Balazuc drill hole (southeast basin, French Deep Geology Program) (abst.): Soc. Geol. de France Mtg., November 1995, Abstracts, p. 161 (in French). First author at CRSCM/CNRS, 1A Rue de la Ferollerie, 45071 Orleans-la-Source, France.

Ten specimens for FI study come from Triassic-Mid Paleozoic formations intersected in the Balazuc drill hole (BA1), and include a quartz-anhydrite geode, and veins of anhydrite, dolomite and/or quartz. Veins in the Triassic, mainly anhydrite, represent fractures open before tilting of a carbonate bar. Veins from Paleozoic rocks were open after this rotation. In anhydrite, P one-phase FI contain L of ~20 eq. wt % NaCl above a halite layer, and 9-15 eq. wt % below, with 112 < Th < 235≤C. All measured FI in dolomite and quartz are S, with 19-24 eq. wt % NaCl and 101 < Th < 163°C. Te measurements, mainly of S FI, indicate Na-Ca-Cl brines.

There were three episodes of F circulation. (1) Pre-rift, epeirogenic stage, represented by one-phase FI in anhydrite, implying crystallization at <70°C. Pore-waters were diluted by a meteoric water influx, and high salinities were generated by halite dissolution. (2) Burial diagenesis stage. Growth bands in dolomite indicate P fluctuation. High salinities and Th = 130°C are compatible with a conductive regime, and formation of veins from local F under abnormal P. S FI in anhydrite, dolomite and quartz are uniform in salinity, near halite saturation. In dolomite and quartz, Th values are less than T attained in a conductive regime at maximum burial. In anhydrite, dolomite and quartz are uniform in salinity, near halite saturation. In dolomite and quartz, Th values are less than T attained in a conductive regime at maximum burial. In anhydrite, more than half of the Th measurements in S FI are greater than this T. The correlation of Th and salinity rules out massive decrepitation of these FI and suggests late influence of a hot, saline F from deep in the basin. (3) Alpine phase, compressional regime. Horizontal, fibrous sulfate veins are rare at Balazuc. (Abridged from authors' abstract and translated by C.J. Eastoe)

RENAC, C., RAMBOZ, C. and MOSSMANN, J.R., 1995, Epigenetic fillings and local fluid influxes at the bottom of BA1 borehole (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 203-204. First author at URA 721 Univ. Poitiers 86022 Poitiers, France.

The scientific BA1 borehole (SE Basin of France 1,730 m) was drilled near a listric fault in the downthrown site [side?] (1669 m depth). During Liassic time subsidence and downthrown block induce compaction and cementation processes which produce pore space reduction. In the borehole primary and secondary porosity are mainly affected by precipitation of anhydrite, Fe dolomite. These process affect the calcarenitic reservoir presently with a low porosity (max 5%). This porosity reduction contributes to prevent the vertical circulation of formation F during burial history (Tmax 145°C; Pagel et al., 1995). So the present pore waters and FI salinities show very contrasted compositions.

F entrapped in anhydritic veins have ubiquitous P monophase FI showing veins formed from cold F with a salinity of 2.5 Meq NaCl. Microthermometric values of S FI (Th ≈170°C and salinity ≈5 Meq NaCl) show allogenic F coming from hot and probable evaporitic levels.

Microthermometric data in dolomite and quartz show similar salinity of anhydrite (4 Meq NaCl) but slightly lower Th values 100 to 140°C. Moreover, petrographic and structural observations indicate [a] later event probably during maximal burying stage.

These dolomitic and anhydritic deposition processes imply F overpressure linked up to non Triassic-Liassic reservoir during recurrent faulting of the margin. Changes of F compositions with depth between marine, evaporite and continental waters suggest several the F flow direction and discontinuity thermal events [were] probably linked to faulting activity. (From authors' abstract by E.R.)

See also FIR, v. 26, p. 145. (E.R.)

RENÉ, M., 1995, Development of greisenization at the Horni Slavkov Sn-W deposit (Bohemian massif) (abst.): Mitt. Österr. Miner. Ges., v. 140, p. 412-413 (in English). Author at Inst. Rock Structure and Mechanics, Acad. Sci. Czech Republic, V Holesovickách 41, 182 09 Prague 8, Czech Republic.

The Sn-W ore deposit of Krásno near Horní Slavkov is genetically and spatially related to lithium-topaz granite cupolas of the Krusné hory batholith. One of the stocks shows abundant Cu, Zn, As, (Mo,Bi) and Sn-sulphides. Microscopic study of FI has proved Th of the PI in cassiterite to be 380°C. Interpreting the P values and assuming a closed system, then the mineralization depth can be put at a level of 960 m. Even the occurrence of intrusive breccias may attest to this rather shallow depth, since they must have been generated relatively close to the surface. The maximum Td is 370°C. Apatite and topaz show Td of 500-600°C. This T could correspond to that of the high-T FI detected very rarely in cassiterite (0.67% of all I out of the total number of 297 investigated I).

The T at the origin of these I is estimated to be 570°C. The T could correspond to that of the transport of ore-bearing solutions. The argillitization T was similar and its value can be estimated from data on cookeite stability at 270-350°C. The above values indicate greisenization and argillitization (cookeite genesis) to take place between 600 and 300°C, particularly within the interval 300-400°C. (From author's abstract by E.R.)

RENYI, C., 1995, Fluid inclusions and isotopic geochemistry of the Sorkuduk skarnoid copper-molybdenum ore deposit, Xinjiang, China: Sci. Geol. Sinica, v. 4, p. 65-71 (in Chinese, English abstract).

RÉQUIA, K.C.M. and XAVIER, R.P., 1995, Fases fluidas na evolução metamórfica do depósito polimetálico de Salobo, Província mineral de Carajás, Pará: Rev. Esc. de Minas, Ouro Preto, v. 49, no. 2, p. 117-122 (in Portuguese, English abstract). Authors at Inst. Geociências, Dept. Metalogênese e Geoquímica, Univ. Estadual de Campinas, Caixa Postal 6152, 13.081-970 Campinas, SP.

The Salobo polymetallic ore deposit, Pará, consists of a primary Cu (Au, Ag, Mo) mineralization, hosted by Archean Fe formations. The Cu mineralization is mostly formed by bornite-chalcopyrite and bornite-chalcocite disseminations, in association with magnetite-rich levels. FI studies showed that two types of FI occur in the Salobo ore deposit: monophase carbonic I (CH_4 <10 mol %) and aqueous I, subdivided into highly saline aqueous I (30.6-58.4 wt % NaCl eq.) and low to moderate saline aqueous I (1-25.8 wt % NaCl eq.). The carbonic F are interpreted as F generated or reequilibrated under high amphibolite facies conditions. The probable sources for the highly saline aqueous F, present during the greenschist facies retrograde event, are conate, formation or magmatic waters, and they seem to be responsible for both Cu and Au remobilization. The isochores corresponding to the saline aqueous FI, combined with the chlorite geothermometer, demonstrated that Cu and Au remobilization probably occurred in the range of 334°-366°C and 3.7-1.4 kb. The decrease in the Cl^- caused by F mixture, combined with the decrease in T, possibly are the main mechanisms of metal deposition, which are transported by Cl^- complexes. (Authors' abstract)

REUTEL, C., LUDERS, V., HOTH, P. and IDIZ, E.F., 1995, Gas migration and accumulation along lineament structures—Lower Saxony Basin (NW Germany) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 205-206. First author at GEOLINK Inc. Göttingen, Gervinusstr. 5 D-37085, Göttingen, Germany.

The Lower Saxony Basin in NW Germany forms part of the Southern Permian Basin gas province in Central Europe. Commonly, CH_4-rich gas generated from Upper Carboniferous sediments and accumulated in Permian sandstones and carbonates.

Aqueous FI in carbonate- and quartz-bearing fissure mineralization of the uplifted Carboniferous sediments are characterised by low Te values and final Tm ice mostly below the eutectic point of the system $NaCl-H_2O$. According to the observed Te values the solution can be interpreted in terms of the $NaCl-CaCl_2-H_2O$ system with salinities of ~20 wt % $NaCl-CaCl_2$ eq. In few cases clathrate melting can be observed with final melting temperatures ≤20°C, indicating a dissolved gaseous component (CH_4?). The Th of P and PS I in carbonates and quartz range between 210-230°C and 180-240°C, respectively.

Based on the phase transitions of monophase gaseous I in quartz, nearly pure CH_4 or varying mixtures of CH_4 and CO_2 can be deduced as main components. Laser-Raman spectroscopical analyses yield compositions of 71-100 mol % CH_4, 0-28 mol % CO_2 and in few cases 1 mol % N_2 or > 1 mol % H_2S.

In contrast, gaseous I in calcites hosted by the overlying Zechstein carbonates always contain H_2S in addition to CH_4 and CO_2, with largely varying compositions of 14-25 mol % CO_2, 5-60 mol % CH_4 and 18-76 mol % H_2S. The H_2S content of these I is probably due to partial thermochemical sulphate reduction within the Zechstein rocks.

Assuming CH_4 saturation of the aqueous F during entrapment the P-T conditions can be reconstructed. The isochoric P-T projection indicates a slight trend of increasing T with depth. However, this conclusion cannot be drawn for P. P estimations derived from the P-T projection show only little correlation with the original sampling depth assuming conditions of lithostatic P. Most of the I reveal much higher P, which may be due to overpressure phenomena.

The geothermal gradient, which can be derived from Th of PI in fissure minerals from different levels of the wells, can be estimated between 58 and 64°C/km, indicating an enhanced heat-flow during F migration and entrapment. Further T estimates derived from vitrinite reflectance data and chlorite thermometry support the idea that the anomalous coalification history and the activity and evolution of hydrothermal F were influenced by a thermal event. Two explanations can be discussed: coupling of an important erosion and a former higher geothermal gradient, or circulation of hydrothermal F in the tectonically activated area during uplift of the Carboniferous block.

Taking in consideration the microthermometric results and important differences in the vitrinite reflectance as well as model T of chlorites between boreholes which are only a few kilometres apart, the latter explanation must be favoured. (From authors' abstract by E.R.)

REYES, A.G., 1995, Interaction of fluids and rocks at the magmatic-hydrothermal interface of the Mt Cagua geothermal system, Northeastern Luzon Island, the Philippines, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 537-541. Author at Victoria Univ. Wellington and Inst. Geological and Nuclear Sciences, Lower Hutt, New Zealand.

FI and alteration minerals indicate that the magmatic-hydrothermal interface is occupied largely by V and is connected to surface fumaroles via a V conduit. Magmatic volatiles released into the system rapidly partition into a brine and a G-rich V. When released into water-logged microfractures, short-lived acid sulfate waters form and precipitate a corresponding alteration assemblage. The inferred magmatic F at Cagua, based on FI, has a Cl content of 15,000 to 30,000 mg/kg, a CO_2 content of 4 molal and high H_2S. Through dilution and boiling this F forms the waters of the groundwater-dominated hydrothermal envelope adjacent to the magmatic-hydrothermal interface. (From author's abstract by E.R.)

The rarity of FI and their small diameters of <2 µm, in the most recent vein calcite, dolomite and zeolites of Well CG-2D, are consistent with the low T indicated by the secondary minerals and measured in the well. On the other hand, FI in calcite, anhydrite, quartz, fluorite, epidote, albite and orthoclase in CG-1D homogenize from 170°C to 310°C at depths of 700-1300 m, and 310-520°C from 1600-1776 m. In many cases, the assumption that freezing point depression temperature (Tm), melting point of dms (Tdm), assumed to be halite, and critical point Th (Tcp) >374.1°C are caused solely by NaCl is not valid as FI petrography shows high CO_2, the presence of gases other than CO_2, and solutes other than NaCl. However, by normalizing all data to apparent salinity, FI associated with the shallower groundwater-dominated, hydrothermal envelope at 700-1300 m, and the magmatic-hydrothermal interface at >1600 m can easily be separated. FI found at depths <1300 m homogenize to the L phase at <310°C and contain <6.5 NaCl wt % eq. Those occurring within the magmatic-hydrothermal interface at >1600 m depths homogenize to the L or V phases or the critical point, with most clustering at ~420°C. High T FI with NaCl >36 wt % eq. contain dms and are closely associated with FI that homogenize to the critical point from ~380-430°C or to the V phase at 370-490°C. The former is consistent with a maximum salinity of 2.5 to 5 wt % NaCl, assuming NaCl to be the main solute. Also found at these depths are FI that homogenize to a critical point of 359°C, implying that they may contain ≤4 molal CO_2. All these findings point to release of magmatic volatiles from low-permeability rocks at very high T. Evaporation forms highly saline FI, V separation leads to I homogenizing to the V or a critical point, and dilution forms the shallow I associated with the hydrothermal envelope. The FI in the shallow and deep zones apparently have a common magmatic parent, whose inferred composition is 15,000 to 30,000 mg/kg Cl and 4 molal CO_2. High H_2S content is suggested by the presence of dissolved S in vein quartz FI. (From author's text by E.R.)

REYF, F.G., PAKHOMOVA, V.A., ISHKOV, Yu.M. and DEMASHEV, S.B., 1994, The role of highly metalliferous solutions in the formation of the Verkhneye tin deposit, Karadub orefield:

Geokhimiya, no. 11, p. 1633-1650 (in Russian; translated in Geochem. Int'l, v. 32, no. 7, p. 58-76, 1995).

The "laser spectral analysis" (LSA) used consists of atomic emission spectrography during a laser burst. The term laser decrepitation AES is also used. Detection limits for ≥20 μm I, in 10^{-12} g are: Pb 300, W 200, Sn 108, Zn 80, Ag 70, Al 50, Mo 40, Mn 20, M 20, Fe 10, B 8, Be 1, Cu 0.4. (E.R.)

Abstract in FIR, v. 27, p. 118 under "Reif." (E.R.)

RHEDE, D. and THOMAS, R., 1995, Microprobe analysis of silicate melt inclusions in quartz from "stockscheider" pegmatite at Ehrenfriedersdorf, Erzgebirge, Germany (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 207-208. Authors at GeoForschungsZentrum, Telegrafenberg A50, D-14473 Potsdam, Germany.

The often extreme difficulties of studying MI in plutonic rocks are justified by the unique information they can provide. The value of MI in igneous petrology cannot be overestimated. It is relatively straightforward to determine the solidus and liquidus T, and to derive values of viscosity and equivalent water content of MI from heating and quenching experiments. Microprobe techniques are well-suited for chemical analysis of the MI but analyses are very difficult in practice. The purpose of this contribution is to discuss problems of analysing MI and give first results which show the promise of this approach.

MI in plutonic rocks are multicrystalline at room T and must be homogenized at liquidus T and quenched to a homogeneous glass, and then polished down until I are exposed at the surface. The search for opened I under the microprobe is best made with back-scatter electron images.

The homogenization and quenching procedure introduces several problems. First, excessive time and T of homogenization causes the I walls to dissolve in the M [sic]. Second, many I decrepitate before complete homogenization; this problem can be avoided by heating under P. A further problem for the P- and F-rich compositions encountered in this study (Table 1) is that some I could not be quenched completely and skeletal crystals formed on cooling.

Table 1 shows the composition of several MI types found in pegmatitic quartz. These are attributed to different stages in pegmatite M evolution and/or heterogeneity in the M. Our analyses of >300 MI has shown that, at the time of trapping in quartz and feldspar, the M was a suspension of a F- and P-rich silicate M with minor immiscible phases of extremely P-rich M, and crystals of quartz, feldspar, apatite, triplite, berlinite, topaz and other solids. Moreover, during crystallization, a KCl-and NaCl-rich F exsolved, leading to coexisting M- and FI. The compositions of the MI from more simple granitic M (1) to the highly-evolved pegmatitic composition (2, 3), extreme volatile-rich M (4) and globules of immiscible P- and Fe-rich M (5) are shown in the table. (From authors' abstract by E.R.)

Table 1. Composition of MI in quartz from the "stockscheider" pegmatite, (1)—granite (aplitic phase), (2) and (3)—pegmatitic phase, (4)—volatile-rich phase and (5)—globules of immiscible high-P glass.

	(1)	(2)	(3)	(4)	(5)
	(n=8)	(n=9)	(n=28)	(n=3)	(n=3)
P_2O_5	0.07	0.20	3.65	8.75	37.75
SiO_2	72.82	72.14	69.98	57.83	1.00
TiO2	0.02	0.12	0.03	0.04	0.06
Al_2O_3	13.79	17.65	15.69	21.65	3.16
FeO	1.02	2.21	0.38	0.54	43.34
MnO	0.06	0.16	0.05	0.10	5.28
MgO	0.08	0.02	0.01	0.00	0.00
CaO	0.13	0.03	0.06	0.16	0.57
Na_2O	2.84	2.34	2.66	2.31	4.91
K_2O	5.88	3.43	3.49	5.95	0.35
F<0.02	1.04	3.44	2.01	2.02	
Cl	<0.02	0.10	0.08	0.16	0.82
Total	96.71	99.44	99.52	99.50	98.74 *
O = F	0.00	-0.44	-1.45	-0.85	-0.85
O = Cl	0.00	-0.02	-0.02	-0.04	-0.18
Total	96.71	98.98	98.05	98.61	97.71

*Actual total as given is 99.26. (E.R.)

RICE, C.M., ASHCROFT, W.A., BATTEN, D.J., BOYCE, A.J., CAULFIELD, J.B.D., FALLICK, A.E., HOLE, M.J., JONES, E., PEARSON, M.J., ROGERS, G., SAXTON, J.M., STUART, F.M., TREWIN, N.H. and TURNER, G., 1995, A Devonian auriferous hot spring system, Rhynie, Scotland: J. Geol. Soc., London, v. 152, p. 229-250. First author at Dept. Geology and Petroleum Geology, Univ. Aberdeen, King's College, Aberdeen AB9 2UE, UK.

The Early Devonian Rhynie hot spring system is the oldest known and is of the low sulphidation type. The Devonian rocks show intense hydrothermal alteration along the fault zone. The main alteration minerals are quartz, K-feldspar, calcite, hematite and illitic and chloritic clays. Multiple chert veining and brecciation are widely developed, and geyserite and vent material are also present. Pyrite occurs in veins and all alteration facies. Sinters and altered rocks contain high concentrations of Au, As, Sb, Hg, W and Mo.

The F responsible for most hydrothermal alteration were near neutral with low S and O activities and dominated by meteoric water. However, incursions of high T (300-440°C) magmatic F occurred with δD -65‰ and $\delta^{18}O$ ~+8.5‰. $\delta^{34}S$ (pyrite) and initial $^{87}Sr/^{86}Sr$ ratios (vein calcite) lie mainly within the ranges +3.4‰ to +8. ‰ and 0.71138 to 0.71402, respectively. These data indicate that late Proterozoic Dairadian metasediments are a likely source for S and Sr but other sources are possible. $\delta^{13}C$ values for caliche and vein calcite imply derivation of C from non-organic sources.

The Rhynie cherts were deposited from a low salinity F of probable meteoric origin ($\delta^{18}O_{chert}$ + 13.1‰ to +16.5‰) which had interacted with the basement rocks and sediments (high Xe/Ar, Br/Cl and I/Cl ratios). Plant-bearing chert yielded an $^{40}Ar/^{39}Ar$ ratio (292.1 ± 0.6) significantly less than that of modern air and may be the first valid determination of a sample of ancient atmosphere. (From authors' abstract by E.R.)

RICHARDS, J.P., 1995, Alkalic-type epithermal gold deposits—A review: Mineral. Assoc. Canada Short Course, v. 23, p. 367-400.

Quotes literature FI data. (E.R.)

RICHARDS, J.P., BRAY, C.J., CHANNER, D.M.DeR. and SPOONER, E.T.S. , 1995a, Fluid processes at the Porgera gold deposit, PNG: New evidence from gas and ion chromatographic analyses of fluid inclusions (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-66.

The Porgera Au mine in Papua New Guinea is a world-class example of an alkalic-type epithermal Au deposit, which overprints a precursor stage of magmatic-hydrothermal Au mineralization. Gas and ion chromatographic (GC-IC) analyses of FI contained in vein minerals from both mineralization stages reveal the presence of three end-member liquids, the most dilute of which was present throughout the mineralization history and is interpreted to represent local groundwater of meteoric origin. More saline liquids were also present during the two main stages of ore formation, and although their compositions differ, both are interpreted to have been dominantly of magmatic origin, and to have carried Au.

Stage I minerals contain FI which decrease in salinity towards this dilute end-member composition throughout the vein paragenesis, reflecting progressive dilution of the magmatic F source by groundwaters. *In situ* F mixing is not thought to have been responsible for ore deposition, however, which may instead have been caused by simple cooling and/or wallrock reactions. The most saline F, present in early quartz and pyrite, contain at least 963 mM Cl^- , 812 mM Na^+, 527 mM Ca^{+2}, 128 mM K^+, 87 mM SO_4^{2-}, 12 mM Li^+, 1.1 mM Br^-, and 0.05 mM I^-, plus variable concentrations of dissolved gases.

Stage II hydraulic breccia veins contain two distinct liquids with contrasting salinities, which were present at different times during veins formation. A higher salinity L appears to have predominated during mineralization, whereas lower salinity groundwaters filled the structures during intervening periods. The ore-forming F may have been at least 1772 mM Na^+, 680 mM Cl^- · 211 mM SO_4^{2-}, 183 mM Li^+, 59 mM K^+, 1.4 mM Br^-, and 0.09 mM I^-, plus 1.47 mole % CO_2, 0.19 mole % CH_4, and 0.04 mole % N_2.

GC analyses of FI from Stage II samples reveal a decrease in total gas content between early unmineralized veins and post-mineralization quartz. The latter samples plot along an experimental gas-saturation curve in the CO_2-CH_4-H_2O-salt system, obtained at conditions similar to those attending ore deposition at Porgera (200-300 bars, ~165°C). These results are interpreted to indicate a period of depressurization-induced phase separation during hydraulic fracturing, which resulted in rich ore deposition. Immiscibility was promoted by the volatile gases CH_4 and N_2 which significantly reduce total gas solubility. (Authors' abstract)

RICHARDS, J., BRAY, C.J., CHANNER, D.M.DeR. and SPOONER, E.T.C., 1995b, Fluid processes at the Porgera Gold Deposit, Papua New Guinea: New evidence from gas and ion chromatographic analyses of fluid inclusions: Abstracts, Mineral Deposits Study Group (Geol. Soc. London), Annual Mtg., Manchester, 18-20 Dec. 1995 (unpaginated).

See previous item. (E.R.)

RIOS, F.J., FUZIKAWA, Kazuo, VILLAS, R.N.N. and PIMENTA, M.A., 1995, Fluidos associados à mineralização tungstênica do granito Musa (PA), Amazônia Oriental: Implicações genéticas apoiadas no estudo de inclusões fluidas (IF) em quartzo de Veios da Jazida Pedra Preta: Rev. Esc. de Minas, Ouro Preto, v. 49, no. 2, p. 146-150 (in Portuguese, English abstract).

The Pedra Preta deposit in Rio Maria, Pará State, consists of wolframite and sulphide bearing hydrothermal quartz veins. They cut greisens and granitic-greenstone rocks. The deposit is genetically and spatially related to Musa Granite. At -50 m, in quartz II (which is coeval to the wolframite), FI consist of $H_2O + CH_4$ in various proportions. At -260 m the F consists of $H_2O + CO_2$ with traces of CH_4. In the quartz from granite at -320 m the same F is in SI. It is considered that CO_2 has contributed to the transport of WO_4^{2-} towards the deposition sites. (Authors' abstract)

RITCEY, D.H., WILSON, M.R. and DUNNING, G.R., 1995, Gold mineralization in the Paleozoic Appalachian orogen: Constraints from geologic, U/Pb, and stable isotope studies of the Hammer Down prospect, Newfoundland: Econ. Geol., v. 90, p. 1955-1965. Authors at Dept. Earth Sciences, Memorial Univ., St. John's, Newfoundland A1B 3X5, Canada.

The Hammer Down mesothermal Au prospect shows carbonate and chlorite alteration and, in part, predates the mineralization; however, there is increasing chloritization near the Au-bearing zones and the mineralized veins contain abundant carbonate. Strong sericite-pyrite-rutile hydrothermal alteration is restricted to narrow zones adjacent to veins. Isotopic compositions of quartz ($\delta^{18}O = 11.4 \pm 0.7$ ‰) and carbonate ($\delta^{13}C = -6.2 \pm 0.7$‰) from Au-bearing veins at Hammer Down are typical of shear-hosted, mesothermal Au deposits of Archean and younger age. O isotope thermometry using quartz, chlorite, and muscovite yields T of vein formation between 245° and 320°C. The ore-forming F have calculated $\delta^{18}O$ and δD values between 1.1 and 5.8 and -36 and -54‰, respectively, and are interpreted to be of mixed origin, dominantly from a metamorphic reservoir with a small component of low ^{18}O meteoric water. (From authors' abstract by E.R.)

ROBB, L.J., LANDAIS, P. and DRENNAN, G.R., 1995, Petrographic, chemical and spectroscopic studies of carbonaceous matter and their bearing on the metamorphic evolution of the Witwatersrand Basin, *in* W.U. Reinold, compiler, Proc. Symp. Economic Significance of the Metamorphic and Fluid Movement within the Witwatersrand Basin: Econ. Geol. Res. Unit, Univ. Witwatersrand, Inf. Circ. No. 296, p. 56-xx.

The presence of carbonaceous matter in the Au- and U-bearing conglomerates of the Witwatersrand Basin is one of the more intriguing and controversial aspects of the genesis of these deposits. Its occurrence and evolution is particularly relevant to an understanding of the metamorphic evolution of the basin since the composition and structural characteristics of hydrocarbons are particularly sensitive to even low P/T changes in the post-depositional history of a sedimentary sequence.

No study of organic matter in a sedimentary setting can be undertaken without some appreciation of the thermal and burial history of the deposit. Several studies have reiterated the view that a regional P-T climax of 350 ± 50°C and 1.5-3 kb applied throughout much of the Witwatersrand Basin. Although the timing of metamorphism is difficult to constrain, review of isotopic age determinations in and around the basin suggest that metamorphism may have been episodic, occurring mainly in response to increments of progressive burial at ca. 2500 and 2300 Ma, and then to a final thermo-tectonic perturbation at ca. 2000 Ma related to intrusion of the Bushveld Complex and/or Vredefort catastrophism.

Organic maturation in the Witwatersrand Basin will have been controlled by the successive increments of post-depositional burial and thermal evolution of the host rocks. The basin was subjected to slow burial, and it is likely that the "oil window" in the upper parts of the sequence was attained long after the termination of sedimentation.

There appear to be at least four modes of occurrence of carbonaceous matter in and around the Witwatersrand, one of which is as quartz vein- and FI-hosted carbonaceous matter. A recent, detailed study of post-depositional F in the Witwatersrand Basin has revealed the presence of, *inter alia*, a hydrocarbon-bearing F population comprising CO_2 and variable proportions of CH_4, C_2H_6, H_2 and N_2. Inclusions bearing these F are occasionally coated by a thin film of solid hydrocarbon, or actually contain bituminous hydrocarbon nodules ≤10 microns in diameter. In addition, small bituminous nodules are occasionally observed along the sites of annealed micro-fractures within quartz pebbles in the conglomerates and have also recently been discovered in association with pyrite and Au from quartz veins that cut the conglomerates and are associated with late-stage faulting in the basin. Quartz vein-hosted bitumen nodules either occur as discrete warty aggregates of hydrocarbon, or intimately intergrown with pyrite and occasionally Au. The presence of these bitumens clearly demonstrates that hydrocarbon circulation in the basin was not restricted to the conglomeratic horizons, but also involved aquo-carbonic solutions migrating along other conduits such as faults and shears. (From authors' abstract by E.R.)

ROBB, L.J., ROBB, V.M. and WALRAVEN, F., 1994, The Albert Silver Mine revisited: Toward a model for polymetallic mineralization in granites of the Bushveld Complex, South Africa: Explor. Mining Geol., v. 3, no. 3, p. 247-262. First author at Dept. Geology, Univ. Witwatersrand, PO Wits 2050, Johannesburg, South Africa.

The old Albert Silver Mine is a polymetallic deposit comprising concentrations of Cu-Pb-Zn-Ag-U-F within a set of sub-parallel quartz-hematite veins which occur within the fine-grained apical phase of the 2050 Ma old A-type Bushveld granites. Accumulation of metals appears to have taken place at the interface between a coarse-grained porphyritic granite and an overlying fine-grained phase: Veins occur in the latter and represent leakage of magmatic F from the differentiated, water-saturated, subjacent granite.

At the Albert Silver Mine, unroofing of the cover sequences at ca. 1600 Ma to 1700 Ma resulted in the incursion of lower-T, high-fO_2 meteoric F which remobilized the earlier sulfides and introduced the paragenetically late U-F mineralization. (From authors' abstract by H.E.B.)

FI Th and salinity data presented and discussed. (H.E.B.)

ROBERT, Francois, BOULLIER, A.M. and FIRDAOUS, Karima, 1995, Gold-quartz veins in metamorphic terranes and their bearing on the role of fluids in faulting: J. Geophys. Res., v. 100, no. 7, p. 12,861-12,879. Author at Geol. Surv. Canada, Ottawa, Ontario, Canada.

Au-quartz vein fields in metamorphic terranes such as greenstone belts provide evidence for the involvement of large volumes of F during faulting and may be products of seismic processes near the base of the seismogenic regime. In the Val d'Or district of the Abitibi greenstone belt, Canada, quartz-tourmaline-carbonate veins form a vein field (30 × 15 km) in the hanging wall of a crustal-scale fault zone, which was the main channelway for upward migration of the deeply generated F. Detailed structural and FI studies provide evidence for generally lithostatic but fluctuating F P (ΔP_f of the order of 200 MPa) and for cyclic stress reversals during vein formation and provide good support for the fault valve model. (From authors' abstract by E.R.)

ROBERTS, S.M. and SPENCER, R.J., 1995a, Paleotemperatures preserved in fluid inclusions in halite: Geochim. Cosmochim. Acta, v. 59, p. 3929-3942. First author at Western College of the Univ. Montana, Dillon, MT 59725.

A variety of paleoclimate proxy records allow determination of *relative* warming or cooling. However, if we are to understand climate change, quantification of past T fluctuations is essential. Our research indicates that FI in halite can yield Th that record surface brine T at the time of halite precipitation.

To avoid problems with stretching, leaking, and initial trapping of air, samples with primary, single-phase (L) FI are chilled in a freezer to nucleate V bubbles. We tested the reliability of this method of obtaining FI Th using modern salts precipitated at Badwater Basin, Death Valley, California. Th correlate well with measured brine T. The same method is applied to FI in Pleistocene halite from a core taken at the same location in Death Valley. Results are at several scales, recording diurnal T variations, seasonal T fluctuations, and longer-term warming and cooling events that correlate with major changes in the sedimentary environment related to climate. This technique is uniquely instrumental for paleoclimate studies because it offers actual, not just proxy, paleotemperature data. (Authors' abstract)

ROBERTS, S.M. and SPENCER, R.J., 1995b, Hexagonal halite pseudomorphs—possible climatic indicator of temperatures below 0°C (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-89. Authors at Dept. Geol. and Geochem., Univ. Calgary, Calgary, Alberta T2N 1N4, Canada.

An odd sub-mm to mm-scale hexagonal halite morphology appears in Pleistocene halite beds cored from an ancient saline lake in Death Valley, California (~150 to 120 ka).

These may be pseudomorphs after pseudohexagonal crystals of hydrohalite, stable <1°C, and hence might help identify cold climate evaporites in other ancient rocks. (From authors' abstract by E.R.)

ROBERTS, S.M., SPENCER, R.J., YANG, Wenbo and KROUSE, R.H., 1995, Deciphering some unique paleoclimate indicators in saline lake deposits from Death Valley, California (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 3. p. 82-83. First author at Dept. Geology and Geophysics, Univ. Calgary, Calgary, AB, Canada.

Saline lake deposits are arguably the best source of midlatitude paleoclimate data. Alternating clastic sediments and evaporites of different chemical composition have long been recognized as very sensitive records of changes in inflow and aridity. Several additional sources of paleoclimate information that are also unique to saline lake deposits are described here—Th of FI in halite, pseudomorphs of a cold-T evaporite mineral, and stable-isotope compositions of FI in halite. Examples of these data sources come from the lower half of a 185-m core drilled in Pleistocene saline lake deposits at Death Valley, California.

Th of FI in primary halite province an actual (not proxy) record of surface brine T. Samples with P FI textures are carefully selected and handled and data are collected from single-phase I chilled to nucleate V bubbles. T variations are observable at the scale of individual crystals (hours to days), single beds (weeks to months or years), and multiples of beds to entire facies (hundreds to tens of thousands of years).

Diurnal and seasonal T variations in saline lake waters create conditions for the appearance and disappearance of T-dependent mineral phases. In the Death Valley core, hexagonal-shaped halite crystals, interpreted as pseudomorphs of hydrohalite ($NaCl.2H_2O$), provide evidence of surface T <1°C.

A $\delta^{18}O/\delta D$ isotope record from the minute quantities of brines in FI in halite is accessible using a method recently developed at the University of Calgary. The record from the Death Valley core is a complex response to varying storm patterns, inflow sources, evaporation history and aridity, and T. (Authors' abstract)

ROBINSON, Michelle and GODWIN, C.I., 1995a, Genesis of the Blende carbonate hosted Zn-Pb-Ag deposit, North-Central Yukon Territory: Geologic, fluid inclusion and isotopic constraints (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-89. Authors at Mineral Deposits Research Unit, Dept. Geol. Sciences, Univ. British Columbia, Vancouver, B.C. V6T 1Z4, Canada.

The Blende Zn-Pb-Ag deposit is spatially associated with a mid-Proterozoic fault zone that cross-cuts stromatolitic dolostones of the middle Proterozoic. FI studies indicate that mineralizing F were ~285°C during main stage mineralization.

Sulfide S isotopes define three populations.

C and O isotopes in host rock and ore-stage dolomite spar are related genetically; both are related to ancient sea water. The calculated isotopes for mineralizing F are characteristic of basinal brines.

Galena Pb isotopes and a close spatial association of mineralization to upper parts of sills and the high T of the F from FI Th supports a genetic relationship between the sills and mineralization. (From authors' abstract by E.R.)

ROBINSON, Michelle and GODWIN, C.I., 1995b, Genesis of the Blende carbonate-hosted Zn-Pb-Ag deposit, north-central Yukon Territory: Geologic, fluid inclusion and isotopic constraints: Econ. Geol., v. 90, p. 369-384. Authors at Dept. Geological Sciences, Univ. British Columbia, Vancouver, British Columbia V6T 1Z4, Canada.

The Blende Zn-Pb-Ag deposit is spatially associated with a mid-Proterozoic fault zone that crosscuts stromatolitic dolostones. Mineralization, largely epigenetic, consists of sphalerite and galena, with lesser pyrite and chalcopyrite, and trace friebergite in quartz-carbonate veins and veinlets. FI studies indicate that mineralizing F were ~285°C during main-stage mineralization. A close spatial association of mineralization to upper parts of sills and the high T of ore F from FI Th supports a genetic relationship between the sills and mineralization. (From authors' abstract by E.R.)

ROCHOLL, A., HEUSSER, E., KIRSTEN, T., OEHM, J. and RICHTER, H., 1995, Cognate and metasomatic noble gases in a Hawaiian mantle xenolith (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 157.

A noble G profile across a Hawaiian mantle xenolith provides information about (a) the possible interaction between xenolith and their magma hosts, (b) the scales of isotopic heterogeneities within such samples. The xenolith is a garnet pyroxenite incorporated in "post-erosional" nephelinitic tuffs at Salt Lake Crater, Oahu, Hawaii.

Correlations between Ar isotopes and CO_2/H_2O ratios in different pyroxenites from Salt Lake Crater including our sample suggest that one component with high $^{40}Ar/^{36}Ar$ and low R/Ra is related to microscopically observed secondary CO_2-rich FI introduced into the pyroxenite by metasomatic F. The observed He isotope disequilibria on a sub-mm scale suggest that the metasomatic event is very young and related to pre-magmatic activity of the xenolith-bearing "post-erosional" host magma. The other component is interpreted as being cognate to the alkali-basaltic magma from which the pyroxenite precipitated. It is suggested that this component resides within mineral lattices and was trapped during magmatic crystallization.

This model agrees with the interpretation that post-erosional Honolulu Volcanics were derived from a more depleted reservoir than the pyroxenite-producing alkali basalts. It also explains the apparent "decoupling" of rare G and solid element isotopes in Hawaiian xenoliths. These results provide the first estimate of the noble G composition of Honolulu Volcanics and the first evidence for non-atmospheric Kr in parts of the oceanic lithospheric mantle. (From authors' abstract by H.E.B.)

ROEDDER, E., 1995a, Magmatic processes as viewed from fluid inclusion studies (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 209. Author at Harvard Univ., Cambridge, MA 02138.

A brief review of the entire range of magmatic I studies, G, L, and glass, giving the present status of methods of study analysis. In particular, some of the newer analytical methods for trace elements in I are helping in the solution of geological problems:

Rare earths in FI by inductively coupled plasma mass spectrometry (ICP-MS). The REEs have been excellent tracers for the evolution of rocks in a host of problems in igneous petrology, and ICP-MS has been in use for years for the analysis of major constituents in FI. But now it is possible to get valid REE patterns on the tiny amounts present in the FI. The results provide valuable constraints on the source and evolution of the F.

Heavy metals in I by synchrotron X-ray fluorescence (SXRF). This method also has been used in several groups for some years for semiquantitative results, and is being improved rapidly. At present the data look good for most heavy metals in the ppm range on individual <10 micrometer I, and have proved particularly valuable in understanding the processes of ore transport and deposition. Measurement and corrections for individual I parameters still provide the major hurdles for truly quantitative analysis.

Ca, Cl, K, Br, I, Se, Ba+Te, U, and isotopes of Ar, Kr, and Xe in I, by laser microprobe noble G mass spectrometry (LMNGMS). This has also been around for several years now, but the leader in the field, James Irwin of Scripps, has greatly improved the sensitivity and accuracy. It has a wide range of possible applications for tracing the source and evolution of the F present during various geological processes. (Author's abstract)

ROEDDER, E., 1995b, Review of Proc. 29th Int'l Geological Congress 1992, Mineral Resources Symposia Vol. A-C (Resource Geology Special Issues Nos. 15-17), S. Ishihara, T. Urabe and H. Ohmoto, executive eds.: J. Geochem. Explor, v. 52, p. 381-382.

The 1172 pages include 120 papers presenting data on a large number of deposits, many of which have never been described in English before. (E.R.)

ROGGENSACK, K., WILLIAMS, S.N., SCHAEFER, S.J. and PARNELL, R.A., 1995, Volatiles from two volcanoes; 1994 eruption at Rabaul Caldera, PNG (abst.): Eos, v. 76, no. 46, p. F659.

The September 19, 1994 eruption at Rabaul ended a long period of unrest at the caldera. As in the previous eruption of 1937, two vents, Tavurvur and Vulcan, located on opposing sides of the caldera, erupted together in unison . Ash deposits sampled during the waning eruption are comprised of interlayered material from Tavurvur and Vulcan (38 cm thick at Rabaul airport). Stratigraphy and eyewitness accounts indicate the initial eruption began at Tavurvur, followed by plinian activity at Vulcan and culminating with Vulcanian activity at Tavurvur. Vulcan deposits are tan and contain pumice whereas Tavurvur deposits are dark grey to brown and contain poorly vesiculated lapilli. Ash leachates of plinian Vulcan ash have a seawater signature (S/Cl 0.19; S 239 ppm; coherent behavior of Na, Ca, Mg, K) which decreases slightly upsection. Leachated from Tavurvur ash have a magmatic signature without identifiable seawater contamination (S/Cl > 2.7; S > 500 ppm; Na, K, Mg << seawater). Vulcan matrix glass (MG) and MI are dacitic (mean 66.5% SiO_2) and MI have ~2.5 wt % H_2O (CO_2 below detection, S 280 ppm, Cl 3300 ppm). These values are similar to those for MI and MG sampled from the 1,400 yBP eruption (mean 67.9% SiO2: ~2.5% H_2O; CO_2 below detection). Olivine crystals found in the Tavurvur ash (61.4% SiO_2) contain basaltic (mean 51.1% SiO2) water-rich MI (3.5 wt %; CO_2 0-400 ppm; S 680 ppm, Cl 1000 ppm). Reported SO_2 released by Vulcan's plinian activity is low (TOMS 80 ± 50 ktons). In contrast, COSPEC measurements indicate high SO2 release at Tavurvur. Measurements 10 days after the beginning of the eruption indicate SO_2 emissions of >25 ktons/d declining to <6 ktons/d by the 20th day. The bulk composition of Vulcan and Tavurvur ash is similar despite contrasting volatiles and eruption styles. In part, this reflects the complex interaction between Vulcan ash and seawater which is consistent with the identification of a low S ice-rich eruption cloud (Rose et al., 1995). The large SO_2 release of Tavurvur and presence of S-rich olivine MI suggests the presence of mafic melt in the system. The 23 years of unrest preceding the eruption may have been driven by mafic melt (McKee et al., 1984). (Authors' abstract)

ROLLINSON, H.R. and HUIZENGA, J.M., 1995, Magmatic CO_2 in granulites from the Limpolo [Limpopo] Belt (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 312.

P FI in quartz in the tonalitic magmatic granulites form as clusters in the centre of grains. There is a bimodal distribution of compositions comprising pure CO_2 gaseous I (compositions confirmed by Laser Raman Probe) and irregular, decrepitated aqueous brine I containing the solid phases halite and carbonate (optically identified). It is argued that these FI indicate the presence of a halide-rich M and a CO_2 V phase coexisting with the tonalite magma. FI in quartz in leuco-granite veins (quartz-mesoperthite- garnet) in the tonalites may be characterised as follows: clusters of decrepitated PI containing saline brines; early I trails containing CO_2, CH_4 and graphite; later I trails containing almost pure CO_2.

The absence of carbonate-rich sediments from the North Marginal Zone (NMZ) and suggest that CO_2 in the NMZ granulites is magmatic in origin. (From authors' abstract by H.E.B.)

ROMANO, C., DINGWELL, D.B. and BEHRENS, H., 1995, The temperature dependence of the speciation of water in $NaAlSi_3O_8$-$KAlSi_3O_8$ melts: An application of fictive temperatures derived from synthetic fluid-inclusions: Contrib. Mineral. Petrol., v. 122, p. 1-10.

Indexed were FI. (E.R.)

ROMANO, C., MUNGALL, J., DINGWELL, D.B., SHARP, T. and BAGDASSAROV, N., 1995b, Fragmentation of vesicular rhyolite: Tensile strength from synthetic fluid inclusions (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 134-135.

The study of synthetic FI in glass quenched from M synthesized at elevated P and T offers the possibility to evaluate the mechanical response of vesicular magma below the glass transition. (From authors' abstract by E.R.)

ROMANO, C., MUNGALL, J.E., SHARP, T., DINGWELL, D.B. and BAGDASSAROV, N.S., 1995b, Explosive behavior of vesicular glassy lava: Experimental constraints derived from fluid inclusions studies (extended abst.), *in* Volcanoes in Town, Roma 27-30 Sept. 1995: Periodico di Mineral., v. 64, p. 261-262. Authors at Bayerisches Geoinst. Univ. Bayreuth, D-95440 Bayreuth, Germany.

The study of synthetic FI in glass offers the possibility to evaluate the mechanical response of vesicular magma below the glass transition. We have synthesized vesicular glasses containing a variety of volatile phases and systematically measured tensile strength of the glass in the vesicle walls. (From authors' abstract by H.E.B.)

RONCHI, L.H., FOGACA, A.C.C., FUZIKAWA, K., GIULIANI, G. and PIMENTA, M., 1995, Fluid inclusions associated to gold quartz veins in Diamantina and Costa Sena, Minas Gerais, Brazil: A comparative study (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 210-211. First author at Univ. Vale do Rio dos Sinos - UNISINOS, Dept. Geologia, Caixa. Postal 275, 93.022-000 Sao Leopoldo, RS, Brazil.

The FI have been classified in three main types: C, L and M.

Type C—three phase, aquo-carbonic. Calcite trapped in these I can also be found as solid I in quartz, reinforcing the criteria for primary origin. Necking down is a frequent feature. Raman spectrometry indicated pure CO_2 in the carbonic phase. The microthermometric data confirmed the Raman analysis and indicated salinity of 10-15 wt % eq. NaCl. Th and Td are in the range from 200 to 250°C.

Type L—two phase, aqueous I, probably PS. The salinity is variable between 10 to 15 wt % eq. NaCl and Th are in the range 130-180°C.

Type C and type L I may occur associated in the same healed fracture. Necking down is responsible for much of the scatter in microthermometric data.

Type M—one phase, aqueous I. They are small (<1 μm to 10 μm), and all secondary in origin.

The results of FI study of free Au-bearing quartz veins at Costa Sena (Ronchi et al., 1991) where aquo-carbonic (type C I) and aqueous (type L I) F were present have been repeated in the Diamantina district. The early stage aquo-carbonic F, represented by type C FI, progressively mixed with an aqueous F, represented by type L FI, at ~350°C and 2.0-2.5 kb, by an aqueous F. The fO_2 of the aquo-carbonic F estimated by the presence of specularite/hematite and absence of sulphides in the veins, is close to the Fe_3O_4-Fe_2O_3 buffer. Deposition of Au is ascribed to the destabilisation of $AuCl_2^-$ complexes in the incoming F as a result of the dilutional process, leading to a pH increase of the F at a relatively constant fO_2.

The similarity of FI and their analytical results found in Costa Sena and Diamantina point out to similar parameters controlling the Au deposition in quartz veins in this whole area. (From authors' abstract by E.R.)

RONCHI, L.H., TOURAY, J.C. and DARDENNE, M.A., 1995a, Inclusões fluidas primárias em relação ao último evento de circulação de fluidos: Caso das fluoritas dos depósitos estratóides do Vale do Ribeira-PR: Rev. Esc. de Minas, Ouro Preto, v. 49, no. 2, p. 102-110 (in Portuguese, English abstract). First author at Dept. Geologia, Caixa Postal 275, 93.022-000, São Leopoldo, RS.

A complex hydrothermal history from late Proterozoic to Mesozoic is recorded in six fluorite deposits localized at latitude 24° south Brazil. Fluorite ores from stratabound deposits with different textures (micro and macrocrystalline) contain the same simple aqueous P FI with low Th (80-150°C) and low salinities (0-4 wt % NaCl eq.). The question discussed in this study is with what evolution stage of the fluorite stratabound deposits are these FI related? The evidence suggests that they are primary in relation to the last F circulation stage, which ore the hydrothermal process linked to the Cretaceous magmatic event. (Authors' abstract)

RONCHI, L.H., TOURAY, J.C. and DARDENNE, M.A., 1995b, Complex hydrothermal history of a roof pendant-hosted fluorite deposit at Volta Grande, Paraná (southern Brazil): Econ. Geol., v. 90, p. 948-955. First author at Univ. Vale do Rio dos Sinos-Dept. Geologia, Caixa Postal 275, 93022-000 São Leopoldo-RS, Brazil.

The aim of this communication is to question the meaning of fluorite REE patterns and microthermometric data from P FI, with respect to a complex hydrothermal history. (From authors' text by E.R.)

See also previous item. (E.R.)

ROSE-HANSEN, John and KONNERUP-MADSEN, Jens, 1995, Advances and trends in fluid inclusion research in Denmark: APIFIS Newsletter 1995, Univ.. Science and Technology Beijing, p. 17-19.

A review of progress on studies of the Skaergaard and Gardar intrusions and the Maarmorilik Pb-Zn deposit in Greenland, plus various other deposits. (E.R.)

ROSELLE, G.T. and BAUMGARTNER, L.P., 1995, Experimental determination of anorthite solubility and calcium speciation in supercritical chloride solutions at 2 kb from 400 to 600°C: Geochim. Cosmochim. Acta, v. 59, p. 1539-1549.

ROSSO, K.M. and BODNAR, R.J., 1995, Microthermometric and Raman spectroscopic detection limits of CO_2 in fluid inclusions and the Raman spectroscopic characterization of CO_2: Geochim. Cosmochim. Acta, v. 59, p. 3961-3975. Authors at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

In many geologic environments, dominantly aqueous solutions contain low concentrations of CO_2. At ambient T, the typical phase assemblage in FI which trap these solutions consists of a CO_2-rich V (where $PCO_2 \approx P_{internal}$) and an aqueous phase containing dissolved salts and CO_2. In this study, the CO_2 detection limits (DLs) using microthermometry and Raman spectroscopy are established in terms of PCO_2, using synthetic H_2O-CO_2 I of known composition. The purpose of the microthermometric experiments was to identify the diagnostic CO_2 phase changes and determine the quantity of CO_2 necessary to result in observable solid CO_2 melting. The results of these experiments show that an observable solid CO_2 melting event in L-rich aqueous I requires $PCO_2 \geq 45$ bars at 25°C.

The Raman spectroscopic detection limits were investigated using a multichannel Raman spectrometer. The CO_2 DLs were obtained by determining signal-to-noise ratios for both the upper and lower v_1-$2v_2$ bands as a function of CO_2 P (5-60 bars) over a range of integration times and incident laser power. The resulting CO_2 DLs are on the order of I bar for the instrument used.

The band splitting of the v_1-$2v_2$ diad as a function of CO_2 P, converted to CO_2 density, was measured up to 500 bars at ambient T. The results are given in terms of the frequency separation between the upper and lower bands and are compared to results of previous studies. An analysis of the estimated errors indicates that the technique can be used to determine CO_2 densities in FI containing a homogeneous, free CO_2 phase to a precision of ~±0.02 g/cm^3.

The T dependence of the intensity ratio of the hot bands to the v_1-$2v_2$ diad was measured from 270-315 K. The close agreement between the calculated and observed results indicates that laser induced sample heating is not significant. The intensity ratio can be used to estimate the CO_2 T and, combined with the Raman density determination, allows calculation of the CO_2 P. (Authors' abstract)

ROWAN, E.L. and GOLDHABER, M.B., 1995, Duration of mineralization and fluid-flow history of the Upper Mississippi Valley zinc-lead district: Geology, v. 23, no. 7, p. 609-612. First author at U.S. Geol. Surv., 345 Middlefield Road, Menlo Park, CA 94025.

Studies of FI in sphalerite and biomarkers from the Upper Mississippi Valley Zn district show Th to be primarily between 90 and 150°C, yet show relatively low levels of thermal maturity. We use numerical calculations to simulate fluid and heat flow through fracture-controlled ore zones and heat transfer to the adjacent rocks. Combining a best-fit path through fluid-inclusion data with measured thermal alteration of biomarkers, we calculated the time interval during which mineralizing fluids circulated through the Upper Mississippi Valley district to be on the order of 200 ka. Cambrian and Ordovician aquifers underlying the district, principally the St. Peter and Mt. Simon Sandstones, were the source of the mineralizing fluid. The duration of mineralization thus reflects the fluid-flow history of these regional aquifers.

ROWAN, E.L., GOLDHABER, M.B. and HATCH, J.R., 1995, Duration of mineralization in the Upper Mississippi Valley zinc-lead district: implications for the thermal-hydrologic history of the Illinois basin (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-328.

The Upper Mississippi Valley (UMV) zinc-lead district is hosted by Ordovician carbonate formations at the northern margin of the Illinois basin . Rb-Sr dating of sphalerites indicates an age of 269±4 Ma for the district. Cambrian and Ordovician aquifers underlying the district, principally the St. Peter and Mount Simon Sandstones, were the source of the mineralizing F. The T and duration of mineralization in the district thus provide information on the F flow history of these aquifers. FI T and biomarker thermal maturity data from the literature were used to constrain a numerical model of upward F flow through fracture-controlled ore zones and the thermal effects on the surrounding rocks. The time-T relationship defined by the biomarker maturities, combined with independent FI T data from the main stages of sphalerite, permit calculation of a duration on the order of 200,000 yr for the hydrothermal, mineralizing event.

Elevated FI T in the UMV district (90-130°C) and across the northern Illinois basin, relative to a maximum burial depth of ≤1 km based on stratigraphic reconstruction, are plausibly explained by gravity-driven regional F flow. A pattern of anomalous concentrations of fluorite in drill cuttings, decreasing northward from the Hicks dome/southern Illinois Fluorite district (both Early Permian in age) suggests northward flow through the Illinois basin. Thermal considerations suggest that FI T >90°C in the UMV district required elevated basement heat flux along the regional flow path and advective transport of the heat by gravity-driven flow. The Hicks dome related igneous rocks in the southern Illinois basin provide an adequate heat source contemporaneous with the UMV district (Bethke, 1986). Independent of flow direction however, the biomarkers permit interpretation of FI T data in terms of duration required to match observed thermal maturities. (Authors' abstract)

ROYER, J.J., GERARD, B., LE CARLIER DE VESLUD, C., DUBOIS, M. and STUSSI, J.M., 1995, Modeling of heat and fluid circulation between sedimentary cover and basement: The example of the Rhine graben, Soultz geothermal field (abst.): Soc. Geol. de France Mtg., November 1995, Abstracts, p. 119 (in French). Authors at Centre de Recherches Pétrographiques et Géochimiques, BP 20, 54501 Vandoeuvre-lés-Nancy, France.

The evolution of the geothermal system at geologic time scale has been reconstructed from petrographic and microthermometric study of FI in quartz and barite veins, recrystallized microstructures, quartz overgrowths in sandstone, authigenic structures, and quartz from hydrothermal alteration zones in granite. In systematic sampling of drill-hole EPS 1, four principal episodes of trapping have been distinguished according to the type of host microstructure and the salinity/density of the FI: (1) F of magmatic origin; (2) post-magmatic F, 350°C, 20 MPa; (3) FI of moderate salinity, 207 eq. wt %, trapped at variable T (180-280°C), both in granite and in quartz overgrowths in Triassic sandstone, possibly of diagenetic or ... origin; (4) F in veins with properties (T 130-160°C, large salinity variations) similar to those of modern F at the site. (Abridged from authors' abstract and translated by C.J. Eastoe)

RUAN, Wenlou and YU, Yaoguang, 1995, Fluid inclusion geochemistry and its prospecting signifiture [signature?] on Xiayinfang gold deposit, Pinquan, Hebei: Precious Metal Geol., v. 4, p. 161-167 (in Chinese).

RUGGIERI, G. and GIANELLI, G., 1995, Fluid inclusions and isotope data from a phreatic breccia of the Monteverdi 5A well

(Larderello geothermal field, Italy) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 212-213. Authors at Int'l Inst. Geothermal Research, Pisa, Italy.

In the geothermal field of Larderello, a level of phreatic breccia was recently found at 1090 m below ground level (b.g.l.).

FI studies and isotope analyses on the breccia cement were carried out in order to reconstruct the physico-chemical nature and the evolution of the F that circulated in the hydrothermally fractured zone of the well, and to compare it with the present geothermal F.

The breccia consists of clasts of sandstone in a cement of calcite, chlorite, dolomite with minor amounts of quartz, anhydrite, albite, hematite and apatite. Textural relationships reveal three stages of hydrothermal deposition. Calcite, chlorite and minor apatite constitute the first stage assemblage. The second stage is characterized by the association of dolomite, quartz, albite and chlorite. The deposition of anhydrite characterizes the last hydrothermal stage.

Preliminary microthermometric measurements were carried out on FI hosted in the calcite and in one anhydrite crystal. Three types of I were identified in the calcite:

(1) One-phase (V) or sometimes two-phase (L+V) V-rich I (V). Many of the V I were considered to be primary. At low T, few of the V I showed the presence of solid CO_2, which dissolved between -62.0/-58.3°C; final Tm ice was observed in the range of -2.2/-1.2. Clathrate formation indicated that some CO_2 is present in most of the V I. Clathrate melted between 4.6/6.3°C. No L CO_2 was observed. ThV varied from 225 to more than 300°C. The wide range of ThV is probably due to heterogeneous trapping of some L together with V.

(2) Two-phase (L+V), low-salinity L-rich I (L1). Some L1 I were primary and appeared to be contemporaneous with V I. Tm ice occurred between -3.3/-1.5°C, giving a salinity of 2.5/5.3 wt % NaCl eq. ThL were between 203/240°C.

(3) Two-phase (L+V) relatively high-salinity L-rich I (L2). L2 I were only observed along one secondary trail. They displayed Tm ice between -4.7/-6.1°C, which correspond to a salinity of 7.4/9.3. wt % NaCl eq.; ThL were in the range of 321/334°C.

Two types of I were observed in the anhydrite:

(1) One-phase (V) I. Microthermometry was not performed on these I because they were too small.

(2) Two-phases (L+V) L-rich I (L). Few L I show primary features. Tm ice occurred at ~-3.0°C corresponding to a salinity of 4.5 wt % NaCl eq., ThL were between 140/165°C. L I appeared to coexist with V I.

The occurrence of contemporaneous L-rich and V-rich I in calcite and anhydrite indicate that these minerals crystallized from boiling F. The hydrothermal F evolved from ~325°C (breccia formation) to 200/240°C (carbonate deposition) to 140/165°C (anhydrite deposition). The latter T is consistent with the present-day T (160°C). No change in salinity with time was evidenced in the studied I. Sporadic inflow of high T, relatively high-salinity F at 1090 m was also recorded by S FI. These and isotopic data indicate that the carbonate cement was deposited by a F in equilibrium with a V phase similar to the present geothermal F. (From authors' abstract by E.R.)

RUI, Zongyao, ZHANG, Hongtao, WANG, Longsheng, CHEN, Renyi, JIN, Bolu, JIN, Fengzhu, WAN, Yusheng, ZHOU, Yongchang and MENG, Qingli, 1995, Porphyry-epithermal copper-gold deposits in Yanbian area, Jilin province: Mineral Deposits, v. 14, no. 2, p. 99-126 (in Chinese, English abstract). First author at Inst. Mineral Deposits, Chinese Acad. Geological Sciences, Beijing 100037, PR China.

Yanbian area of Jilin is an important metallogenic province in the circum-Pacific belt of China. Spatially and genetically, the porphyry-epithermal Cu-Au deposits related to Mesozoic volcanic-subvolcanic-intrusive activities make up a metallogenic series. Exemplified by four typical ore deposits, namely, Xiaoxinancha, Naozhi, Wufeng and Ciewigou, the present paper deals with geological characteristics and ore-forming mechanism of this metallogenic series. The Xiaoxinancha Cu-Au deposit, a deposit of porphyry type, occurs in the upwarped zone on the margin of the Mesozoic volcanic basin; mineralization is controlled by concealed Yanshanian granite porphyry and diorite porphyrite dike, with the major mineralized bodies present in Variscan diorite at the top of the concealed granite porphyry body and in Lower Paleozoic biotite felsic hornfels; the T and salinity of the ore F vary in the range of 100-550°C and 27.9-56 wt % NaCl, respectively, suggesting that the ore F are mainly magmatic water, mixed with some subordinate meteoric water. The Naozhi Au (Cu) deposit, being of porphyry-epithermal transitional type, occurs in the uplifted district within the Mesozoic volcanic basin; mineralization is controlled jointly by faults and Yanshanian subandesite porphyrite, with the major mineralized bodies existent in Variscan granodiorite; the T and salinity vary in the range of 150-450°C and 0.8-50 wt % NaCl, respectively, implying that both magmatic water and meteoric water make up remarkable [significant?] proportion. The Wufeng and Ciweigou Au deposits, belonging to epithermal type, occur in the interior of the Mesozoic volcanic basin; mineralization is controlled by faults, and the major mineralized bodies exist in Mesozoic volcanic rocks, with the deep mineralized body extending to the basement rock; the T and salinity of ore F are 100-400°C and 0.2-5.5 wt % NaCl, respectively, suggesting that meteoric water plays a dominant role and magmatic water is less important; the metallogenic position corresponds to the discharge system of the geothermal spring. (Authors' abstract)

RUSSELL, Norman, KESLER, S.E. and BELL, David, 1995, Metallogeny of the Sierra Maestra, Cuba (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 239.

Indexed under FI. (E.R.)

RUTHERFORD, M.J., KIM, Sarah and VENEZKY, D.Y., 1995, Petrologic melt and sulfide inclusion evidence for preeruption gas phase production in silicic calc-alkaline magmas (abst.): Eos, v. 76, no. 17, p. S267. Authors at Dept. Geological Sciences, Brown Univ., Providence, RI 02912.

The recent study of in-progress eruptions such as Mount St. Helens, Redoubt, and Mount Pinatubo has lead to the suggestion that these magmas were volatile saturated at the time of the eruption and, in fact, may have contained an excess G phase. However, evidence for the existence of an excess G phase is often problematic because there are other possible explanations for the observations used to make the G saturation argument. Studies of the Mount St. Helens 1980 white dacite and a 30-100 ka rhyodacite pumice from Mount Rainier provide petrological evidence that a G phase was generated in these magmas prior to their eruption. In both cases the evidence consists of abundant rounded sulfide I in phenocrysts of Fe-Ti oxides which indicate that the magma was S-saturated during one phase of phenocryst growth. No sulfide is found in the interstitial glass in either case. New experiments on a sulfide-saturated Mount St. Helens dacite with 5 wt % dissolved H_2O at 900°C, and a log fO_2 of NNO +1 contain 150 ± 15 ppm dissolved S in the melt phase. MI in phenocrysts of low-Ca pyroxene and plagioclase contain an average of 80 ± 20 ppm S, significantly below sulfide saturation at 900°C. MI in hornblende generally contain similar S contents, but a few were found with ≤140 ppm, which is consistent with the observation that hornblende was the only phenocryst other than Fe-Ti oxides found containing sulfide I. This evidence indicates that the dacitic magma was S saturated during Fe-Ti oxide phenocryst growth at which time a reaction of sulfide was occurring to produce the oxides. S released in this reaction could only have gone into a G phase since no other S-bearing phase is present. This G phase production is also the only way to explain the S-undersaturated melts trapped during the final stage of phenocryst growth. A similar dataset was obtained for the 835°C Mount Rainier rhyodacite. Although this I evidence indicates that a preeruption G phase was developed, it does not indicate whether this phase was still present at the time of the eruption. (Authors' abstract)

RYAN, C.G., 1995, Development of PIXE and the proton microprobe and the non-destructive analysis of fluid inclusions in minerals (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 214-215.

A review of the analysis of ore elements in natural FI from various deposits using literature data. (From author's abstract by E.R.)

See also next item. (E.R.)

RYAN, C.G., HEINRICH, C.A., VAN ACHTERBERGH, E., MERNAGH, T.P., BALLHAUS, C. and KHIN, Zaw, 1995, The non-destructive analysis of fluid inclusions in minerals using the

Proton Microprobe (abst.), *in* Proc. 9th Australian Conf. on Nuclear Techniques of Analysis, Newcastle, ISSN 1325-1694, p. 147-148.
See previous item. (E.R.)

RYE, R.O. and STOFFREGEN, R.E., 1995, Jarosite-water oxygen and hydrogen isotope fractionations: Preliminary experimental data: Econ. Geol., v. 90, p. 2336-2342.

RYZHENKO, B.N., 1994, The physicochemical bases of hydrogeochemical and hydrothermal processes: Geokhimiya, no. 6, p. 825-835 (in Russian; translated in Geochem. Int'l, v. 32, no. 1, p. 57-70, 1995).

SACCOCIA, P.J. and GILLIS, K.M., 1995, Hydrothermal upflow zones in the oceanic crust: Earth Planet. Sci. Lett., v. 136, p. 1-16.

Breccias recovered from the Mid Atlantic Ridge south of the Kane Fracture Zone (MARK) and the East Pacific Rise at Hess Deep record distinct alteration signatures associated with the upwelling of hydrothermal F shallow oceanic crust. Two breccia types have been defined based on the mineralogy of the matrix. Type I breccias have a matrix characterized by Fe-rich chlorite, quartz, pyrite, and anatase. Type II breccias exhibit a matrix consisting of Mg-rich chlorite, epidote, quartz, pyrite, and titanite. FI analyses indicate a similar range in Th for the two breccia types (150-375°C) but distinct ranges in salinity. Type I breccias have salinities greater than that of seawater (3.3-10 wt % NaCl) whereas type II breccias display much lower salinities (<0.1-5.6 wt % NaCl). Supercritical phase separation at T from 450-500°C and 550-625°C in the lower crust at Hess Deep and MARK, respectively, is consistent with the observed salinity variations. Mineral stability relationships coupled with the FI data suggest that the type I breccias were produced by hydrothermal F relatively enriched in Cl and depleted in H_2S whereas the type II breccias were associated with hydrothermal F relatively depleted in Cl and enriched in H_2S. These chemical trends are consistent with those displayed by hydrothermal F actively venting on the sea floor. Thus, we propose that the observed variability in the chemistry of modern submarine vent F is paralleled by distinct alteration assemblages in the upflow zones below the sea floor, as defined by the type I and type II breccia suites. Based on these results, we predict that the relatively H_2S-depleted vent systems at TAG, southern Juan de Fuca, and 11-13°N along the East Pacific Rise should be characterized by upflow zones with a mineralogy similar to the type I breccias. Conversely, the relatively H enriched vent systems at 21°N and 11-13°N along the East Pacific Rise are likely associated with upflow zones that have a mineralogy similar to the type II breccias. As more fossil upflow zones in the oceanic crust are identified, these results could be used to define temporal variability of upwelling F chemistry at specific ridge sites on a geologic time scale. (Authors' abstract)

SACKETT, W.M., 1995, The thermal stability of methane from 600 to 1000°C: Organic Geochem., v. 23, p. 403-406.

SAMSON, I.M. and GAGNON, J.E., 1995, Episodic fluid infiltration and genesis of the Proterozoic Maclellan Au-Ag deposit, Lynn Lake greenstone belt, Manitoba: Exploration and Mining Geology, v. 4, no. 1, p. 33-50.

SAMSON, I.M., LIU, Weining and WILLIAMS-JONES, A.E., 1995, The nature of orthomagmatic hydrothermal fluids in the Oka carbonatite, Quebec, Canada: Evidence from fluid inclusions: Geochim. Cosmochim. Acta, v. 59, p. 1963-1977. First author at Dept. Geology, Univ. Windsor, Windsor, Ontario N9B 3P4, Canada.

FI in apatite, monticellite, and calcite from the Oka carbonatite complex generally comprise either aqueous L + V or aqueous L + V + halite. Some I also contain a variety of trapped solids, including calcite, strontianite, nahcolite, and mirabilite. Microthermometry and Raman spectroscopy indicate that CO_2 is not an important constituent of these F. Microthermometric data also indicate that the hydrothermal F liberated from the carbonatitic magma had a wide range of salinities (4.2 to 49 eq. wt % NaCl) and densities (0.77 to 1.26 g/cm^3). Most of the F had relatively low concentrations of SO_4^{2-} and CO_3^{2-} (<6 wt %); however, the nature of the trapped minerals and the phase behaviour of some I indicate that some F may have had higher concentrations of SO_4^{2-}, CO_3^{2-}, and/or HCO_3^- .

Textural relationships indicate that the crystallization sequence for the host minerals was monticellite apatite calcite, which, when combined with FI data from the three minerals, indicates that F salinity decreased and F density increased during progressive crystallization of the magma. The density increase is thought to have been mainly caused by decreasing T. Isochoric projections indicate that the F were exsolved at minimum P of 4 to 8 kb. These data provide a basis with which to assess the involvement of orthomagmatic aqueous F in the formation of hydrothermal rare element mineralization associated with carbonatites. (Authors' abstract)

SAMSON, I.M., WILLIAMS-JONES, A.E. and LIU, Weining, 1995, The chemistry of hydrothermal fluids in carbonatites: Evidence from leachate and SEM-decrepitate analysis of fluid inclusions from Oka, Quebec, Canada: Geochim. Cosmochim. Acta, v. 59, p. 1979-1989. First author at Dept. Geology, Univ. Windsor, Windsor, Ontario N9B 3P4, Canada.

Apatite and calcite from calcite carbonatites at Oka, Quebec, Canada, contain P, L-V and L-V-halite FI. Leachate analysis of these I indicate that they contain significant concentrations of Na, K, and Cl and lower concentrations of Fe, Mg, and probably Ca. Energy-dispersive X-ray (SEM) analysis of decrepitates from these I confirm that Na, K, and Cl are abundant. In addition, significant S was detected in the decrepitates.

A correction was applied to the spectra from decrepitates on apatite in order to subtract the contribution from the substrate (apatite). The reliability of a decrepitate analysis depends on the concentration of an element in the decrepitate relative to that in the substrate and to the relative contributions to the spectrum of decrepitate and substrate. Each elemental analysis was screened for its reliability based on the concentration of the element in the mixed analysis and its concentration in the substrate. The only reliable results were for Na, K, Cl, and S.

Both the leachate and decrepitate analyses indicate that Na > K. K/Na + K ratios fall within a narrow range, from 0.01-0.11. K was a more important constituent in the LV than in LVS I. Coupled with high salinities indicated from microthermometric data, these data confirm that aqueous F with high concentrations of alkalis may have evolved from low-alkali carbonatitic magmas. In contrast to the K/Na + K ratios, Cl/Cl + S ratios cover a wide range, from 0.17 to 0.93. The presence of sulphate minerals indicates that the S existed as SO_4^{2-} (and associated species) in the F. Chlorinities based on microthermometric data range from 2.5-11.4 m, which indicates SO_4^{2-} molalities of 1-22.7. Charge imbalances indicate that other anions, probably HCO_3^- and CO_3^{2-} are important constituents of the F. (From authors' abstract by E.R.)

SANO, Yuji and MARTY, Bernard, 1995, Origin of carbon in fumarolic gas from island arcs: Chem. Geol., v. 119, p. 265-274.

Based on new $^3He/^4He$ and $\delta^{13}C$ data and those in the literature, we present the first quantitative estimates of the upper mantle, sediment and limestone, including slab components in CO_2 of volcanic and hydrothermal F from subduction zones. Up to 20% of the C in high-T volcanic gases in subduction zones is derived from a MORB-type source, while the major fraction of the gases is attributable to CO_2 produced by decarbonation of subducted marine limestone and slab carbonate. (From authors' abstract by E.R.)

SANTOS, R.V. and CLAYTON, R.N., 1995a, Variations of oxygen and carbon isotopes in carbonatites: A study of Brazilian alkaline complexes: Geochim. Cosmochim. Acta, v. 59, p. 1339-1352. First author at Dept. Geophysical Sciences, Univ. Chicago, Chicago, IL 60637.

We conclude that fractional crystallization and L immiscibility may not significantly affect the O and C isotopic compositions of carbonatites. (From authors' abstract by E.R.)

SANTOS, R.V. and CLAYTON, R.N., 1995b, The carbonate content in high-temperature apatite: An analytical method applied to apatite from Jacupiranga alkaline complex: Am. Mineral., v. 80, p. 336-344. First author at Dept. Geological Sciences, Univ. Chicago, Chicago, IL 60637.

The results indicate that the CO_2 content of apatite depends not only on total F C content, but also on the C speciation in the F. (From authors' abstract by E.R.)

SANTOSH, M., NADEAU, S. and JAVOY, M., 1995, Stable isotopic evidence for the involvement of mantle-derived fluids in Wynad gold mineralization, south India: J. Geol., v. 103, p. 718-728. First author at Centre for Earth Science Studies, PB 7250, Akkulam, Thuruvikkal Post, Trivandrum 695 031, India.

Major Au deposits of the world are often associated with carbonate alteration halos and CO_2-rich FI. The source and transfer mechanisms of the F that concentrate Au within quartz vein systems are topics of debate. Here we investigate the C, O, and S stable isotopic composition of CO_2-rich FI, and quartz, calcite, and sulphide minerals associated with the Au-quartz veins from the Wynad Gold Field, emplaced within the Proterozoic Moyar-Bhavani transcrustal shear system in the granulite facies terrain of southern India. Optical and microthermometric studies of FI in auriferous quartz veins reveal that the dominant F is CO_2-H_2O ($\rho\, CO_2 = 0.80$-0.90 g cm^{-3}), with high XCO_2 (0.7-1.0) and low salinity (ca. 4-5 wt % NaCl eq.). The C isotopic composition of CO_2 extracted from FI by crushing shows a remarkably narrow range of $\delta^{13}C$ values, -4.1 to -5.9‰. O isotopic composition of the quartz veins range from +9.2 to +10.9‰. The $\delta^{13}C$ (-9.1 to -9.2‰) and $\delta^{18}O$ (+7.6 to +7.8‰) values of calcite from carbonate veins also define a distinctly uniform range. S isotopic values in pyrite, chalcopyrite, and pyrrhotite associated with Au display a $\delta^{34}S$ range of +1.4 to +4.8‰. The C isotopic of FI and carbonates from Wynad are identical T those reported for low-T carbonate alterations in high-grade terrains induced by mantle-derived CO_2. The narrow spread in isotopic values associated with veins traversing compositionally variable host rocks is consistent with a model involving derivation of CO_2 by degassing of underplated mantle-derived magmas and transfer of juvenile CO_2 to higher crustal levels through felsic magmatic conduits. We envisage a common link between Proterozoic CO_2 influx and incipient charnockite formation, carbonate alteration, and Au mineralization in this terrain. (Authors' abstract)

SASADA, Masakatsu, 1995, Trends in fluid inclusion researches in Japan: APIFIS Newsletter 1995, Univ.. Science and Technology Beijing, p. 19-21.

A review of recent research activities, including particularly a use of synthetic FI technique in geothermal boreholes for logging to 1500 m and plans for extension to 4000 m and T >400°C, where conventional electric logging will not work. (E.R.)

SASADA, Masakatsu and GOFF, Fraser, 1995, Fluid inclusion evidence for rapid formation of the vapor-dominated zone at Sulphur Springs, Valles caldera, New Mexico, USA: J. Volcanol. and Geothermal Research, v. 67, p. 161-169. Author at Geothermal Research Dept., Geol. Surv. Japan, Tsukuba 305, Japan.

Microthermometric measurements were obtained for 618 FI in hydrothermal quartz, fluorite and calcite and magmatic quartz phenocrysts in intracaldera tuffs from the VC-2A core hole in order to study evolutionary processes of the Sulphur Springs hydrothermal system in the Valles caldera. Relatively high Th values in samples from shallow depths indicate erosion of ~200 m of caldera fill since deposition of hydrothermal minerals at shallow depths in the Sulphur Springs hydrothermal system, accompanied by a descent in the water table of the L-dominated reservoir. For samples collected below the current water level of the well, the minimum values of Th fit the present thermal profile, whereas minimum Th values of samples from above the water level are several tens of degrees higher than the present thermal profile and fit a paleo-thermal profile following the boiling point curve for pure water, as adjusted to 92°C at 20 m below the present land surface. This is attributed to development of an evolving V zone that formed subsequent to a sudden drop in the water table of the L-dominated reservoir. We suggest that these events were caused by the drainage of an intracaldera lake when the SW wall of the caldera was breached ~0.5 Ma. This model indicates that V zones above major L-dominated geothermal reservoirs can be formed due to dramatic changes in geohydrology and not just from simple boiling. (Authors' abstract)

SASADA, Masakatsu and SAWAKI, Takayuki, 1995, Synthetic fluid inclusion logging for temperature measurement and fluid sampling in geothermal wells at higher than 350°C: Chinetsu (Geothermal Energy), v. 32, no. 1, p. 1-13 [also "J. Japan Geothermal Energy Assoc.," v. 32, p. 1-13].

Synthetic FI logging is a new tool for T measurement and F sampling in geothermal wells. Healing of cracked quartz in a F in capsule results in formation of FI under borehole environment. Downhole T can be determined by measurement of Th of I synthesized in the F whose PVT relation is known, and by their P corrections. NaCl solution is suitable for the capsule F to be trapped in I at high T because the critical point of NaCl solution is higher than that of water. Another vessel containing a cracked quartz is used for F sampling. The vessel is opened when a rupture disk is crushed at the sampling depth. The geothermal F comes into small fractures in quartz, and crack healing results in formation of FI containing *in situ* F. The vacant I as the product of decrepitation of natural I might be more suitable for F sampling because the cracks developed around the decrepitated I are much finer than those formed by an ordinary thermal quenching method. Since a-quartz is stable as high as 573°C, this tool can be applied to high T geothermal wells where conventional tools cannot work. (Authors' abstract)

See also Sawaki et al., this volume. (E.R.)

SASAKI, Munetake, IIZASA, Kokichi and SAWAKI, Takayuki, 1995, Characteristics of gases in fluid inclusions from the Nurukawa Kuroko deposit and submarine sulfide deposits of the Izu-Ogasawara Arc, Japan: Resource Geology, v. 45, p. 1-10. Authors at Geol. Surv. Japan, Higashi 1-1-3, Tsukuba 305, Japan.

G compositions of FI from the Nurukawa Kuroko deposit of north Japan and the Myojinsho and Kita-Bayonnaise submarine sulfide deposits of the Izu-Ogasawara Arc, NW Pacific, are reported. Th of FI in quartz from the Nurukawa deposit range from 105 to 305°C with apparent salinities between 3.2 and 7.0 wt % NaCl eq. FI in barite from the Myojinsho deposit range in Th from 245 to 305°C with salinities between 2.2 and 4.2 wt % NaCl eq. FI in barite from the Kita-Bayonnaise deposit have Th ranging from 150 to 215°C with salinities between 3.0 and 5.0 wt % NaCl eq. Most of apparent salinities for the Nurukawa and Kita-Bayonnaise deposits are slightly higher than the salinity of the normal seawater (3.5 wt % NaCl eq.) whereas most of apparent salinities for the Myojinsho deposits are slightly lower than the salinity of the normal seawater. The apparent salinities higher than the salinity of the normal seawater for the Nurukawa and Kita-Bayonnaise deposits may be attributed to CO_2 dissolved in the FI. The apparent salinities lower than the salinity of the normal seawater for the Myojinsho deposit may be the result of subsurface boiling.

The H_2O, CO_2, N_2, CH_4 and Ar contents in FI from the Nurukawa, Myojinsho and Kita-Bayonnaise deposits all have similar ranges, i.e., 99.4 to 99.7 mol % H_2O, 0.24 to 0.54 mol % CO_2, 0.024 to 0.067 mol % N_2, 0.0011 to 0.0074 mol % CH_4 and <0.0035 mol % Ar. The similarity of G contents might be one of features for submarine sulfide deposits generating in island-arc settings. (From authors' abstract by E.R.)

SASAKI, Munetake, SASADA, Masakatsu, FUJIMOTO, Koichiro, MURAMATSU, Yoichi, KOMATSU, Ryo and SAWAKI, Takayuki, 1995, History of post-intrusive hydrothermal systems indicated by fluid inclusions occurring in the young granitic rocks at the Kakkonda and Nyuto geothermal systems, northern Honshu, Japan: J. Resource Geol., v. 45, p. 303-312 (in Japanese, English abstract).

FI study was performed on igneous quartz to understand evolution of hydrothermal systems related T the very young granitic intrusives at depths in the Kakkonda and Nyuto geothermal areas, northern Honshu, Japan. FI observed in the quartz are classified as follows: V-rich I (type V), L-rich I (type L), halite-bearing polyphase I (type P_1), X_1 (Fe-chloride), and halite-bearing polyphase I (type P_2), and X_1-X_2 (sylvite), and halite-bearing polyphase I (type P_3).

Th of the type L I from the Kakkonda geothermal system are >330°C with salinities <20 wt % NaCl eq. Most of the type L I show Th values from 330 to 350°C with salinities <1 wt %. Th of the type P_1 and type P_2 I from the Kakkonda geothermal system are >310°C with salinities between 35 and 75 wt %. Th of the type P_3 I range from 380 to 510°C with salinities between 60 and 75 wt % while Na/K mole ratio of the type P_3 I ranges from 1.2 to 2.3.

Th of the type L I from the Nyuto geothermal system range from 130 to 350°C with salinities <3.5 wt % except one I of ~10 wt %. The type P_1 I has not been observed in the Nyuto granitic rock. Th of the type P_2 I range from 560 to 620°C with salinities between

65 and 75 wt %. Th of the type P_3 I range from 480 to 620°C with salinities between 75 and 85 wt % while Na/K ratio of the type P_3 I ranges from 1.5 to 4.4.

The Th of the relatively low salinity type L I from each system correspond to the measured downhole T, and the type L I are considered to have trapped geothermal F presently circulating in the each granitic intrusive. Conversely, the type P_3 I from each system are considered to have trapped hydrothermal F equilibrated with each granitic intrusives at high T because the Na/K ratios of the type P_3 I are similar to the ratios of the F equilibrated with granitic rocks that have been experimentally determined by Whitney et al. (1985). The type P_1 and type P_2 I have trapped F generated by mixing of highly saline F with low salinity F because the ranges in Th and salinity for the type P_1 and type P_2 I are intermediate between those for the type L I and type P_3 I. The F circulating in the granitic intrusive of the Kakkonda geothermal system have continuously changed from highly saline F to low salinity F. However, hydrothermal activities of highly saline F and low salinity for the Nyuto geothermal system might have occurred at different ages. (Authors' abstract)

SASAKI, M., SAWAKI, T. and SASADA, M., 1995, Gas composition of fluid inclusions from a well of HJ-4 in Hachijojima (abst.): Abstracts (FIR) of 1995 Annual Mtg., Geothermal Research Soc. Japan (in Japanese).

Hachijojima consists of two basaltic to andesitic volcanoes names Higashiyama and Nishiyama. NEDO drilled eight wells as a survey for promotion of geothermal energy. HJ-4 was drilled near the top of the Higashiyama. Calcite veins and anhydrite veins are dominantly observed in HJ-4, and anhydrite veins collected at depths of 955.4 m, 1123.9 m, 1222.1 m, 1235.2 m, and 1412.2 m were used in this study. FI consist of L/V two-phase, and gypsum was sometimes observed as a dm in FI. [That] FI trapping boiling F was recognized in some samples. Th of FI ranges from 135 to 200°C. Their salinities were generally <3 wt %, 7 wt % at the maximum. Main components of FI are H_2O (>99.5 mol %), with small amounts of CO_2 (0.19 to 0.54 mol %), N_2 (0.011 to 0.088 mol %), CH_4 (0.0002 to 0.0052 mol %) and Ar (<0.00006 mol %). FI trapping boiling F occur at depths deeper than boiling point curve of pure H_2O, indicating that occurrence of boiling attributes to local P decrease due to fracture development. N_2/Ar ratio of samples from HJ-4 shows from 217 and 450, indicating contribution of magmatic F. (Authors' abstract, translated courtesy the author)

SAUNDERS, J.A. and SCHOENLY, P.A., 1995, Boiling, colloid nucleation and aggregation, and the genesis of bonanza Au-Ag ores of the Sleeper deposit, Nevada: Mineral. Deposita, v. 30, p. 199-210. Authors at Dept. Geology, Auburn Univ.., Auburn, AL 36849-5305.

A deep "parent" composition for bonanza ore-forming F at the Sleeper deposit was calculated by the computer program SOLVEQ using FI microthermometric and G data, and by assuming equilibrium with the minerals present in vein samples below the bonanza zones. The calculated dissolved Au content of 295 ppb is ~2 orders of magnitude higher than that assumed for typical geothermal systems. The various factors apparently led to nucleation of colloidal Au particles that were entrained in the upward-flowing hydrothermal solutions and grew as they traveled. (From authors' abstract by E.R.)

SAVARD, M.M., CHI, G., KONTAK, D.J. and FALLARA, F., 1995, Temperature, chemistry, water-rock interaction and mineralization processes around the Gays River and Jubilee Zn-Pb deposits, basal Windsor Group, Nova Scotia (abst.): Atlantic Geoscience Soc., Abstracts, 1995 Colloquium and Annual General Mtg., Antigonish, Nova Scotia, published in Atlantic Geol., v. 31, p. 59-60. First author at Centre Géoscientifique de Québec, Geol. Surv. Canada. 2700 Einstein St., Ste-Foy, Quebec G1V 4C7, Canada.

FI investigations include that (1) the regional background T around the Jubilee deposit was lower than around the Gays River deposit; (2) hydrocarbons were abundant during mineralization at Jubilee, but rare at Gays River; and (3) both deposits show Tm-Th trends typical of mixing of two or more F, among which, one was heated (≤250°C), saline (≤25-30 wt % eq. NaCl) and had Na/(Na+Ca) ≥0.7-0.8. In both deposits, O and Sr isotope covariations and $\delta^{34}S$ suggest mixing of two or more F and S of marine affinities. The mineralizing F of the Jubilee and Gays River deposits could have had distinct heated sources and could have mixed with background basinal brines. (From authors' abstract by H.E.B.)

SAVARY, V. and PAGEL, M., 1995, Thermal history of the Francevillean basin (Gabon) and of nuclear reaction zones at Oklo: Contribution of fluid inclusion study (abst.): Soc. Geol. de France Mtg., November 1995, Abstracts, p. 157 (in French). Authors at CREGU and GR CNRS 77, BP 23, Vandoeuvre-lés-Nancy Cedex, France.

The Franceville basin contains the Oklo U deposits. FI were studied to determine the nature of diagenetic F, P-T conditions of burial, and the physicochemical conditions of nuclear reactions.

Diagenetic minerals—Lastoursville basin. FI were studied in "nodules" of quartz and organic matter with calcite veins. In quartz, FI types are: Q1—aqueous, 0.4 to 3.4 eq. wt % NaCl, Th = 135 ± 12°C; Q2—salinity 3-8 eq. wt % NaCl, Th 160 ->300°C with mode ~180°C. Tm hydrate is between -8 and 27°C, indicating the presence of CH_4; Q3—one-phase CH_4-CO_2 FI. At low T, three phases (solid, L, V) appear. Th of F lies between -93 and -77°C. Tm CO_2 solid is between -98 and -89°C. The proportion of CH_4, from the Raman microprobe, is 0.95 ± 0.2%. In calcite, FI types are: C1—aqueous, salinities > 18 eq. wt % NaCl, and Th between 102 and 233°C; C2—10-50% V, with salinity 0.7 to 8 eq. wt % NaCl and Th between 127 and 260°C. Hydrate melts between 19 and 23°C, indicating the presence of CH_4; C3—one-phase I, with Th (V to L) between -88 and -82°C. From the immiscibility of the aqueous solutions and the CH_4-CO_2 F, the T and P of formation of the FI can be determined. Th of aqueous FI saturated in CH_4 represents the trapping T. The intersection of the isochores of the CH_4-CO_2 FI with this T range, 160-190°C, gives a P of 1000 ± 200 bars, indicating a lithostatic regime and an overlying sediment thickness of 4.0 ± 0.8 kb.

Diagenetic minerals—Franceville basin. Quartz overgrowths and calcite veinlets from the Oklo-Ok'lobondo sector were studied. Two-phase FI (L + V) have Th between 120 and >300°C, with a mode of 150-200°C, and salinities of 0.5 to 8 eq. wt % NaCl. These F are associated with siliceous diagenesis. A P correction is difficult because of a lack of P indicators.

Inclusions in and around reactor zones. Fission reactions generated much heat, increasing T in the enclosing rocks and causing mineralogical transformations, particularly formation of illite and Mg-Al chlorite, removal of silica and redeposition at the edges, formation of secondary apatite at the center of the reactors, and calcite veining at the edges. Increase in T caused an increase in P, leading to hydraulic fracturing, expulsion of F, and the formation of quartz veinlets. FI in eq. wt % NaCl and Th of 192-370°C, demonstrating the wide variation of T in the reactors. For 1 kb, the highest T reached was 520°C. These hot F dissolved detrital quartz and formed silicification haloes. In apatite crystals concurrent with a late phase of the nuclear reactions, the T is 175-332°C. A change in chemistry is clearly indicated by high salinities (13.4-24.1 eq. wt % NaCl). Finally, calcite was deposited at even lower T, and in the presence of much more saline solutions. The increase in salinity is no doubt due to water uptake by illite and chlorite formed in a relatively impermeable medium. At the contact between reactor 10 and its surrounding sandstone, unusual FI were observed. These contain either O_2 and H_2 or H_2 and CH_4. The presence of O_2 and H_2 is associated with radiolysis of H_2O. The uptake of O_2 by organic compounds leads to a highly reduced environment, allowing the formation of oxides of U, actinides and certain fission products. By contrast, in zones poor in organic matter, the environment becomes oxidizing because H_2 diffuses more rapidly than O_2. (Abridged from authors' abstract and translated by C.J. Eastoe)

SAVARY, V., PAGEL, M., and HOLLIGER, Ph., 1994, Thermal history of natural nuclear reaction zones at Oklo (Gabon) (abst.): 15th Mtg. of Earth Sciences [15e Réunion des Sciences de la Terre], 26-28 April 1994, Nancy, France, p. 45 (in French).

Nuclear fission reactions took place 1.97 Ga ago in the U deposit of Oklo (Gabon). The host rocks of the reactors underwent an intense hydrothermal alteration, connected with the activity of the nuclear reactions. T and composition of the F involved have been determined by studying FI in the authigenic minerals. Microthermometric measurements have been done on I in crystals of quartz, apatite and calcite in reaction zones 10 and 16. In quartz, salinities are low (2 to 4 eq. % NaCl) and the minimal trapping T (Th) are high, sometimes reaching 370°C. Salinities in apatite are higher (15 to 20 eq. % NaCl), but Th is lower (<300°C). In calcite, salinities are even higher (>23 eq. % NaCl) and Th is still lower (on avg. 125°C). Moreover, another hydrothermal episode has been detected at 20 m from reactor 10 in quartz crystals associated with galena. Microthermometry showed the presence of a F of low salinity (1 to 3 eq. % NaCl) and Th between 160 and 250°C.

These FI data indicate that the F present during the nuclear reactions are comparable to those of the regional diagenesis as determined by Openshaw et al. (1978). Textural observations show that apatite and calcite are formed late; this is evidenced by an important increase of the salinity during the lowering of the T towards the end of the nuclear reactions. The results obtained on the quartz crystals associated with galena, combined with Pb isotope data on this galena, are compatible with a hydrothermal episode connected with the intrusion of the dolerite located at ~70 m south of reaction zone 10. (Authors' abstract, translation courtesy Dr. E.A.J. Burke)

SAWAKI, T., 1994, A review of analytical methods of fluid inclusions: Application to geothermal exploration: J. Japan Geothermal Energy Assoc., v. 31, p. 343-356 (in Japanese).

Many new FI analytical methods have been developed; for example, quadrupole mass spectrometer, Raman microprobe, G chromatography, PIXE, SIMS, etc. This paper introduces the new methods and application of them to geothermal exploration. (Abstract courtesy the author)

SAWAKI, Takayuki, 1995, The present situation of study of fluid inclusions in Washington University and Virginia Polytechnic Institute and State University: Newsletter of Japanese Assoc. Of Geothermal Fluid Inclusionists No. 6, p. 1-5 (in Japanese).

SAWAKI, Takayuki, SASADA, Masakatsu and SASAKI, Munetake, 1994, Temperature logging by the intra-borehole growth of artificial fluid inclusions: Extended Abstracts of Workshop on Deep-seated and Magma-ambient Geothermal Systems, March 8-10, 1994, Tsukuba, Japan, p. 71-73.

See adjacent items. (E.R.)

SAWAKI, Takayuki, SASADA, Masakatsu, SASAKI, Munetake, TSUKIMURA, Katsuhiro, MURAOKA, Hirofumi, YAGI, Masahiko, HYODO, Masami and OKABE, Takashi, 1995, Synthetic fluid inclusion logging: Proc. World Geothermal Congress 1995, Florence, Italy, 18-31 May, v. 2, p. 1065-1066. First author at Geol. Surv. Japan, Higashi 1-1-3, Tsukuba, Ibaraki 305, Japan.

A new logging tool of synthetic FI has been developed for T measurements in high-T geothermal wells. F trapped in fracture planes of a mineral results in FI through healing. FI in quartz can be synthesized easily in the borehole environment. Cracked crystals of quartz soaked in silica-saturated alkaline solution in a Au capsule mounted on a container are placed in a geothermal borehole for T measurements. Tt of FI in quartz are determined by microthermometric measurements using a heating stage, and by P correction. Since α-quartz is stable to 573°C, this tool can be applied to high T geothermal boreholes whose T cannot be measured by conventional tools. (Authors' abstract)

See also Sasada and Sawaki, this volume, and adjacent items. (E.R.)

SAWAKI, T., SASAKI, M., KOMATSU, R. and MURAMATSU, Y., 1995, Geochemical features of fluid inclusions from the shallow geothermal reservoir of the Kakkonda geothermal system (abst.): Abstracts (FIR) of 1995 Annual Mtg., Geothermal Research Soc. Japan (in Japanese).

G compositions of FI from the shallow geothermal reservoir of the Kakkonda geothermal system, NE Japan, were analyzed by a quadrupole mass spectrometer and a capacitance manometer at the GSJ. Analyzed samples were hydrothermal quartz and anhydrite from geothermal wells drilled in Kakkonda. All of the FI are L-rich, two-phase I. Bulk analyses show that the I are mainly composed of H_2O (99.8 mol %<), with small amounts of CO_2 (0.11 mol %>), N_2 (0.046 mol %>), CH_4 (0.0021 mol %>) and Ar (at detection limits of the analytical system). The G contents are higher than present-day discharge F, and the I were formed by trapping geothermal F before considerable degassing. Individual I analyses show that FI relatively rich in G occur at >1000 m. This suggests that geothermal F rich in G flow and/or flowed at >1000 m. (Authors' abstract, translated courtesy T. Sawaki)

SCAMBELLURI, M., PHILIPPOT, P. and PENNACCHIONI, G., 1995, High-salinity brines in eclogitized metabasites as the result of rock hydration during high pressure metamorphism (Mt. Emilius Austroalpine Unit, Italian Western Alps) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 216-217. First author at Dept. Scienze della Terra, Genova, Italy.

F-induced eclogitization of granulite-facies rocks has been described in a variety of high P terranes. By means of a study of FI from omphacite veins in the Mount Emilius crustal Austroalpine unit, we want to emphasize the control exerted by hydration processes at eclogite facies conditions on the composition of the coexisting F and on rock rheological behaviour.

All veins contain abundant P to PS FI trapped along the growth zones of sector-zoned omphacite, or disposed parallel to the long axis of pyroxene fibres in syntaxial stretched crystal type of veins. The FI fall into two main categories: (1) type A two-phase aqueous I (L + V; L/V ratios = 20-25% vol); (2) type B three-phase I (L + V + a salt cube). Most of these I shows depression of Te between -28 and -50°C, suggesting the presence, besides NaCl, of extra components such as $CaCl_2$ and $MgCl_2$. Average salinity estimates of type A I is of 20-25 wt % salts. Inclusions with lower salinity (10-15 wt % NaCl eq.) are also present. Halite dissolution T of type B I indicate salinities between 33 to 46 wt % salts. $CaCl_2$ content of type B I ranges from 1 to 4 wt %. No CO_2, H_2S, CH_4 and N_2 have been detected (Raman). These data indicate that the F populations filling the eclogitic veins in both the eclogite and metagranulite host rocks contain moderate to highly saline aqueous brines of similar composition. Eclogitization of the metagranulite is driven by infiltration of aqueous F dehydrating micaschists during high-P metamorphism. (From authors' abstract by E.R.)

SCAMBELLURI, M., ROBBIANO, A. and PICCARDO, G.B., 1995, High-pressure veining and fluid inclusions in an alpine eclogitized peridotite: Recycling of oceanic fluids? (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 218-219. Authors at Dept. Scienze della Terra, Genova, Italy.

The FI analyzed are from high P veins within the peridotite. The FI mainly occur within diopside as clusters of tubular FI parallel to the {010} face of pyroxene. Textures testify that I entrapment predates the eclogitic deformation and is related to crystallization of diopside during an early eclogite stage of veining. The PI (5 to 30 microns) are mostly three phase (L+V+halite) and may contain additional solid phases consisting of magnetite, ilmenite and locally quartz. The three-phase I may be associated with two-phase I showing a L + V assemblage at room T. During freezing the two-phase I usually precipitate a salt cube, suggesting that their salinity is close to halite saturation (~20 wt % NaCl eq.). In all analyzed I, the total range of Te extends from -39 to -26°C, which can be taken to imply the presence of $MgCl_2$ and probably KCl in the F. Halite dissolution T in the three-phase I (315 to 380°C) point to salinities of 40 to 45 wt % NaCl eq. These data testify for an aqueous saline brine containing 20 to 45 wt % dissolved NaCl, KCl and $MgCl_2$. The SEM qualitative data thus confirm that the daughter salts are mixtures of NaCl, KCl and $MgCl_2$.

The FI analysis demonstrates that saline aqueous F containing Na, K and Mg chlorides were present in the peridotite at an early stage of eclogite-facies metamorphism. Alkalies, Cl and H_2O were incorporated in serpentine and chlorite at the seafloor; breakdown of such minerals thus influences the composition of the F released at high P. Rock control on the F composition is also suggested by the presence of Mg chloride in the peridotite F. The presence of apatite in veins opening close to gabbroic dikes further confirms that the F composition is locally controlled by rock variabilities. The deposition of high P veins containing hydrous assemblages determines consumption of water from the aqueous F and may result in increase in the bulk F salinity. (From authors' abstract by E.R.)

SCHALAMUK, I.B., FERNÁNDEZ, R.R. and ETCHEVERRY, R.O., 1995, Gold-silver epithermal veins in the Macizo del Deseado, Argentina, *in* Pasava, Kríbek and Žák, eds., Mineral Deposits:

Balkema, Rotterdam, p. 385-388. Authors at Inst.. Recursos Minerales, Univ. Nacional de La Plata, Argentina.

In the last ten years several Au-Ag occurrences, occasionally very important, hosted in upper Jurassic acid volcanics have been found in the Macizo del Deseado. They are mainly vein-type and were formed between 150 to 300°C from lower salinity F. These discoveries make the region an interesting target for exploration. (Authors' abstract)

Th values ≤370°C are recorded; sal. avg. 3-8% NaCl. (E.R.)

SCHALAMUK, I.A., RIOS, F.J., FUZIKAWA, K. and PIMENTA, M.A., 1995, Fluid inclusion studies in epithermal auriferous-quartz deposits of Macizo Del Deseado, Santa Cruz, Argentina (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 220-221. First author at UNLP-CONICET, La Plata, Argentina.

FI studies were carried out on samples from five localities. Figure 1 is the histogram for all Th obtained in this study. Samples from Bajo Pobre area presented many FI in growth zones (primary) of quartz crystals. One-phase FI dominate over the two-phase ones [sic]. The aqueous F indicated almost pure water (0.18-0.35 wt % NaCl eq.). The measured Th may be somewhat lower than the highest values (~230°C, Fig. 1) as necking down is a common feature.

In the Manantial Espejo area, Rios et al. (1994) indicated low salinity (4 wt % NaCl eq.) aqueous FI in quartz from Veta Maria. A sample from a breccia pipe indicated higher salinity (5.0-6.6 wt % NaCl eq.). Quartz crystals from both samples present growth zones with decreasing Th: from 300 to 180°C in the vein and from 240 to <160°C in the breccia.

In the Dorado/Monserrat area barite which is of late stage paragenesis presented only one phase FI of fairly large size (~15 µm), with Tm ice = -1.0°C (1.74 wt % NaCl eq.). Common occurrence of superheated ice metastability precluded further measurements. FI in quartz indicated salinities of 0.71-1.4 wt % NaCl eq. and Th in the range of 190-280°C.

At Cerro Vanguardia deposit quartz from Atila vein presented fairly good FI related to growth zones. The Tm ice all fell in the narrow range of -0.2 to 0.0°C (0.35 wt % NaCl eq.). The Th were between 200 and 310°C, the highest Th found in this study. The obtained composition and T of F fit well within the values known for veins in volcanics of epithermal Au deposits. (From authors' abstract by E.R.)

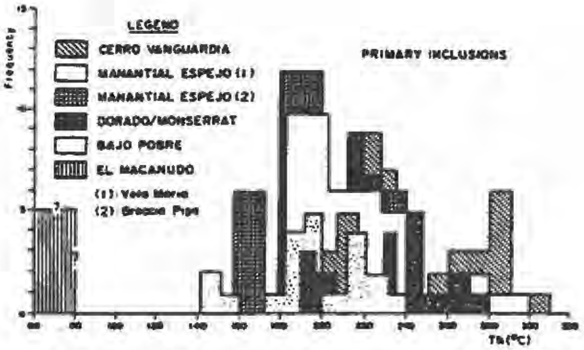


Figure 1. Composed histogram of aqueous two-phase FI Th from the studied areas.

SCHIANO, P. and CLOCCHIATTI, R., 1995, Deep silicate melts in convergent and intraplate settings (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 334-335.

Silicate melts migrating through the upper mantle beneath oceanic and continental intraplate regions (Schiano and Clocchiatti, Nature 368, 621-624, 1994). Silicate M migrating through the upper mantle beneath oceanic and continental intraplate regions and through the mantle wedge beneath an arc-front volcano (Batan Island) have been identified and characterized as MI trapped within minerals in mantle xenoliths. They are characterized by a number of common features, in particular silica-alumina-alkali-rich compositions which differ strongly from those of erupted, mantle-derived lavas. The dm paragenesis, the major and volatile element composition, and the trace element signature of silicate MI trapped in both intraplate and arc ultramafic xenoliths reflect the input of small amounts of metasomatic M phases. These M must have reacted with the primary mantle lithologies by altering the bulk composition and mineralogy of the host peridotite, to produce hybridized enriched mantle peridotites. Nevertheless, chemical differences can be observed between M in intraplate peridotites and M in arc peridotites, e.g., intraplate M are CO_2-rich, indicating a silicate-carbonate primary composition, whereas arc M show evidence for a H_2O and S-rich initial composition. The Th for MI is ~1250°C for intraplate xenoliths and ~900°C for arc xenoliths, which also point to differences in their genesis. Finally, the relationship between the migrating M and the erupted lavas can be distinguished clearly in the two geodynamical contexts: intraplate M do not seem to be related with erupted basalts, but play a role in metasomatic transformation of the lithosphere. Whereas arc M, which show the expected trace element signature of slab-derived M, display simple chemical trends with erupted andesites indicating a close genetic relationship. (Authors' abstract.)

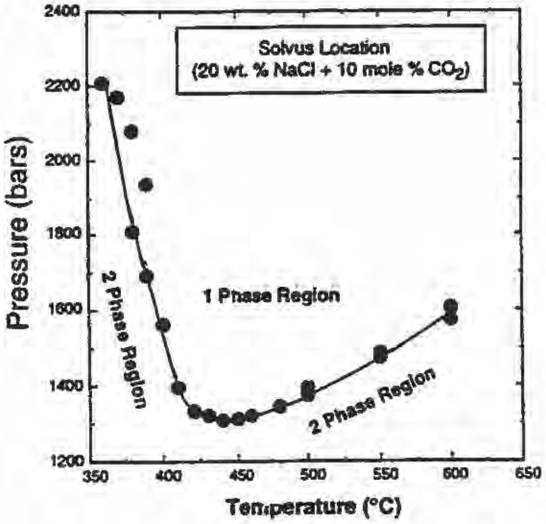
SCHIANO, P., CLOCCHIATTI, R., SHIMIZU, N., HOFMANN, A.W., MAURY, R.C. and ALLEGRE, C.J., 1995, Occurrence of high-silica melts in the sub-arc mantle and their relationships with erupted arc lavas (abst.): Eos, v. 76, no. 17, p. S267. First author at Lab. Geochimie et Cosmochimie, IPG Paris, 4 Place Jussieu, 75252 Paris, France.

Silicate melts migrating through the upper mantle, and identified as MI within mantle minerals or as interstitial glasses in xenoliths, are characterized by high silica contents. In contrast, erupted mantle-derived magmas have a basaltic or andesitic composition and seem not to be influenced by these high-silica melts. Here we identify remnants of the M and F migrating through the mantle wedge beneath island arcs, by examining M and FI trapped within mantle xenoliths in a calc-alkaline arc-front volcano (Batan island, Luzon arc, Philippines). These xenoliths, found within young potassic basaltic andesites, are essentially harzburgite and pyroxenite corresponding to previously metasomatized mantle fragments incorporated in the lavas during ascent. In addition to the primary porphyroclasts (ol, opx, spinel), some xenoliths contain late undeformed metasomatic minerals (Fe-enriched ol and opx, cpx, phlogopite, amphibole). Silica-saturated dacitic MI, accompanied with H_2O-F and sulphide I, are identified within both primary and metasomatic minerals. These high-silica melts ($54\% < SiO_2 < 63\%$), which display the expected trace element signature of slab-derived M, can be considered as trapped remnants of a metasomatic volatile-rich M phase percolating through the depleted mantle wedge. Reactions between the M and primary lithologies, recorded by trace element enrichment and crystallization of the metasomatic paragenesis, result in the production of a hybridized mantle displaying the chemical characteristics of an island-arc source region. In addition, the high-silica M display simple chemical trends with Batan calc-alkaline basaltic andesites, which indicates the existence of a close genetic relationship between the two. The trends cannot be accounted for by differentiation processes, but rather by a mixing mechanism between two M components, or by a continuous evolution leading towards formation of calc-alkaline andesites as end product. (Authors' abstract)

SCHMIDT, C. and BODNAR, R.J., 1995, Volumetric properties and solvus location in the pseudobinary (H_2O- 20 wt % NaCl) - CO_2 for carbon dioxide concentrations ≤30 mole % (abst.): Eos, v. 76, no. 46, p. F683.

FI having compositions of 20 wt % NaCl and 10, 20 and 30 mol % CO_2, both relative to H_2O, were synthesized in cold-seal P vessels at P from 2 to 5 kb and T between 400° and 700°C. The solvus location and the P-T slopes of iso-Th lines and isochores were determined for bulk F densities above the critical density for a constant composition of 20 wt % NaCl and 10 mol % CO_2, based on microthermometric and Raman-spectroscopic analysis. For higher CO_2 concentrations, molar volumes were calculated from microthermometric data for the density of the CO_2 phase, and the solvus location was estimated.

For 10 mol % CO_2, the high density portion of the bubble-point curve show a P minimum of ~1300 bars and 440°C (see Figure). At lower T, the solvus has a steep negative slope, whereas the solvus P increases only slightly at T >440°C. Addition of CO_2 to an aqueous solution of 20 wt % NaCl results in a significant shift of the bubble point curve towards higher P: the minimum P is between 2 and 3 kb for 20 mol % CO_2 content and between 4 and 5 kb at a CO_2 concentration of 30 mol % relative to water. The slopes of the iso-Th lines for a constant composition of H_2O + 20 wt % NaCl + 10 mol % CO_2 decrease nonlinearly from ~22 bars/°C for Th(L-V) of 360°C, to ~3 bars/°C for Th(L-V) = 600°C. (Authors' abstract)



SCHMIDT, C., ROSSO, K.M. and BODNAR, R.J., 1995, Synthetic fluid inclusions: XIII. Experimental determination of PVT properties in the system H_2O + 40 wt % NaCl + 5 mol % CO_2 at elevated temperature and pressure: Geochim. Cosmochim. Acta, v. 59, p. 3953-3959. Authors at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

The location of the L + V → L phase boundary and the P-T slopes of iso-Th lines were determined for a constant composition of 40 ± 0.1 wt % NaCl and 5 ± 0.15 mol % CO_2 (both relative to H_2O) at high density. Synthetic FI with this composition were formed in cold-seal pressure vessels at P of 2 and 4 kb and T between 350° and 700°C. The I were analyzed on a G-flow heating/cooling stage to determine the T of halite dissolution [Tm(H+L+V → L+V)] and total homogenization [Th(L+V → L)].

Addition of 40 wt % NaCl to an aqueous solution containing 5 mol % CO_2 causes a significant shift of the L + V → L boundary towards higher P. The slopes of the iso-Th lines decrease from 29.5 bars/°C for Th(L+V → L) of 400°C, to 6.4 bars/°C for Th(L+V → L) = 600°C. Addition of 5 mol % CO_2 to an aqueous solution containing 40 wt % NaCl results in halite dissolution T that are slightly higher [Tm(H+L+V → L+V) ≈ 332°C] than the literature value of 323°C for the V-saturated liquidus of an H_2O-40 wt % NaCl mixture.

Calculated molar volumes for 40 wt % NaCl + 5 mol % CO_2 solution at 2 and 4 kb show trends are similar to those of other compositions in the ternary system H_2O-CO_2-NaCl at the same P and T. In the P-T range of this study, all excess volumes are negative and lie between the values for the compositions H_2O-5 mol % CO_2 and H_2O-40 wt % NaCl. (Authors' abstract)

SCHMIDT MUMM, A., BLENKINSOP, T. and OBERTTHÜR, T., 1995, Gold mineralization and regional fluid mobilization during the Eburnean crustal consolidation in Ghana, West Africa (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 222-223. First author at Inst. Geologische Wissenschaften, Domstr. 5, D-06108 Halle, Germany.

The Ashanti Belt in Ghana contains numerous epigenetic gold deposits that are hosted by greenschist metamorphic sediments, volcanics and also late kinematic granitoids.

FI in samples from these deposits were investigated in order to determine the physicochemical characteristics of the mineralizing conditions. Conservative P-T estimates based on FI data indicate a depth interval of at least 15 km within which Au deposition from these CO_2 >> N_2 > CH_4-rich F took place. For Ashanti and Prestea the high densities of F in I point to 15 to 20 km depositional depth, the mineralization of the Ayanfuri granite took place at rather shallow 5 to 8 km depth at ~330 to 340°C. The Abosso Damang mineralization is inferred to have occurred at a similar depth but considerably lower temperatures of 180 to 270°C.

The near absence of aqueous FI bears some problems with respect to the composition of the mineralizing F. A yet unknown process of selective trapping of the gaseous components is in conflict with the abundant CO_2-H_2O I at Ayanfuri. If secondary selective leaching had extracted the aqueous phase from initially mixed I, this process must have been very effective over 250 km along strike and at least 15 km to depth; still, the Ayanfuri mineralization was left out. Can we envisage these F as potential mineralizing agents in crustal processes? Very little is known of the physical and chemical characteristics or the solvent properties of these volatile-rich F at the considered P-T conditions.

The mobilization and migration of the CO_2 >> N_2 > CH_4-rich F and associated Au mineralization was a regional process, traceable for 250 km along strike of the Ashanti belt, and diacroneously to the west in the Kibi-Winneba area. The source of these F is not finally cleared. Stable isotope ratios of O, C and S suggest metamorphic mobilization from the sedimentary country rock.

The high content of gaseous (CO_2 + N_2 + CH_4) components in the FI appears to be of regional significance for the process of Au enrichment in the Ashanti belt and may serve as a pathfinder for exploration. (From authors' abstract by E.R.)

SCHMIDT MUMM, A., BLENKINSOP, T., OBERTHÜR, T. and WEISER, T., 1995, The mineralization at the Viceroy Gold Mine, Harare-Bindura greenstone belt, Zimbabwe (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 224-225. First author at Inst. Geologische Wissenschaften, Domstr. 5, D-06108 Halle

The Viceroy Au mine is in quartz veins in an E-W trending arm of the Harare-Bindura greenstone belt, Zimbabwe. The ore mineral assemblage involves the system Au-Bi-S-Te.

C isotope compositions of calcite ($\delta^{13}C$ in ‰ PDB) range from -9.8 to -5.6‰ (mean -6.8) in the mineralization and -3.4 to -3.6‰ in the hydrothermal breccia. O isotope compositions ($\delta^{18}O$ in ‰ SMOW) of calcite range from 9.4 to 10.7‰ and of quartz from 11.6 to 12.2‰. From this the isotopic composition of the F can be calculated (Table 1). Together with δD values of FI in quartz of -51 and -31‰ a surficial affinity of the mineralizing F may be inferred. S isotope composition ($\delta^{34}S$ in ‰ CDT) of sulfides (arsenopyrite) ranges from 1.9 to 3.3‰, which is compatible with a derivation of the S from magmatic rocks.

FI studies revealed a complex pattern of F systems. Primary and secondary generations of aqueous I associated with the Au mineralization are of low but complex salinity (Tm: mostly 0 to -7°C, sometimes as low as -22.7°C, Te: mostly -20 to -35°C, sometimes as low as -55°C) and homogenize over a wide range from 150 to 317°C. The higher Th were measured on I which also showed clathrate melting or even a separate gas (CO_2) phase. SI on intersecting secondary fracture planes may have mixed salinities at or near the intersection line. Closely associated with the aqueous I are gaseous, CO_2-rich I which may locally contain additional CH_4. Evidence for phase separation is present but not unequivocal. In the wallrock of the mineralized shear zones I in small quartz carbonate segregates are aqueous and of high, complex salinity; Th are 150 to 190°C. FI were also analyzed in the carbonate breccia pipe. Here aqueous I have moderate but complex salinities (Te: -55 to -65°C, Tm: -10 to -18°C) and homogenize over 180 to 280°C. The abundant gaseous I in the breccia pipe carbonate show strong evidence for the presence of increased CH_4 contents (Tm: -184 to -172°C, Th: -84 to -77°C).

Petrographic, structural, and isotopic as well as FI data point to a very complex evolution of the shear zones and mineralization at the Viceroy mine. At least two episodes of mineral deposition can be distinguished: The first one postdates metamorphism but clearly occurred at increased T to cause biotitization of the country rock. Field relations also suggest that the carbonate breccia pipe originates from this event. The second mineralizing system, which lead to the Viceroy deposit was active at a later stage and at considerably lower T. FI and the ore mineral paragenesis provide evidence for a hydrothermal system at shallow depth which may have interacted with meteoric waters in the course of this second episode. Regional structural interpretation even raises the possibility of a Proterozoic origin of this second mineralizing system. (From authors' abstract by E.R.)

SCHMIDT MUMM, A., CHENGERAI, K.G., BLENKINSOP, T.G., OBERTHÜR, and CHATORA, D., 1995, Metallogenesis of the Redwing gold mine, Mutare greenstone belt, Zimbabwe (abst.), *in* T.G. Blenkinsop and P.L. Tromp, eds., Sub-Saharan Economic Geology: Geol. Soc. Zimbabwe Spec. Pub. 3, p. 187-212.

SCHMIDT MUMM, A., LEHNER, C., SAWATZKI, J. and IDIZ, E., 1995, Gas analysis in fluid inclusions by NIR FT Raman spectroscopy (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 226-227. First author at Inst. Geologische Wissenschaften und Geiseltalmuseum, Domstr. 5, D-06108 Halle

Raman spectroscopy may not be suitable for samples with I of higher hydrocarbons or organic impurities due to effects of fluorescence. The problem of fluorescence can be substantially reduced by the use of near IR excited FT-Raman techniques. The long wavelength/low energy excitation (1064 nm) avoids the effects of fluorescence as well as local heating. Fluorescent materials would thus be accessible for Raman microprobe. For the investigation of microscopic samples an FT-Raman microscope coupled to the bench of an FT-Raman spectrometer was used. The excitation source was a diode-pumped NIR Nd:YAG laser of 1064 nm, providing a power of 100 mW at the sample location.

FI of 5 to 12 μm diameter were analysed in calcite from a calcite-sphalerite vein in the Upper Permian Zechstein. Initial microthermometric analyses provided strong indications for the presence of CH_4 and in some cases also N_2 through Tm of -196.3 to -171.4°C and Th of -117.2 to -81.2°C. These could not be analyzed by conventional Raman because of an intense fluorescence of the hosting carbonate, which was several orders of magnitude stronger than the expected Raman signals. An example of the spectra obtained by NIR FT Raman is given in Figure 1. CH_4 is the dominant hydrocarbon phase with a well-developed peak at 2912 cm^{-1}. The relatively wide base of this peak may be indicative for further hydrocarbon components as the CH stretching vibrations fall in the range of approximately 2850 to 3100 cm^{-1}. The peak for N_2 at 2329 cm^{-1} is much smaller, but may still represent significant amounts of N_2 in the I as the Raman scattering cross section of N_2 is several times smaller than for CH_4. However, calibration measurements of I of known composition are needed for a quantification of the results.

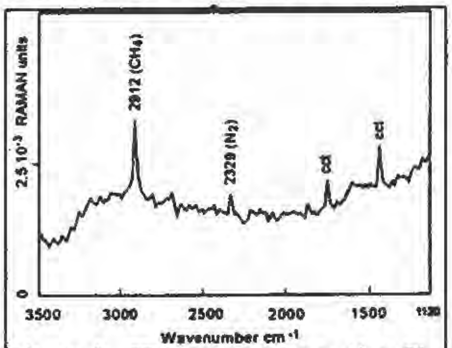


Figure 1: FT-Raman spectrum of a CH_4-N_2 inclusion in calcite. Spectral resolution 12cm^{-1}, scan accumulations 20000, laser power 100mW, objective 40x numerical apperture 0.65. cct = calcite

Figure 1. FT-Raman spectrum of a CH_4-N_2 I in calcite. Spectral resolution 12 cm^{-1}, scan accumulations 20000, laser power 100 mW, objective 40x numerical aperture 0.65. cct = calcite.

Instrumental development of the NIR FT-Raman spectroscopes, mainly in spectral stabilisation of the laser source and optimisation of the detectors has lead to an improvement of the detection limits and also spot size for the application as a method for non-destructive microanalysis. Analysis of gaseous components in natural FI by NIR FT-Raman is at present the only method when fluorescence inhibits the use of the high energy excitation from Ar lasers. This may be especially useful for FI studies related to generation, migration and fixation of hydrocarbons. (From authors' abstract by E.R.)

SCHWARCZ, H.P. and YAMAMOTO, Masahiro, 1981, Oxygen isotope analysis of fluid inclusions in speleothems: Mass Spectrometry, v. 29, p. 75-79 (in Japanese, English abstract). First author at Dept. Earth Sciences, Fac. Sci., Okayama Univ., 3-1-1 Tsushimanaka, Okayama 700, Japan.

A bromine pentafluoride line was built for H_2O samples after O'Neil and Epstein (1966). The line is used to decompose H_2O to produce O gas by reacting with bromine pentafluoride and subsequently to convert the O gas to CO_2 gas for O isotope analysis. It was applied to H_2O samples from FI in speleothems. H_2O was extracted from speleothems by crushing them in a stainless steel tube in a manner initially developed by Roedder et al. (1963).

The precisions of bromine pentafluoride line for standard H_2O samples, V-SMOW and NBS-1, were ±0.15 and ±0.20‰, respectively. The precision for the whole analytical procedure including the step of crushing speleothems was checked using natural flowstone samples from Bermuda and was found to be ±0.24‰. (Authors' abstract)

SCHWARTZ, M.O., AKANYANG, P., TRIPPLER, K. and NGWISANYI, T.H., 1995, The sediment-hosted Ngwako Pan copper deposit, Botswana: Econ. Geol., v. 90, p. 1118-1147. First author at Bandesanstalt für Geowissenschaften und Rohstoffe, PO Box 510153, 306311 Hannover, Germany.

The stratabound Ngwako Pan Cu deposit is hosted by sediments metamorphosed at lower greenschist facies conditions and tightly folded. The Th of FI in secondary quartz are in the range of 57° to 254°C, the median being 179°C. Various features indicate that at least part of the disseminated mineralization or its precursor sulfide minerals was deposited before major compaction was completed. (From authors' abstract by E.R.)

SCHWARTZ, M.O., RAJAH, S.S., ASKURY, A.K., PUTTHAPIBAN, P. and DJASWADI, S., 1995, The Southeast Asian Tin Belt: Earth Sci. Rev., v. 38, p. 95-293.

A book-length review of all aspects, including a summary of literature FI evidence (p. 234-237) and its interpretation, in terms of experimental data on the NaCl-H_2O-CO_2 system. (E.R.)

SCIUTO, P.F. and OTTONELLO, G., 1995a, Water-rock interaction on Zabargad Island, Red Sea—A case study: I. Application of the concept of local equilibrium: Geochim. Cosmochim. Acta, v. 59, p. 2187-2206. Authors at Dept. Earth Sciences, Univ. Genova, 16132 Genova, Italy.

We apply a nonlinear minimization routine to study this complex event in the framework of the postulate of local equilibrium in disequilibrium processes (Prigogine, 1955). Such a study allows a rough estimate of the chemistry of interacting F (and of P, T conditions at equilibrium). The process took place at an average P of 1 kb and, after an initial hydration stage, a thermal maximum was reached at ~500°C, corresponding to the zone of retrograde formation of olivine gems, after which the T progressively fell to ~200°C. F were hypersaline and extremely aggressive (pH = 2-3.5). The composition of the F plots in the three-phase region of the H_2O-CO_2-NaCl system (i.e., an "aqueous" L coexisting with a CO_2-rich G phase and halite). (Authors' abstract)

SCIUTO, P.F. and OTTONELLO, G., 1995a, Water-rock interaction on Zabargad Island, Red Sea—A case study: II. From local equilibrium to irreversible exchanges: Geochim. Cosmochim. Acta, v. 59, p. 2207-2213. Authors at Dept. Earth Sciences, Univ. Genova, 16132 Genova, Italy.

In spite of the complexity of the alteration paragenesis at Zabargad Island, the evolution of the chemical parameters is sufficiently continuous and smooth. This, through examination of the activity coefficients of solutes, allows a tentative appraisal of reaction kinetics in the quasistationary state, i.e., calculated F molalities are related to an overall progress variable (ε) and the compositional matrix is solved on the main solid phases (olivine, chrysotile, tremolite, diopside, enstatite, dolomite, amorphous silica) by application of three external constraints (absolute reaction rates of amorphous silica and pyroxenes), which allow contemporaneous evaluation of the overall rate of the system. The absolute reaction rates obtained are internally consistent and agree with field observations. The highest (negative) reaction rates of olivine gem formation are observed in the zone of the thermal maximum, coupled with a high (positive) rate of chrysotile dissolution and (negative) tremolite production. Dolomite is near a detailed balancing condition throughout the process. (Authors' abstract)

Pertinent in view of the extensive studies of the FI in the gem olivine. (E.R.)

SEAL, R.R., II, AYUSO, R.A., FOLEY, N. K. and CLARK, S.H.B., 1995, Geochemistry of supergene barite from the Barite Hill gold mine, S.C.: Implications for ancient acid drainage formation (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-117.

Geochemical evidence supports the interpretation of a supergene origin for the barite in the oxidized ores. FI hosted by supergene barite are L-only, whereas those hosted by hypogene barite are L + V and L-only. ε_{Nd} values for hypogene barite range from -10 to -9 and are grossly similar to Late Proterozoic-Early Cambrian seawater values. The $\delta^{34}S$ values of supergene barite (8.6 to 13.3 ‰) are intermediate between those of hypogene massive sulfide (1.0 to 5.3‰) and massive barite (25.0 to 28.0‰). Mass balance considerations indicate that ~70% of the S in the supergene barite was derived from the oxidation of pyrite, whereas 30% was derived from the dissolution of hypogene barite. The $\delta^{18}O$ values of hypogene barite (5.9 to 6.2 ‰) are consistent with a seawater derivation. The range of δ18O values for supergene barite (4.9 to 8.1 ‰) probably reflects pyrite oxidation and acid generation that occurred under (1) variable conditions of changing meteoric water compositions due to seasonal variations or longer term climatic changes, and(or) (2) variable contributions of ground-water and atmospheric O. The isotopic data are consistent with an origin for the supergene barite in which dissolution of hypogene barite provided Ba and sulfate to the ground waters, and the subsequent addition of sulfate derived from the oxidation of pyrite returned the solution to barite-saturated conditions, and thus preserved a record of ancient acid drainage formation that would otherwise be unobtainable. (From authors' abstract by H.E.B.)

SEDOVA, I.S., SEMENOV, A.P. and BALTYBAEV, Sh.K., 1995, Fluid inclusions in quartz veins of low-middle metamorphic grade rocks of Ladoga complex, Baltic Shield: Geokhimiya, 1995, no. 10, p. 1433-1447 (in Russian, English abstract).

FI in 20 polished sections of quartz vein rocks have been studied. The quartz veins are located in the low-middle metamorphic grade rocks of Ladoga complex metamorphized in the T interval 450-780°C under increasing P 3.5-4 to 5-6 kb. Four generations of quartz veins have been distinguished. Veins of second generation (V_2) are considered to be synchronous with the metamorphism culmination, whereas the third generation veins (V_3) reflect the beginning of regression stage. Four main types of I (H_2O of different salt contents, H_2O-CO_2, CO_2, CH_4-N_2) and three additional ones (CH_4-N_2-H_2O, H_2O-CH_4-N_2, and H_2O-NaCl-$NaHCO_3$) have been isolated in V_2 and V3. It has been shown that the total degassing of quartz (as measured by G chromatography) and the number of CO_2 I increases as compared to H_2O and CH_4-N_2 ones during progressive metamorphism. Mole fraction of CO_2 substantially increases in the III zone where the first migmatites appear. H_2O/CO_2 ratio was estimated to be 0.8/0.2 for V2 of low grade metamorphic zone (zone II) and 0.6/0.4 for zone III. Evolution trend of progressive and regressive metamorphism of these complexes was proposed based on the data of solid state thermometry, densities of CO_2 I of different age, and Th of H_2O I. (Authors' abstract)

SEDOVA, I.S., SEMENOV, A.P., LOKHOV, K.I. and KRASOTKIN, S.I., 1995, The relationship between fluid and chemical composition of the polymigmatites in the Tupaya Guba region of Lake Kovdozero, northwest White Sea area: Dokl. Ross. Akad. Nauk, v. 342, no. 2, p. 226-229 (in Russian).

Numerous G chromatographic analyses were made. (E.R.)

SEGALSTAD, T.V. and BERG, H.-J., 1995, Geochemistry of gold in hydrothermal systems, *in* P.M. Ihlen, M. Pedersen and H. Stendal, eds., Symp. Gold Mineralization in the Nordic Countries and Greenland, Univ. Copenhagen, Denmark, 19-20 Oct. 1995: Geol. Surv. Greenland Open File Series 95/10 (unpaginated). Authors at Mineralogical-Geological Museum, Univ. Oslo, Sars' Gate 1, N-0562 Oslo, Norway.

Hydrothermal Au deposits may be divided into two major types: oxidized (O-type) near the co-stability of pyrite, hematite, and magnetite, and reduced (R-type) near the co-stability of pyrite and pyrrhotite. Cu- or As-minerals may be present in both types.

Solubility data from the literature for the aqueous Au complexes $AuCl_2^-$, $Au(HS)_2^-$, and $Au_2(HS)_2S^{2-}$ have been evaluated. The solubility of Au with respect to these complexes (of which the first two are important ore formers) has been calculated in equilibrium with quartz, hematite, magnetite, pyrite, chalcopyrite, bornite, pyrrhotite, siderite, arsenopyrite, and löllingite. The calculation conditions were 200-450°C, pH 2-9, Fe and Al present in solution, and different activities of O2, ΣS, ΣC, and Cu.

The solubility of Au in the form of these complexes is a function of T under otherwise equal conditions. For O-type deposits at fixed Cl = 0.5 m and S = 0.05 m, the calculated log activity for $AuCl_2^-$ is -10 and -3 at 200°C and 400°C, respectively; for $Au(HS)_2^-$ -10 and -13; and for $Au_2(HS)_2S_2^-$ -15 and -20. The $Au_2(HS)_2S_2^-$ complex is therefore less important here.

There is a large difference between the solubility of Au complexes in equilibrium with Au only, compared to when the complexes occur also in equilibrium with other minerals. By considering the solubility of Au in equilibrium with common characteristic hydrothermal minerals, <300°C the Cu-minerals in particular have a strong tendency to promote deposition of native Au from solution.

L-V inhomogeneity ("boiling") has been modeled for the Cl- and HS-complex in equilibrium with Au. This shows that open system, continuous separations, boiling of the HS-complex is the most effective for depositing Au, especially at shallow depths, at T ≤250°C. Closed system boiling will not deposit Au from the HS-complex, while open system, multistep separations is not a very effective Au depositing process. Any type of boiling of the Cl-complex will lead to Au deposition, but intermediary in efficiency compared to the two types of open system boiling of the HS-complex.

The solubility modeling is used to discuss different models for magmatic and hydrothermal processes leading to Au concentration at the source stage, leaching or partitioning of Au from the source to an aqueous solution, transport of Au complexes, and deposition of Au, in different geologic settings. (From authors' abstract by E.R.)

SEIFERT, W. and THOMAS, R., 1995, Silicate-carbonate immiscibility: A melt inclusion study of olivine melilitite and wehrlite xenoliths in tephrite from the Elbe Zone, Germany: Chem. Erde, v. 55, p. 263-279. Authors at GeoForschungsZentrum Potsdam, Germany.

The Tertiary olivine melilitite (polzenite) from the Zeughaus dike, SE-Saxony, is characterized by unusual mineral zoning patterns and MI in several minerals. Olivine phenocrysts occur in two populations:

(a) normally-zoned crystals with decreasing Mg/(Mg + Fe) ratios from core to rim and (b) reversely-zoned crystals. Matrix olivines are unzoned. Spinels show Cr-rich cores with rims of pleonaste, and are surrounded by titanomagnetite margins. MI occur in olivine, clinopyroxene, phlogopite, apatite, and titanomagnetite. Generally, three different types can be distinguished: (1) MI, exclusively in olivine, with SiO_2 and CaO amounts similar to those in the bulk rock, (2) SiO_2-CaO-rich I, and (3) SiO_2, CaO-rich MI, especially in apatite and titanomagnetite. The latter two types are also characterized by high F contents. We interpret these phenomena as evidence for L-L immiscibility. PT determinations indicate an early separation of carbonatitic M at a depth of ~40-50 km and an embryonic stage of separation of carbonatitic M.

Silicate-carbonate immiscibility phenomena also were found in wehrlite xenoliths from tephrite of the Grosser Winterberg near the Zeughaus dike. Here, MI and grain-boundary M pockets consist of silicate glass with (Ca, Fe, Mg)-carbonate globules. The generation of the original carbonate-rich M is interpreted as the result of mantle metasomatism by CO_2-dominated F. (Authors' abstract)

SEKINE, Ryota, IZAWA, Eiji, WATANABE, Koichiro and ITAYA, Tetsumaru, 1995, Timing of volcanism and hydrothermal alteration in the Onta-Yamakuni gold area, northern Kyushu, Japan: Resource Geol., v. 45, p. 295-302 (in Japanese, English abstract). First author at Sumitomo Metal Mining Co., Ltd., Hishikari, Kagoshima 895-27, Japan.

Hydrothermally altered volcanic rocks in the area host Au-bearing quartz veins and clay deposits. On the basis of alteration mineral assemblages, the Au area was divided into four zones, the chlorite zone which widely distributes in the central part, the mixed layer mineral zone which surrounds the chlorite zone, the smectite zone and unaltered zone. The smectite zone is subdivided into the inner quartz-smectite subzone and the outer cristobalite-smectite subzone. Au-bearing quartz veins and sericitized rocks occur in the chlorite zone. FI studies on quartz and calcite indicate that the mineralization T are 140-260°C in the Asahi Au deposit, and that the alteration T are 220-270°C in the chlorite zone, and ca. 170°C in the mixed layer mineral zone. (From authors' abstract by E.R.)

SELLECK, B.W., 1995, Alteration of Proterozoic basement rocks and burial diagenesis of Paleozoic rocks in the Northern Appalachians: A signature of MVT fluid flow linked to continental-scale events: (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 1, p. 81. Author at Geology Dept., Colgate Univ., 13 Oak Drive, Hamilton, NY 13346.

Alteration of Proterozoic basement lying beneath the Potsdam Sandstone in Ontario and New York resulted from interaction with MVT-type F. Significant features include alteration of silicate minerals in the basement to low-T phyllosilicates and oxides, dissolution and dolomitization of basement marbles, accumulation of hematite in the vicinity of basement marbles, and precipitation of fracture- and void-filling minerals such as quartz, illite, k-feldspar, barite, fluorite, pyrite, galena, sphalerite and others.

FI, stable isotope, clay polytype analysis and the neoformed mineral assemblages in the basement rocks indicate that these features formed during an episode of hydrothermal F flow that altered both basement rock and the overlying early Paleozoic strata. T >300°C, and sal. >20% NaCl eq. have been reported. These features are consistent with a widespread event analogous to the MVT F flow events reported elsewhere in the Appalachians, the mid-continent U.S., the Cordillera, and in many other sedimentary basins worldwide.

Diagenetic illite from the Potsdam Sandstone in northern New York indicates that the major MVT-F event in that area occurred in late Devonian time, contemporaneous with reported MVT-mineralization elsewhere in North America. This suggests that MVT-F flow may have been triggered by an event of continental (or even global) scale. Rapid sea level fall caused by the onset of glaciation in Gondwana in late Devonian time may have lowered hydrostatic P within mid-Paleozoic foreland sediment wedges, bringing about sudden degassing of hydrocarbons and CO_2, leading to rapid F migration and MVT-type mineralization. SEDEX barite and sulfide deposits may have formed in abundance at this time within deep foreland basins or along continental margins. Widespread brine and hydrocarbon exhalation at this time may also be linked to the extinction of numerous marine groups (the Frasnian-Fammenian event) and to C isotope excursions that characterize the extinction event. (Author's abstract)

SELVERSTONE, Jane, AXEN, G.J. and BARTLEY, J.M., 1995, Fluid inclusion constraints on the kinematics of footwall uplift beneath the Brenner Line normal fault, eastern Alps: Tectonics, v. 14, no. 2, p. 264-278. First author at Dept. Earth and Planetary Sciences, Univ. New Mexico, Albuquerque, NM.

Dynamic models of isostatic footwall uplift in response to normal faulting can be divided into those in which uplift is accomplished by flexural failure and those in which uplift occurs via subvertical simple shear. Each class of model predicts a different incremental strain history that should be recorded in the footwall. In the Tauern Window (eastern Alps), postmylonitic structures in the footwall of the Brenner Line normal shear zone predominantly consist of closely spaced, steep, west down and east down microfaults. Formation of the west down faults before and at greater depths than the east down faults would be consistent with unroofing via subvertical simple shear. In contrast, formation of the two fault types as a conjugate set would be more indicative of unroofing via clastic processes. The field data alone do not provide a sufficient test of the two hypotheses because crosscutting relations are only rarely observed and there is no control on the depth at which the structures formed. However, both depth and timing constraints on the formation of the late structures can be obtained by correlating the orientations of FI-lined microfaults with the macroscopic west down and east down faults, obtaining density data for the I, and correlating these data with previously obtained geochronologic data. The results indicate that the west down structures formed at depths of 10-20 km and T >450°C in the mid to late Oligocene and that the east down structures formed at 2- to 10-km depth and T of 300 ± 50°C in the mid-Miocene. These data support the hypothesis that a "rolling hinge" was present in the footwall of the Brenner Line and that isostatically driven footwall deformation was accomplished predominantly by subvertical simple shear. The depths at which west down and east down faulting occurred, coupled with the angle of dip of the Brenner Line, yield a minimum lateral displacement on the fault of 15-26 km. Approximately coeval ductile shearing and brittle faulting at depths of 15-20 km and T >400°C may reflect local variations in strain rate as the footwall rocks entered the zone of rolling hinge deformation. (Authors' abstract)

SEMIANI, A., BOIRON, M.C and MARIGNAC, CH., 1995, Fluid evolution in a mineralized shear-zone: Gold deposits of Tirek and Amesmessa (Hoggar, Algeria) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 228-229. First author at ORGM, Boumerdes, Algeria.

Quartz porphyroclasts are clouded with small FI, which could not be studied. Measurable FI are later and were found in various types of quartz. From Raman analysis and interpretation of Tmcl and Th-Tmi data, it is deduced that five kinds of F components were involved in F circulation along the shear zone—two (aqueous)-carbonic {Ca: CO_2-(H_2O?); Cb: CO_2-N_2-(H_2O?) (≤5 mole % N_2)} and three aqueous (Wa: H_2O-NaCl-R_2+Cl_2 (≥25% wt eq. NaCl, Wb: H_2O-NaCl (5 to 7 % wt eq. NaCl); Wc: H_2O-(NaCl)).

These basic types were variously mixed to yield a variety of intermediates. It is precisely the mixing of these three aqueous fluids which caused ore deposition in the quartz veins.

Combining isochore computation and external constraints derived from mineral composition and geological data, it was possible to reconstruct P-T conditions prior to and during ore deposition:

- early brines (Lw1) circulated under a lithostatic P of 1.3 kb (ca. 5 km), at high T (≤400°C), decreasing down to 250°C.
- aqueous-carbonic F (Lc-w) circulated under the same P, ≤300°C, i.e., after reheating.
- late aqueous F (Lw2 and Lw3) circulated after a P drop, down to 0.5 kb (lithostatic-hydrostatic transition) and deposited Au and sulphides at a rather low (ca. 200°C) T. (From authors' abstract by E.R.)

SEMIANI, Abdelkader, FOURCADE, Serge, KIENAST, J.-R. and MARIGNAC, Christian, 1994, The gold deposits of Amesmessa and Tirek (NW Hoggar): Structural evolution, gold deposition and fluid nature (abst.): 15th Reunion Sci. de la Terre, p. 78 (in French). First author at Geosciences Rennes, Fr. 35042 Rennes Cedex, France.

The vein deposits are localized along the length of a N-S shear zone, which separates the In-Ouzzal block to the west from a Proterozoic block to the east: N-S veins (Amesmessa) within ultramylonites with the same direction; veins N30-40E in the oblique shear zones (Tirek), exclusively mineralized at the intersection between vein mylonites N-S. The history of these mineralizations started at the end of the major ductile period (Ferkous and Leblanc, 1993). Other veins, N30-40E, mark out the shear zones reactivated by the Pan African in the In-Ouzzal block.

At Amesmessa, three cycles have been distinguished. Cycle I: (1) alteration of the ultramylonites, to quartz/Fe-carbonates/sericite/pyrite (beresites), the length of which later veins of quartz (2), which formed by hydraulic fracturing; then (3) ductile deformation of beresites (P shadows of quartz around pyrite), equally perceptible in the quartz; (4) a major episode of carbonation (Fe-dolomite) in the beresites and especially the quartz veins, which have obliterated [masked?] the earlier deformations; finally (5) ductile, dextral deformation N-S, which has mylonitized the quartz veins. The sericite and beresite chemistry suggests that the events were deep (0.4-0.6 GPa, 300-350°C). Cycle II: a brittle period, with a succession of cataclastics and vein fractures; brines with divalent cations circulated at this stage (19-26% eq. NaCl). Cycle III: (1) influx of C-O-H to pure CO_2 F the length of the permeable zones created by the mylonitization I (5) and the cataclasis II; (2) deposition of sulphides (sphalerite then galena) and Au, with dissolution/recrystallization of quartz, in the same permeable zones; the Au, strictly contemporaneous with galena, was deposited alone; the F were aqueous, weak to medium salinity (0.4 to 9.7% NaCl).

At Tirek, the N30-40E veins were not affected by Cycle I, but show all the events of Cycles II and III. Stylolitic joints formed between Cycles II and III (similar joints occur at Amesmessa, but their timing is uncertain). Here, the deposition of Au by aqueous F is very late and associated with a last circulation cycle, implied to be also a carbonic F. (Authors' abstract; translation courtesy of Dr. A.P. Gize)

SEMIANI, A., MARIGNAC, Ch., FOURCADE, S., PEUCAT, J.-J., BOIRON, M.-C., LORON, J.-L. and KIÉNAST, J.R., 1995, Metallogenesis of the gold-bearing East-Ouzzal shear-zone (Hoggar, Algeria), *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 187-190. First author at ORGM, Boumerdes, Algeria.

In late Panafrican, Au was leached from the In Ouzzal granulites and deposited into quartz veins along the inactive East-Ouzzal Shear Zone, under deep geothermal conditions, triggered by acid magmatism. (Authors' abstract)

As indicated by $\delta^{18}O$ and $\delta^{13}C$ data, early circulation in the EOSZ (ultramylonite and stage I) involved both metamorphic and mantle-derived F. During stage II, R^{2+}-bearing brines (≤25% wt eq. NaCl) circulated through the E-W microfractures in the quartz veins of the EOSZ. They were characterized by heavy hydrogen (δD ≤ca. 10‰) and probably originated from the sedimentary basins.

Circulation of a C-O-H-N F heralded the mineralizing events (stage III). As shown by Raman spectrometry, this F resulted from the mixing of a CO_2-dominated N_2-bearing (≤5 mol % N_2) F with an aqueous F of moderate salinity. Similar F were later involved in the deposition of sulphides (sphalerite, galena) and Au, by mixing with warmer brines similar to the Wa F. (From authors' text by E.R.)

SEMPLE, D.G., CORBETT, G.J. and LEACH, T.M., 1995, The Tolukuma gold silver-vein system, Papua New Guinea: PACRIM '95, p. 509-514. First author at PO Box 1440, Broadbeach, Qld 4218, Australia.

A diatreme breccia, localised at an intersection of structures and a relationship of Au to base metal sulphides, are indicative of a strong porphyry association. Typical epithermal features such as crustiform banded quartz and quartz pseudomorphing platy calcite are also present and locally contain lesser Au mineralisation. Preexisting dilatant structures have acted as a host to the ore F. A F flow model suggests that mineralizing F were sourced from a diatreme margin and migrated laterally along dilatant structures. Bonanza Au grades are interpreted to be derived through F quenching. (From authors' abstract by E.R.)

FI data on quartz (from text): Th range (avg.) 230-240°C; sal. 0-2 wt % NaCl eq. (S. Simmons)

SEYFRIED, W.E., Jr. and DING, K., 1995, The hydrothermal chemistry of fluoride in seawater: Geochim. Cosmochim. Acta, v. 59, p. 1063-1071.

SHARYGIN, V.V., 1995, Crystallization conditions of hauyne phonolites of Laaher See Volcano (E. Eifel, W. Germany) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 230-231. Author at Inst. Mineralogy and Petrography, Univ. pr. 3, 630090 Novosibirsk, Russia.

The primary MI have been found in all mineral phenocrysts (excepting biotite). Mono- and two-phase I (glass + gas) with Thom = 1080-1150°C are most common of the earliest phenocrysts (hauyne, apatite, sphene). Pyroxene- and amphibole-hosted I (Thom = 1030-1120°C) consist of glass + some G bubbles, sometimes carbonate occurs as a dp. Some glassy I in the latest phenocrysts (plagioclase and sanidine) contain also [a] cavity with fine-devitrified salt aggregates (salt melt?) in glass and/or salt crystalline phases in G bubble. The melting of the salt phases proceeded at 780-900°C. Complete homogenization of these I are 950-1050 and 980-1120°C (for sanidine and plagioclase, respectively). The I hosted by plagioclase are characterized by different extent of crystallization: from glassy (glass + G) to partly crystallized (glass + dps + F), while latter corresponds to the rock groundmass in modal composition.

The electron microprobe analysis of MI in the ULST phenocrysts has shown that initial glasses in the earliest minerals (hauyne -> sphene) correspond to bulk rock composition, while residual glasses in later minerals (pyroxene -> sanidine) are close to groundmass glass.

Raman investigation of G bubbles in MI has shown that only bubbles of hauyne-hosted I contain high concentration of CO_2 (89 mol %, 11 mol % N_2). The presence of CO_2 is also detected in bubbles of sanidine-hosted I (57 mol %, 43 mol % N_2).The bubbles of the partly crystallized MI in other phenocrysts and groundmass bubble contain N_2 only. The same distribution of CO_2 seems to depend on extent of I devitrification. In partly crystallized I CO_2 partitioned between glass, bubble and dps (for example, due to carbonate formation).According to mathematical modeling, a possible magma, parent for the Laaher See Tephra phonolites, might be basanitic liquid during common fractionation processes. FI study of basanite and leucite tephrite related to the phonolites confirms these conclusions. Basanitic melt might be parent for the phonolites during widespread processes of crystal fractionation under conditions of shallow-deep magmatic chamber. (From authors' abstract by E.R.)

SHARYGIN, V.V. and STOPPA, F., 1995, Zr-Ti-bearing disilicates from inclusions in minerals of pegmatoid venanzite (Pian Di Celle Volcano, San Venanzo, Italy) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 232-233. First author at Inst. Mineralogy and Petrography, Univ. pr. 3, 630090 Novosibirsk, Russia.

Rare diorthosilicates (götzenite, cuspidine, khibinskite) have been found during FI study of the Pian di Celle rocks. They occur as trapped/dps of the I hosted by minerals of pegmatoid venanzites. Melilite (≤5 cm), olivine and leucite form a large frame with numerous cavities in pegmatoid venanzites.

Zr-Ti-rich disilicates were observed in polycrystal, silicate-melt and combined (polycrystal assemblage plus adhered glass and/or G) I (10-100 µm) hosted by olivine and melilite of the pegmatoid venanzite. All I are confined to healed micro-fractures in the host minerals and seen to be secondary in origin. Other minerals of the rock also contain FI, but no Zr-Ti-disilicates are found in them.

Cuspidine has been identified only in melilite-hosted I. It forms euhedral colorless crystals (≤40 µm), sometimes with pronounced zoning. Its composition strongly varies in CaO (58.2-44 wt %), Na_2O (0.5-3.6 wt %), F (10.1-8.5 wt %) and ZrO_2 (0.2-10.5 wt %) from the core to rim of the crystals. The considerable variations in these components suggest the existence of limited solid solution between cuspidine $Ca_4[Si_2O_7]F_2$ and hiortdahlite $NaCa_2Zr[Si_2O_7]OF$ (probably, hiortdahlite-2) due to possible combined substitution $2Ca^{2+} + F^- \Leftrightarrow Na^+ + Zr^{4+} + O^{2-}$. Maximum content of ideal hiortdahlite end-member in the Pian di Celle cuspidines may be ≤33 mol %.

Three varieties of götzenite $(Ca,Na)_{3.5}(Ti,Zr)_{0.5}[Si_2O_7](O,F)_2$ are found in the I: pure Ti-götzenite (10.2 wt % TiO_2), Zr-rich (6.9-7.3 wt % TiO_2, 5.8-8.3 wt % ZrO_2) and REE-rich (7.8 wt % TiO_2, 2 wt % ZrO_2, 5.5 wt % TR_2O_3) götzenites. Earlier, only Zr- götzenite were reported as I in melilite of pegmatoid facies of venanzites. Our data show that Ti-variety is typical of the melilite-hosted I, while Zr-götzenite occurs in both melilite- and olivine-hosted I. REE-rich variety has been observed in olivine-hosted I only and is compositionally close to the groundmass götzenite.

Khibinskite $K_2ZrSi_2O_7$ has been observed only in an olivine-hosted polycrystal inclusion together with phlogopite, perovskite, FeS and kalsilite. It contains ≤1.15 wt % Na_2O and 0.8 wt % FeO.

Preliminary microthermometric investigations of the secondary MI hosted by olivine and melilite of pegmatoid venanzites have shown that silicate glass began to melt at 680-720°C during heating. The colorless dps (kalsilite, cuspidine and götzenite), which are optically indistinguishable in the I, fused at 770-860°C. Decreasing of G bubble fixed ≤850-900°C. Unfortunately, neither olivine-hosted nor melilite-hosted I homogenized due to possible leakage. Only heating experiments with the primary MI in kalsilite were successful (Thom - 835-840°C).

High abundances of CaO (≤18 wt %), TiO_2 (≤3.3 wt %), F (≤0.5 wt %) and Zr (>1000 ppm) in initial M of pegmatoid venanzites and agpaitic character of its crystallization under low P were responsible for the appearance of cuspidine and götzenite in the intermediate and late stages. Khibinskite seems to be crystallized at the latest stages, when M was rich in alkalis, Zr and poor in F. (From authors' abstract by E.R.)

SHEETS, R.W., NESBITT, B.E. and MUEHLENBACHS, K., 1995, Stable isotope evidence for a meteoric component in high salinity magmatic fluid in porphyry copper systems, Babine Lake area, B.C. (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-67.

Coexisting V-rich and high salinity (≥40 wt % NaCl eq.) salt-bearing FI in porphyry deposits are typically cited as evidence for involvement of pristine magmatic F in early stages in mineralizations. Typical isotopic values for F in equilibrium with degassed calc-alkaline intrusions range from 5 to 9‰ and -40 to -85‰ for δD, respectively. Early F from quartz-carbonate veins in porphyry Cu deposits and prospects of the Babine Lake area are isotopically depleted relative to these accepted magmatic values, although the veins contain predominantly V-rich and high salinity FI.

FI and stable isotopes have been investigated from six Eocene porphyry Cu (±Mo±Au) deposits and prospects in the Babine Lake area. Mineralizations consists of chalcopyrite ± bornite disseminated within quartz ± carbonate stockwork veins, which are enclosed in the phyllic alteration assemblage at Bell deposit (highest grade deposit) and in potassic-propylitic alteration assemblages in the remainder of the deposits and prospects. FI in early formed, quartz ± carbonate stockwork veins are dominated by coexisting V-rich and high salinity salt-bearing I. S FI in these early veins typically contain halite dms with only a minor number of low salinity (5 to 20 wt % NaCl eq.) I in secondary trails. FI in late, carbonate veins which are typically enveloped by argillic alteration are predominantly L-rich, low salinity FI.

The δD compositions of high salinity F from early mineralized veins vary among the deposits and prospects. All early veins have δD values that range from -94 to -113‰ (N = 13), while FI in late carbonate veins and breccias have δD values between -139 to -158‰ (N = 14). Multiple δD analyses of veins F are consistent (±5‰), which suggest mixing of FI populations and trace contaminants did not contribute to the δD values. A positive correlation between δ13C carbonate (from -5.5 to +1.5‰; N = 21) and δD_{FI} indicates that H diffusion did not significantly after I compositions. Mixing of magmatic and external F at the site of mineralization could produce the observed D depletion, though due to thermal and mass balance consideration this is not considered to be likely. Incorporation of external low D material into the mineralizing intrusions, either from deep circulation of evolved meteoric F or by crustal assimilation, is required to explain the observed δD values of the early veins. (Authors' abstract)

SHELTON, K.L., BURSTEIN, I.B., HAGNI, R.D., VIERRETHER, C.B., GRANT, S.K., HENNIGH, Q.T., BRADLEY, M.F. and BRANDOM, R.T., 1995, Sulfur isotope evidence for penetration of MVT fluids into igneous basement rocks, southeast Missouri, USA: Mineral. Deposita, v. 30, p. 339-350.

SHEN, A.H., CHOU, I.M. and BASSETT, W.A., 1995, A new equation of state for $NaCl-H_2O$ solutions over wide P-T-X range (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 71.

A new equation of state (EOS) for $NaCl-H_2O$ solutions was obtained by regressing 36 isochores determined in the diamond-anvil cells (DAC) using the method described in Shen et al. (1994, Mineral. Mag., 58A, 823) and 45 isochores determined by Zhang and Frantz (1987, Chem. Geol., 64, 335). The PTX range of the DAC experiments covered ≤11 kb, 850°C, and from 5 to 26 wt % NaCl. (From authors' abstract by E.R.)

SHENG, Jifu, ZHANG, Dequan and LI, Yan, 1995, Fluid inclusion geochemistry of metallic ore deposits in the south-central sector of the Da Hinggan Mountains in China: Acta Geologica Sinica (Dizhi Xuebao), v. 69, no. 1, p. 56-66 (in Chinese, English abstract); also Acta Geol. Sinica (English edition), v. 8, p. 289-302. Authors at Inst. Mineral Deposits, Chinese Acad. Geological Sciences, Beijing, P.R. China.

The Da Hinggan Mountains are an important metallogenic belt in China. In this belt there are five types of deposits: porphyry Cu and Sn-Ag-Cu, skarn Pb-Zn and Fe-Cu, hydrothermal vein Cu and Pb-Zn, greisen W-Sn and granite REE

The authors have studied FI of several major deposits in the study district in detail. They observed the characteristics and phase changes of FI at different T and analysed the compositions of both V and L phases of I. By this way they determined the T, P, salinity, density, composition and boiling of ore F and several physicochemical parameters of mineralization such as pH, Eh, fO_2 and the reducing parameter (R).

This study also indicates that the deposits that belong to the same type of deposit have some similar FI geochemical features and physicochemical parameters though they occur in different minerogenetic series, while the composition of I are not conditioned by deposit types but clearly related to the minerogenetic series of deposits. (From authors' abstract by E.R.)

SHEPHERD, T.J. and CHENERY, S.R., 1995, Laser ablation ICP-MS elemental analysis of individual fluid inclusions: An evaluation study: Geochim. Cosmochim. Acta, v. 59, p. 3997-4007. Authors at British Geol. Surv., Kingsley Dunham Centre, Keyworth, Nottingham NG12 5GG, UK.

Details are given of the elemental analysis of single FI using a UV laser ablation microprobe interfaced to an inductively coupled plasma mass spectrometer. The UV laser, a frequency quadrupled Nd:YAG operating at 266 nm, allows higher spatial resolution (<2 µm) than can be achieved using near-IR or visible wavelengths. Tests have been carried out on 10-100 µm diameter aqueous (L + V) I in fluorite, quartz, and halite ≤60 µm beneath the surface. A key feature of the system is a novel high T ablation cell which substantially improves the efficiency and reproducibility of F release. Calibration was carried out using a dual G flow system that allowed use of standard solutions and NIST glasses for tuning the instrument and for obtaining relative sensitivity factors. As an alternative to synthetic FI, a new calibration approach is described involving the encapsulation of microdroplets of standard solutions in hydrophobic epoxy resins *FI analogues*. To illustrate the scope and performance of the instrument, data are reported for Ba, Ca, Cs, Cu, K, Mg, Mn, Na, Pb, Rb, Sr, and Zn in saline aqueous I associated with evaporite and low T base metal deposits. Element detection limits vary according to the mass of material released for analysis and are thus related to the volume and composition of each I. Precision is estimated to be >30%. (Authors' abstract)

See also next item. (E.R.)

SHEPHERD, T.J., CHENERY, S.R. and MOISSETTE, A., 1995a, Laser ablation ICP-MS analysis of single inclusions in evaporite minerals (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 234. Authors at British Geol. Surv., Nicker Hill, Keyworth, Nottingham NG12 5GG, UK.

High spatial resolution laser ablation ICP-MS (LAMP-ICP-MS) using a 266 nm UV laser microprobe marks an important breakthrough in the acquisition of elemental data for aqueous I. Though simple in concept, establishing a working protocol has proved more difficult. By redesigning the ablation cell to incorporate variable T control of the sample, and using synthetic FI standards, factors limiting analytical reproducibility have been identified and successfully minimised. Detection limits are related to the volume of the I (i.e., the mass of F released). For a 20 µm diameter I, detection limits for Cu and Zn are estimated to be ~10-25 ppm. Reproducibility for the major and minor cations is generally >25%. Significant progress has also been made in the measurement of Cl/Br ratios. To test these improvements on naturally-occurring I, samples of I-rich halite have been analysed from the Cheshire Basin, UK, and Lorca Basin, Spain. A comparison of LAMP-ICP-MS data and Mg, K and Na analyses obtained by cryogenic XRF shows that agreement is generally good and confirms the added value and desirability of using integrated techniques for the analysis of single. (From authors' abstract by E.R.)

See also previous item. (E.R.)

SHEPHERD, T.J., CHENERY, S.R. and MOISSETTE, A., 1995b, Optimization of laser ablation ICP-MS for the chemical analysis of fluid inclusions in evaporite minerals (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 344.

Establishing a working protocol has proved difficult. However, by redesigning the ablation cell to incorporate variable T control of the sample, in conjunction with synthetic FI standards, factors limiting analytical reproducibility have been identified and successfully minimised. Data will be presented for a wide range of alkali, alkaline earth and transition metals in brine I associated with European salt and potash deposits. Reference will be made to the direct measurement of chlorine/bromine ratios in single FI. Other points to be discussed will include ICP-MS optimization procedures, calibration strategies, working detection limits and application to I in other minerals. (From authors' abstract by E.R.)

SHEPPARD, S.M.F., CHAREF, A. and BOUHLEL, S., 1995, Pb-Zn mineralization and saline diapirs: a general model (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 197.

Saline diapirs mantled by cap rocks (anhydrite-gypsum-calcite) are often associated with Pb-Zn-(Sr-Ba) mineralization, oil, G and native S. A general model is proposed based on (1) Tunisian examples (T), where Pb-Zn is being exploited (<1 Mt metal per deposit) but hydrocarbons and S are uneconomic, and (2) Gulf Coast region, U.S.A. examples (GC), where oil, G and native S are exploited but the metals have not been mined. In both regions, 10^{-2} or more polyphase diapirs arrived at or very near the surface or seafloor; ~100 Ma and >~5 Ma after deposition in T and GC respectively. Important occurrences of Pb-Zn have been identified both within carbonate (GC,T) and sulphate (GC) cap rock, in adjacent wall rocks (GC,T) and as metal-rich sediments (exhalative deposits) around the diapir (T). Both native S and major sulphide deposits require the presence of hydrocarbons, anhydrite cap rock and biogenetic oxido-reduction processes.

FI and isotopic data imply that F, presumably from below, entered the evaporites that formed the diapirs (at <~275°C with $N_2 + CO_2$ (T)). During diapirism, cap rock development requires massive leaching of halite by surface waters with concomitant transfer of deeper buried halite towards the surface. The diapirs and their associated fracture systems episodically focused the circulation of hot brines from the adjacent deep basin plus hydrocarbons, metals and probably thermochemically reduced sulphate to the cap rock region (celestite at <170°C; sulphides at <130°C(T)). Essential processes include the biogenetic reduction of diapir sulphate, oxidation of hydrocarbons, mixing of basin brines with meteoric and, in certain deposits, multiple sources of metals and S. Precipitation of metals would be limited if sufficient sulphide S was not available from both the brines and the cap rock sulphates (T were too high for biogenetic reduction reactions). Major native S production rather than sulphide deposition implies that formation brines were either too depleted in metals or not available (temporally and/or spatially). Economic Pb-Zn deposits contain several types of mineralization. (Authors' abstract.)

SHERLOCK, R.L. and BARRET, T.J., 1995, Preliminary fluid inclusion results from the Eskay Creek, Myra Falls and Anyox volcanogenic massive sulfide deposits (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-97. Authors at Mineral Deposits Research Unit, Dept. Geol. Sciences, Univ. British Columbia, Vancouver, B.C. V6T 1Z4, Canada.

The Eskay Creek deposit is an extremely precious metal enriched volcanogenic massive sulphide deposit in northwestern BC. Microthermometric and combined gas and ion chromatography analysis of FI hosted in footwall stockwork quartz veins and stratiform sphalerite suggests overall low F T ranging from ~90 to 170 °C with no variation between ore zones. Gas ratios suggest L-V phase separation occurred at depths of ~160 m. F salinities, calculated from final melting point depressions, vary from ~3 to 11 eq. wt % NaCl. Cation and anion ratios suggest that the low salinity F were seawater dominated, however, high salinity F have ionic ratios consistent with magmatic ratios. This suggests that the original seawater hydrothermal F was modified by the addition of salts in proportions consistent with magmatic ratios. Non-reactive gas ratios support a mixing trend between seawater and felsic volcanic volatiles.

The Myra Falls deposit is a polymetallic volcanogenic massive sulphide deposit on central Vancouver Island, BC. Preliminary microthermometric results on FI hosted in quartz interstitial to massive sulphides, sphalerite in the massive sulphide lens, and footwall stockwork quartz veins, suggest F T mainly between 170 and 200°C. F T may be spatially zoned, with localized high T F approaching 260°C, reflecting areas of more intense F upwelling. F salinities, calculated from final melting point depressions, vary from ~4 to 7 eq. wt % NaCl.

The Anyox deposit, in NW BC, is a series of cupiferous pyrite-pyrrhotite lenses, hosted in mafic volcanics and overlying turbiditic mudstones. Two vein sets are recognized, a quartz-pyrrhotite-chalcopyrite vein set in the footwall to the massive sulphide lens, which likely represent feeder veins to the cupiferous sulphide lens. A second vein set is recognized, best exposed on Granby Peninsula, composed of quartz and base metal sulphides ± precious metals, and is likely related to a Tertiary hydrothermal system. Preliminary microthermometric results on FI hosted in the footwall stockwork veins suggest F T ~230 to 270°C. F salinities, calculated from final melting point depression, range from ~3 to 12 eq. wt % NaCl. Results for the Tertiary vein system are in sharp contrast to those from the stockwork vein system. Hydrothermal F that formed the Tertiary vein system were high salinity (>10 eq. wt % NaCl), high T (>300°C) and very high gas contents, with common three phase (CO_2 L, CO_2 V and H_2O L) FI, suggesting a relationship with the nearby Coast Plutonic Complex. (Authors' abstract).

SHERLOCK, R.L. and LEHRMAN, N.J., 1995, Occurrences of dendritic gold at the McLaughlin Mine hot-spring gold deposit: Mineral. Deposita, v. 30, no. 3-4, p. 323-327.

SHERLOCK, R.L., TOSDAL, R.M., LEHRMAN, N.J., GRANEY, J.R., LOSH, Steven, JOWETT, E.C. and KESLER, S.E., 1995, Origin of the McLaughlin mine sheeted vein complex: Metal zoning, fluid inclusion, and isotopic evidence: Econ. Geol., v. 90, p. 2156-2181. First author at Dept. Geological Sciences, Univ. British Columbia, Vancouver, British Columbia V6T 1Z4, Canada.

The McLaughlin deposit is a large hot spring-type Au deposit located in the northern Coast Ranges of California at the faulted lithologic contact between the Coast Range ophiolite and the Great Valley sequence. The McLaughlin deposit is centered around the sheeted vein complex, a large multistage vein swarm, localized in a dilation zone formed by rheologic contrasts in the footwall polymictic melange. The surface expression of the sheeted vein complex is a subaerial sinter terrace. Metal zoning in the sheeted vein complex is highly telescoped. The sinter is enriched in Hg, whereas Au and Ag are restricted to the upper 350 m, with the proportion of Au to Ag decreasing with depth. Au is typically present as electrum and is associated with Ag and base metal-bearing sulfosalts. Below 350 m mineralization is dominated by small quartz veins with base metal sulfides.

FI studies indicate that NaCl is the main dissolved salt, in concentrations averaging 2.4 wt % NaCl eq. The bulk of the salinity data can be explained by variable amounts of adiabatic boiling and mixing with steam-heated ground water. FI homogenization data ranges from 121° to 263°C with the deepest portion of the system examined having the highest T and the shallowest samples having the lowest T. FI G concentrations vary with depth below the sinter; CO_2, and to a lesser extent CH_4, shows a systematic increase with depth. F P, calculated from FI Th and G analysis, are in excess of the hydrostatic P and approach, or exceed, lithostatic P. Self-sealing of the system and tectonic dilation most likely resulted in catastrophic phase separation and hydrothermal eruption breccias. Geothermometry results, based on FI G ratios, show a reasonable correspondence with the highest FI Th. There is a strong trend for decreasing $\delta^{18}O_{quartz}$ values with depth due to the effect of T. The calculated $\delta^{18}O(H_2O)$ values are fairly constant at ~9 to 10‰. O and H isotope values, as well as geologic relationships, are consistent with those of hydrothermal F originating as meteoric water; these evolved to increasingly high ones by interaction with Great Valley sequence sedimentary rocks. Pb isotope compositions, of sulfides and potential source rocks, indicate that Pb, and by inference other metals, was derived from a crustal source. The Pb source may have been detritus from the Sierra Nevada batholith that comprises the Great Valley sequence, or alternatively, it may have been derived from a thorough mixture of radiogenic Pb and nonradiogenic Pb that occurred prior to mineralization. (Authors' abstract)

SHEVEDENKOV, G.Yu., LEPEZIN, G.G., BULBAK, T.A. and OSORGIN, N.Yu., 1995, Experimental studies of cordierite saturation of the C-O-H fluid components: Geokhimiya, no. 2, p. 251-262 (in Russian, English abstract).

Incorporation of hydrocarbons in the channels of cordierite crystalline structure was experimentally proved. It is necessary for the basing of estimates of complex metamorphic F composition. It was found that cordierite selectively incorporates H_2O and CO_2 molecules in relation to CH_4, CO and other components of C-O-H F. New experimental technique of CO-H_2O, CH_4-H_2O F generation and after run G phase composition measurement were developed. (Authors' abstract)

SHI, Jixi, YU, Xiaoying and WANG, Huayun, 1995, The role of ancient oil reservoirs, bitumens and bitumen inclusions in metallogenetic research: Acta Mineralogica Sinica, v. 15, no. 2, p. 117-122 (in Chinese, English abstract). First author at Inst. Geochemistry, Chinese Acad. Sci., Guiyang 550002, PR China.

Ancient oil reservoirs, bitumens and bitumen I as well as some metallic ore deposits are all products of metallogenesis in nature. They have close spatial-temporal and genetic connections. They can be used to study the material sources of reworked deposits of chemically mobile elements such as Hg, Sb, As, Au, U, Cu, Pb, Zn, etc., [their path] of migration, the physicochemical conditions of ore deposition, how to divide the reworking stages, and how to serve as indicators for ore prospecting. They are also of great theoretical significance in discussing the relationship between organic matter and metallogenesis. (Authors' abstract)

SHIBATA, Tomo, TAKAHASHI, Eiichi and OZIMA, Minoru, 1994, Noble gas partition between basaltic melt and olivine crystals at high pressures, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 343-354.

SHIBUE, Y., 1995, Redlich-Kwong equation of state: An equation for fluid: Resource Geol., v. 45, p. 121-127 (in Japanese).

A review. (E.R.)

SHIBUE, Y., KAZAHAYA, K. and KUSAKABE, M., 1995, Stable isotope geochemistry of the Kaneuchi W deposit, Japan, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 219-222. First author at Geoscience Inst., Hyogo Univ. Teacher Education, Japan.

O, H and C isotope geochemical data on the Kaneuchi W deposit in Japan are obtained to consider the F mixing and F-rock interaction at the fossil hydrothermal system. O isotope data indicate that a magmatic F interacted with host sedimentary rocks under the condition of the low F/rock ratio. On the other hand, F mixing changed H isotopic composition of the F. The magmatic F mixed with a deuterium-depleted F at the earliest stage of the mineralization and with a deuterium-enriched F at the late stage. The F flowing into the magmatic hydrothermal system at the late stage is further characterized as low in salinity and relatively enriched in dissolved C. Present results indicate that F mixing and F-rock interaction under the rock-dominated condition occurred at the Kaneuchi hydrothermal system. (Authors' abstract)

H_2O, CO_2, and CH_4 in FI are extracted by vacuum ball-milling technique and are analyzed with respect to their H or C isotopic composition by the method and procedure described in Kazahay and Matsuo (1985). H isotopic compositions of FI range from -64 to -73‰ for W minerals, -53 to -73‰ for vein quartz, and from -53 to -63‰ for drusy quartz. The range of the δD values of FI cover the range of the magmatic F. The relatively heavy δD values of FI in drusy quartz suggest that the magmatic F mixed with a deuterium-enriched F at the late stage of the mineralization. (From authors' text by E.R.)

SHIGA, T., HYODO, M., SASADA, M., SAWAKI, T., YAGI, M. and TAKAGI, H., 1995, Measurement and study of homogenization temperatures of synthetic fluid inclusions in the WD-1 well (abst.): Abstracts (FIR) of 1995 Annual Mtg., Geothermal Research Soc. Japan (in Japanese).

Synthetic FI logging was carried out by the GSJ and NEDO at five levels in the deep geothermal research well, WD-1, in the Kakkonda geothermal area in 1994. This study reports precision of results of Th measurement of the synthetic FI. Th of the I were almost consistent with borehole T measured by a conventional logging tool, but the Th with P corrections have dispersion (2-15°C), contrary to their expectations. The authors statistically studied [the] cause of the dispersion, but they could not find out parameters controlling the dispersion. For the next borehole experiments in 1995 and 1996, the problem must be solved. (Authors' abstract, translated courtesy T. Sawaki)

SHIKAZONO, Naotatsu, UTADA, Minoru and SHIMIZU, Masaaki, 1995, Mineralogical and geochemical characteristics of hydrothermal alteration of basalt in the Kuroko mine area, Japan: Implications for the evolution of a Back Arc Basin hydrothermal system: Appl. Geochem., v. 10, p. 621-642. First author at Dept. Earth Sciences, Keio Univ., Kohoku-ku, Yokohama-shi, Kanagawa 223, Japan.

Basalt in the Furutobe District of the Kuroko mine area in Japan is characterized by abundant chlorite and epidote. FI studies indicate that chlorite is formed at lower T (230-250°C) than epidote (250-280°C). The seawater/basalt mass ratio for the early chlorite-rich alteration was high (max. 40), but that for the later alteration was low (0.1-1.8). The CaO, Na_2O and SiO_2 of the bulk rock correlate negatively with MgO, while FeO and ΣFe correlate positively with MgO. These changes in the characteristic features of hydrothermal alteration from early to late are generally similar to those for a mid-ocean ridge geothermal system accompanying basalt alteration. (From authors' abstract by H.E.B.)

SHIMAZAKI, H., NAKAMURA, T. and KUSAKABE, M., 1995, Oxygen isotopic composition of ore-forming fluid for the Ashio polymetallic deposits (abst.): J. Soc. Resource Geol., v. 45, no. 4, p. 269 (in Japanese).

SHIMIZU, N., 1995, Chromatographic chemical modifications during migration of MORB melts (abst.): Eos, v. 76, no. 17, p. S266-S267. Author at Woods Hole Oceanographic Inst., Woods Hole, MA 02543.

A suite of 22 MI hosted by high-Mg olivines ($Fo_{89.5-90.7}$) in a single lava (ALV 519-4-1) from the FAMOUS area is characterized by: (1) La(N) varies from 2 to 25, whereas Yb(N) from 8.5 to 14; (2) Ti/Zr varies from 200 to 100 with increasing concentrations (Ti from 2500 to 4700 ppm, Zr from 12 to 47 ppm); (3) SiO_2 (47.5-50.8 wt %) and CaO (11.4-14.3%) show broadly negative correlation with MgO (9.2 to 12.9%), whereas FeO (6.4-9.9%) is positively correlated with MgO; (4) 14 MI are multiply saturated with mantle minerals at 8.5 + 2 kb, 1265 + 35°C, whereas eight contain too much normative cpx and plag components to be cotectic with mantle. Although covariations of incompatible trace elements (e.g., La/Sm vs. Ti/Zr) are consistent with a notion that early small-degree M derived from depleted mantle source in the presence of garnet are sample as MI, characteristics of moderately incompatible trace elements (e.g., M~HREE) and major elements strongly indicate that "garnet signatures," if ever present, have been erased. A preferred mechanism to achieve the contrasting geochemical characteristics is chromatographic fractionation of elements during migration of the M, whereby elements with higher mantle/M partition coefficients were modified much closer to equilibrium with mantle than more incompatible elements during mantle/M reaction. It is suggested that "garnet signatures" recognized by the U-series disequilibrium may be better preserved than those shown by the Lu-Hf systematics because of the difference in partition coefficients. It is concluded that MORB melt migration must involve extensive reaction between M and wall-rock mantle, in which chromatographic effects essentially determine trace element abundance patterns. (Author's abstract)

SHIMIZU, Toru, 1995, Genesis of gold and silver mineralization at the Koryu mine, southwestern Hokkaido, Japan: PhD dissertation, Hokkaido Univ., 184 p.

The Koryu mine is an epithermal Au-Ag-quartz vein deposit in SW Hokkaido, Japan. It occurs in E-W shear zone of black mudstone in Miocene. The deposit consists of eight major veins with general E-W strike. According to the detailed underground survey, and hand specimen and microscopic observations, major veins numbered 1 to 3 show variable internal structure and texture, both in vertical and horizontal directions. Those veins have been divided into two mineralization epochs, the Earlier and the Later, on the basis of crosscutting relationships and mineral parageneses. The Earlier mineralization is further divided into three stages (E-I, II, III) while the Later one into seven stages (L-I, II, III, IV, V, VI, VII).

K-Ar ages for adularia from No. 3 vein are 1.2 ± 0.7 (stage L-I-a), 1.19 ± 0.09 Ma (stage L-III-c) and 0.91 ± 0.19 and 0.81 ± 0.17 Ma (stage L-VII). They indicate a Pleistocene age of mineralization.

The Earlier mineralization stages are characterized by the occurrences of manganocalcite, johannsenite and small amounts of ore minerals, while the Later ones are characterized by the occurrence of large amounts of ore minerals including electrum and interstratified chlorite/smectite. They are intimately associated with microcrystalline quartz precipitating alternatively with adularia and comb texture quartz. The representative Au-Ag bearing minerals are electrum, acanthite-aguilarite, polybasite, pearceite, pyrargyrite-proustite, mckinstryite, jalpaite, hessite, Ag-Te-Se-S mineral and tetrahedrite.

The Tf (°C) and sal. (NaCl eq. wt %) in each mineralization stage based on FI studies are 253-269, 2.0-2.7 (E-I ~ III) and 196-261, 0.5-3.3 (L-I ~ VII), respectively.

Boiling phenomena are recognized in P FI in comb texture quartz precipitating alternatively with electrum. Combined with the P-V-T data of dilute saline solutions, the FI data indicate that P_{total} of ore F was ~68 bars, indicating 850 m as the depth of mineralization. This value is consistent with an estimated value of 670-870 m based on geological and geographical studies.

δD values of FI in comb quartz are -84.6 to 87.1‰ (L-I-a) and -78.0 to -76.6‰ (L-VI-c). Calculated $\delta^{18}O$ values of ore F in the Earlier and Later mineralization stages are -5.8 to -5.2‰ and -9.9 to -6.0‰, respectively. δD and $\delta^{18}O$ values of local meteoric water around the Koryu mine are -78.6 to -65‰ and -12.7 to -10.2‰, respectively. $\delta^{18}O$ values of unaltered mudstone are from ~10-15‰.

The paragenetic, FI and stable isotope studies suggest that there were two types of hydrothermal F (types 1 and 2) for the mineralization. Both types were meteoric water in origin, interacted with surrounding rocks under the high water/rock ratio. Type 1 was high saline and high $\delta^{18}O$ F responsible for both the Earlier and Later mineralizations, while type 2 was low saline and low $\delta^{18}O$ F. The type 2 was mixed with type 1 F during the Later mineralization. Type 1 F might be charged more effectively by underlying basement rocks. After a drastic tectonic break, the Later mineralization had started; Type 1 F were mixed with type 2 F carrying large amounts of Au. When the mixed F ascended to the boiling zone in the shallow level (850 m), Au could be precipitated by intermittent boiling of the F, resulting in destabilization of Au bisulfide complex. (Author's abstract)

SHINOHARA, Hiroshi, KAZAHAYA, Kohei and LOWENSTERN, J.B., 1995a, Volatile transport in a convecting magma column: Implications for porphyry Mo mineralization: Geology, v. 23, no. 12, p. 1091-1094. First author at Geol. Surv. Japan, 1-1-3 Higashi, Tsukuba 305, Japan.

We propose that convection in a column of silicic magma allows transport of volatile components from large (>50 km^3) magma chambers to the sites of shallow (~3 km) porphyry-type Mo deposits. Using constraints from the Henderson and Pine Grove systems, we show that even at T as low as 700°C, a granitic magma with 30 vol % phenocrysts can flow through a magma column with a 150 m radius at a rate >10 km^3/yr—enough magma to contribute the Mo necessary to form an ore deposit in a geologically reasonable timeframe. This process requires an efficient mechanism for bubble separation at the top of the magma column to produce degassed magma that can descend down through the column. It also requires slow rates of crystallization in the silicic magma, consistent with experimental studies. Hydrothermal F released from the convecting magma column can explain many geologic features of the deposits. (Authors' abstract)

See next item. (E.R.)

SHINOHARA, Hiroshi, KAZAHAYA, Kohei and LOWENSTERN, J.B., 1995b, Volatile transport in a convecting magma column: Implications for Climax-type porphyry Mo mineralization (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-97. First author at Geological Survey of Japan, 1-1-3, Higashi Tsukuba 305, Japan.

We propose that convection in a column of silicic magma can allow transport of volatiles from large (>50 km^3) magma chambers to the sites of shallow-(2-3 km) porphyry Climax-type Mo deposits. The driving force of the convection is the density contrast between non-degassed magma ascending from a magma chamber and degassed magma descending from top of the magma column (Fig.). Flux of the convecting magma is estimated on the basis of simple F-dynamic models; Poiseuille flow through a concentric double-walled pipe and descent of degassed magma spheres through ascending magma. Using constraints from the Henderson and Pine Grove systems, we show that even at T as low as 700°C, a granitic magma with 30 vol % phenocrysts can flow through a magma column with a 150 m radius at a rate 4 to 67 km^3/year, enough to form an ore deposit in a geologically reasonable time frame. This process requires an efficient mechanism for bubble separation at the top of the magma column to produce bubble-free magma that can descend down the center of the conduit. It also requires slow rates of crystallization in the silicic magma, consistent with experimental studies. Hydrothermal F released from the convecting magma column can explain many geological features of the deposits, such as localized ore at the top of intrusions, interlayered USTs (unidirectional solidification textures) and fine-grained aplite, an absence of high T veins below USTs, and open-space veins. (Authors' abstract).

See previous item. (E.R.)

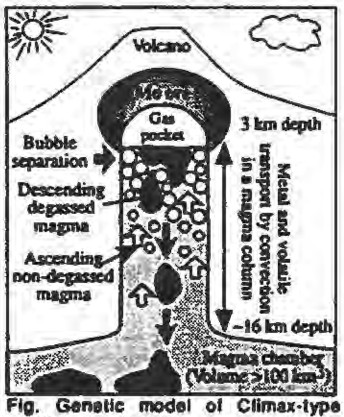


Fig. Genetic model of Climax-type porphyry Mo deposit.

SHOCK, E.L., 1995, Organic acids in hydrothermal solutions: Standard molal thermodynamic properties of carboxylic acids and estimates of dissociation constants at high temperatures and pressures: Am. J. Sci., v. 295, p. 496-580.

SHOCK, E.L. and KORETSKY, C.M., 1995, Metal-organic complexes in geochemical processes: Estimation of standard partial molal thermodynamic properties of aqueous complexes between metal cations and monovalent organic acid ligands at high pressures and temperatures: Geochim. Cosmochim. Acta, v. 59, p. 1497-1532.

SHOJI, Tetsuya and ZAW, Than, 1990, Fluid inclusions of granitoids and their bearing on mineralization in South Korea: J. Korean Inst.

Mining Geol., v. 23, no. 2, p. 127-133 (in English).

Relation between FI and mineralization has been studied for 30 granitoid specimens from 19 localities in South Korea. Polyphase I are found in granitoid specimens of nine localities. In the vicinities of six localities among them occurs [various] W, Cu or Fe deposits of the vein-, stockwork-, skarn- or pegmatite-type. On the contrary, no ore deposit is reported near the granitoids characterized by no polyphase I except only one locality. This fact implies that the occurrence of polyphase I is a good indicator for such kinds of mineralization. Ores and country rocks of some of the deposits contain polyphase I in their quartz crystals. The fact that many polyphase I occur in granitoids and ore constituents suggests that highly saline hydrothermal solution played an important role for the formation of such kinds of deposits. On the contrary, the granite and the ore of the Mugug Au deposit have many FI but are free from the polyphase type. (Authors' abstract)

SHUKOLYUKOV, Y.A. and MESHIK, A.P., 1995, Is there chemically fractionated uranium fission xenon in mantle rocks, gases, and the Earth's atmosphere?: Geokhimiya, v. 8, p. 1072-1093 (in Russian).

SHUMLYANSKIY, V., 1994, Lithogenesis and hypogenic ore formation (Sources of ore matter and fluids in a magmatic platform and fold area): Pub. of Izd. IFI Ukr. Nauchn. Assoc., Inst. Fundamental Sciences, Scientific Assoc. of Ukraine, Kiev, 75 p. (in Russian; extended English abstract; abstracted courtesy Dr. Shumlyanskiy).

Deposits of Hg, Au, polymetals, barite and fluorite are studied in various platform and fold areas in Ukraine and Turkmenistan. It is established that hypogenetic ore accumulation started usually at the stage of catagenesis while formation of disseminated mineralization and "microoil" (L hydrocarbons at the stage of deep catagenesis) within permeable layers of sedimentary rocks. The most amount of mineralization is ascertained within zones of underground waters in hydrogeological basins with elysion [sic] or exfiltrational regimes [sic]. More concentrated mineralization is localized within zones with strained geothermal regime to be mapped as paleohydrothermal anomalies.

Heat regime of ore accumulation is determined by: (1) higher initial T of hypogenetic mineral formation than T of cata- and metagenesis of host rocks; (2) thermostating of the ore-accumulation processes owing to coincidence of T of ore-bearing solutions and host sedimentary rocks. Thermostating is of particular significance for accumulation of sulphides under conditions of T interval of sulphide-ion activity; (3) supplying of hypogene F (heat carrier), signs of which are high T of initial stage of hydrothermal process (>400°C); calculated depth of hydrothermal chamber ~7-10 km; high content of CO_2 and H_2 in G phase; high content of Hg; and (4) formation of hydrothermal convection cells (or systems of them) connected with deep heat chambers (may be cryptic intrusions). (Author's abstract)

SHUMLYANSKIY, V. and BEZUGLA, M., 1995, An ore content in salt domes: Pub. of Izd. IFI Ukr. Nauchn. Assoc., Inst. Fundamental Sciences, Scientific Assoc. of Ukraine, Kiev, 65 p. (in Russian; extended English abstract; abstracted courtesy Dr. Shumlyanskiy).

The book deals with the geological structure of some large basins characterized by presence of both determined and supposed salt domes. Among these are the Dniper-Donets Basin (DDB), Southern and Northern Atlas, Gulf Coast depression, Enisey-Khatanga trough, Paradox basin, Doungchuan district in China, and Flinders Range in southern Australia. The geologic-genetic model for Pb-Zn deposit of salt dome type and the Adamovskoe U-bitumen deposit in DDB are described on the basis of our original results.

The mineral composition of metasomatites, ore mineralization, evolution of ore-forming process, and geochemical peculiarities of ores are studied. The Th of G-L I in minerals [and the] salt concentrations in ore-forming solutions are described. Isotope composition of C, O and S in minerals from various types of metasomatites and ores is given.

The connection between $\delta^{18}O$ H_2O of solutions and the salt concentration in these solutions allows supposition that mixed waters were the basis of ore-forming solutions: deep (metamorphic?) one with lower salt concentration and with isotopically heavier O that predominated during the stage of preore quartz-carbonate metasomatism, and underground brines of the Devonian deposits that were characterized by lesser content of $\delta^{18}O$ in water. These brines predominated probably in the stage of carbonate metasomatism and ore forming. (Authors' abstract)

SHUMLYANSKIY, V., DEMIHOV, Yu., DEREVSKA, E., DUDAR, T., ZELENSKIY, S., ZINCHUK, Y., IVANTISHINA, O., KURILO, M. and SYNGAEVSKIY, E., 1994, A geologic-genetic model for the Bobrikovo gold-polymetallic deposit: Geologichesky J., Nat'l Acad. Sci. Ukraine, v. 3, p. 95-106 (in Russian, English abstract).

A tentative geologic-genetic model for the Bobrikovo gold-polymetallic deposit in the Donets Basin is created. The ore formation evolution with the change of source of hydrothermal solution, the contribution of deep C- and S-containing F to the ore formation, Pb extraction from underlying rocks, repeated heterogeneity and outgassing of solutions, the increase in O fugacity as the solution evolves, the interaction of the solution with the carbonaceous material of rock, and Au redeposition and coarsening, are taken into account. Based on crush-leach analysis it is established that the ore-forming solution contains such anions: Cl (83-97%), bicarbonate-ion (3-11%), sulphate-ion (3-7%), fluorine (≤1%). Na (87-97% is the predominant cation, the rest is Ca, K and Mg; Li is present in all analyses (≤4%); pH of solutions is from 7.0 to 13.1%. CO_2 (32.25-82.53%), N_2 (16.41-64.25%) and CH_4 (0.57-3.5%) are established in the G composition of FI in quartz and siderite. The content of CH_4 is increased to 16.38% in sulfides, and there are C_2H_6 (≤0.41%) and H_2S (≤4.25%). T of the ore-forming process are 360-340°C during the first stage, 290-280°C for the second stage, 260-240°C for the third stage, and post-ore mineralization is formed under 220-150°C. Heterogenization and outgassing of the solutions were ~285-255°C and P ≤230 MPa, and ~170°C and 82 MPa. Au was precipitated from the ore-forming solutions during the second and third stages predominantly. (Authors' abstract)

SHUMLYANSKIY, V., DUDAR, T., BAZUGLA, M., IVANTISHINA, O. and ZUBOV, V., 1994, Geological peculiarities of the Stepok lead-zinc deposit of the salt-dome type: Reports of Ukraine Acad. Sci., v. 6, p. 94-99 (in Russian and Ukrainian, English abstract).

A comparison is made between the Stepok Pb-Zn deposit and the geologic-genetic model of the salt dome-type deposit, which was made by the authors earlier. The metasomatites of the quartz-chlorite-carbonate composition are described first. The data of FI studies show the metasomatites are formed at 210 to 240°C. Isotope composition of C in calcite in quite homogeneous ($\delta^{13}C$ from -6.4 to -10.8‰, PDB). Based on T of carbonates forming and isotope composition of O in these carbonates, $\delta^{18}O$ H_2O is from +16.4 to +19.8‰ SMOW. This suggests that a long-time equilibrium had taken place before ore formation between H_2O of hydrothermal solution and metamorphic rocks. Ore-bearing carbonate metasomatites are characterized by Th in G-FI in carbonates from 160 to 193°C. Isotope composition of C in carbonates ($\delta^{13}C$) is -5.6 to -8.8‰ PDB. O isotope composition of H_2O in the solution is characterized by $\delta^{18}O$ from +14.5 to +16.6‰ SMOW, and it indicates entering of meteoric water in the solution. Perhaps it is a sedimentogenous salt brine, because the salt concentration in G-L I in dolomite is 31-33% NaCl eq.

Carbonates of post-ore veinlets are formed under 70-150°C. Isotope composition of C in carbonates is not constant; $\delta^{13}C$ from +2.4 to -21.5‰ PDB. Isotope composition of O in H_2O of the ore-forming solution is characterized by $\delta^{18}O$ from +2.5 to +11.4‰ SMOW, indicating an increasing role of meteoric water. (Authors' abstract)

SHUMLYANSKIY, V. and IVANTISHINA, O., 1994, On correlation of lithogene and hypogene constituent part in outgasing of the Earth crust of inversion-folded area, *in* A.E. Lukin, V.A. Shumlyanski, G.I. Dlyachenko and O.M. Ivantishina, Pub. of Izd. IFI Ukr. Nauchn. Assoc., Inst. Fundamental Sciences, Scientific Assoc. of Ukraine, Kiev, p. 46-69 (in Russian; extended English abstract).

Copetdag-external zone of the Alpine folded belt (Tethis) has been chosen as a standard young folded area. Rocks of the thick (6-

12 km) amagmatic carbonate-terrigenous megacomplex outcrop here. The most part of cinnabar-calcite-quartz (with polymetals) ore manifestations is connected with rocks of metagenesis zone that coincides with the Fore Fault zone. Witherite-barine (with polymetals, sporadically with Hg) fields are situated within a zone of deep catagenesis (West-Copetdag megasinclinorium). Chalcopyrite (calcosite [i.e., chalcocite])-calcite-quartz veins are spread within both zones of main anticlinorium.

Study of G phase of G-L I in minerals of ore fields and manifestations and also composition of ore-forming solutions (by water extracts) established the participation of underground waters (and gases) of host Aptian-Albian deposits situated within a zone of late catagenesis in the Western Copetdag and underground waters and gases of host Neocomian and underlying Jurassic rocks (zone of early metagenesis) within the zone of the fore fault. They contain considerably less CO_2 but more CH_4 and its homologues.

High T of ore-forming F (≤300-400°C) and peculiarities of the H_2O O isotope composition of this solution suggests participation of F from a depth ~8-12 km. This F is probably in paragenetic connection with a latent magmatic center. Fluorine and Hg participated in its composition parallel with water vapors and CO_2. (Authors' abstract)

SIMAKOV, S.K., 1995, Computer simulation of diamond-bearing fluid in the upper mantle (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 18.

Use literature data (E.R).

SIMMONS, S.F., 1995, Magmatic contributions to low-sulfidation epithermal deposits: Mineral. Assoc. Canada Short Course, v. 23, p. 455-477.

A review including some details on Fresnillo, Mexico. With some caveats, He isotopes and N_2-Ar-He ratios can provide the most diagnostic evidence of magmatic contributions to epithermal deposits; the few available data indicate that these components are promising tracers of F origins and deserve much further investigation. In contrast, enrichment in both O and H isotopes relative to meteoric water, and high concentrations of chloride, can provide permissive evidence of magmatic contributions. Currently, Fresnillo is the only deposit for which all of these techniques have been applied, though there is a gap in the continuity of samples investigated from this deposit, and the isotope studies are reconnaissance in scale.

Only at Fresnillo, for which high-salinity brines of magmatic origin are interpreted, can a cause and effect relationship between magmatic inputs and mineralization be considered. For other deposits, such as Hishikari and Comstock, the availability of metal-transporting ligands in mineralizing F cannot be assessed by current analytical techniques and, therefore, any genetic link between magmatic inputs and mineralization is inferred only. (From authors' text by E.R.)

See also next item. (E.R.)

SIMMONS, S.F. and ALBINSON, Tawn, 1995, Mexican Ag-Au and Ag-Pb-Zn epithermal deposits: Hydrothermal products of a magmatic(?) heritage: PACRIM '95, p. 539-544. First author at Geothermal Inst. and Geology Dept., Univ. Auckland, Auckland, New Zealand.

Mexican epithermal deposits can be broadly grouped into two types based on their contained metals, distribution, associated igneous rocks and FI compositions. Ag-Au deposits (e.g., Tayoltita) mostly occur in the western part of northern Mexico where host rocks consist of Eocene, intermediate composition volcanic and intrusive rocks; FI studies indicate that mineralizing F were <300°C and dilute (≤3 eq. wt % NaCl). In contrast, Ag-Pb-Zn deposits (e.g., Fresnillo) mostly occur in the central part of northern Mexico where they are temporally associated with Oligocene-Miocene volcanic rocks and intrusions of felsic composition, but commonly hosted within underlying Paleozoic-Mesozoic sedimentary rocks; FI studies indicate that mineralizing F ranged from 200 to 400°C and were saline (≥10 eq. wt % NaCl). The distribution of these two deposit types, crosscutting major crustal sutures, and the close spatial-temporal relationships between mineralization and magmatism, together suggest that magmatic processes were more important in the formation of mineralizing solutions, as a source of both ligands and metals, than the segments of crust hosting deposits. (Authors' abstract)

Includes data (Table 1) on 19 Mexican deposits, giving T and sal., 17 of these from the literature: data on Taxco (Guerro)—210-280°C and 1-14% sal., and on El Oro (Mexico DF)—150-200°C and 0-3.5% sal., are unpublished data by Albinson. See also previous item. (E.R.)

SIMON, K., 1995, The isotopic composition of fluid inclusions: method and application (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 347.

This contribution presents a new approach that directly constrains the H_2O isotopic composition of water trapped in quartz. To achieve this goal we have designed a new type of rock mill that keeps adsorption of H_2O onto the newly formed grain surfaces minimal and that is very effective with respect to the degree of crushing. Different grain size-fractions of quartz samples have been investigated by thermal and mechanical decrepitation. This combined approach gives an estimate of the amount of H_2O that may occur at structurally different locations within quartz which include large and small FI, vacuoles in the size range from 1 μm to 20 nm, H_2O and H^+ bond to the quartz lattice, and submicroscopic mineral I. Crushing opens preferentially large FI, which decrease in size when applied to smaller grain size fractions. Heating of the samples H_2O from all reservoirs. With decreasing grain size fractions there is an increase in the amount of structurally bond H_2O and H^+ and of submicroscopic mineral I.

As the result, δD values of I water seems to be function of the I size. This relationship might indicate preferentially loss of water from smaller I relative to larger I which argues for the open system behaviour of FI.

The O isotopic composition of the FI water is dominantly controlled by re-equilibration processes with the host quartz. Re-equilibration seems to be very effective and gives insight into time-depending processes (speedometer). (Authors' abstract.)

SIMONETTI, Antonio and BELL, Keith, 1995, Nd, Pb, and Sr isotope systematics of fluorite at the Amba Dongar Carbonatite Complex, India: Evidence for hydrothermal and crustal fluid mixing: Econ. Geol., v. 90, p. 2018-2027.

Uses literature FI data. (E.R.)

SIMONOV, V.A., SILANT'YEV, S.A., MILOSNOV, A.A. and KOLOBOV, V.Yu., 1995, Fluid inclusions in metagabbroid amphiboles and plagioclases from the 15°20' Cape Verde fracture zone, central Atlantic: Dokl. Ross. Akad. Nauk, v. 341, no. 5, p. 676-681 (in Russian).

FI in plagioclase and amphiboles show Th 280-375°C, Te -32 to -50°C, and sal. 12-36%. (E.R.)

SISSON, T.W. and LOWENSTERN, J.B., 1995, Volatiles in primitive arc basalt from the 1982-83 eruption of Galunggung, Indonesia, and dynamics of mantle-wedge melting (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-98. Authors at U.S. Geol. Surv., MS-910, 345 Middlefield Rd., Menlo Park, CA, 94025.

Glass I [15-90 μm] are common in olivine phenocrysts and preserve pre-eruptive volatiles of the primitive Galunggung basalts. Concentrations of the H_2O and CO_2 were measured by transmission FTIR spectroscopy in doubly-polished glass I. H_2O concentrations are low and fall in a narrow range from 0.29-0.39 wt % [n = 8], comparable to enriched MORB and OIB. Appreciable CO_2 concentrations [480-140 ppm, n = 5] preclude shallow degassing as the cause of the low H_2O and establish that primitive volcanic-front basalts can be water-poor. Dry melting experiments on a similar Aleutian basalt [Draper and Johnston, 1992] suggest that Galunggung basalts separated from the mantle at ~1320°C and 12 kb. Sisson and Layne [1993] showed that primitive low-K basalts of the Cascade arc are also water-poor [0.2-0.3 wt %], but are accompanied by more water-rich basalts. (From authors' abstract by E.R.).

SKINNER, D.N.B. and BRATHWAITE, R.L., 1995, The Wakamarina gold-scheelite-quartz lodes, Marlborough, New Zealand: PACRIM '95, p. 557-562. Authors at Inst. Geological and

Nuclear Sciences Ltd., PO Box 30-368, Lower Hutt, New Zealand.

The lodes are ribbon-banded mesothermal veins composed of bands of milky "buck" quartz with thin laminae of schist. (From authors' abstract by E.R.)

The buck quartz is clouded with tiny (<1 μ) single-phase FI, but very small (≤3 μ) two-phase I occur in rare patches of clear unrecrystallised quartz. These I have Th of ~117°C and freezing point depressions of ~0°C, indicating that they are composed of pure water and are secondary. Remnants of larger single phase angular I, commonly arranged in stars, are interpreted as PI that have decrepitated due to reduction in P during uplift (R. Goldfarb, pers. comm., 1995). (From authors' text by E.R.)

SKVIRSKY, A.L. and PRESNJAK, A.S., 1995, The algorythm of determination of the physico-chemical system equilibrium composition: Fluid composition: Geokhimiya, no. 1, p. 139-149 (in Russian, English abstract; translated in Geochim. Int'l, v. 32, no. 10, p. 8-19).

The new modification of Gibbs free energy minimisation method in concern with the solution of the problem of equilibrium composition of a heterogeneous system evolving the chemical interaction is presented. A new algorythm was worked out and used by means of FLUID PC program. The comparison of results of test system calculations performed by use of FLUID and EQ3/6 is made. Quartz solubility calculations are presented and compared with the corresponding experimental data. (Authors' abstract)

SKYSCTH, T. and REITAN, P., 1995, Geology and genesis of Gautelisfjell gold deposit, Rombak Window, Northern Norway: A link between retrograde Caledonian metamorphism and saline fluids (abst.), *in* P.M. Ihlen, M. Pedersen and H. Stendal, eds., Gold Mineralization in the Nordic Countries and Greenland, Symp. held at Geological Inst., Univ. Copenhagen, 19-20 Oct. 1995, Volume of Extended Abstracts: Geol. Surv. Greenland Open File Series 95/10, p. 94-98.

SLABY, E., KOZLOWSKI, A., CZERWOSZ, E., DIDUSZKO and BANERJEE, A., 1995, Investigation of synthetic fluid inclusions in hydrothermal analcimes (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 235-236. First author at Inst. Geochemistry, Mineralogy and Petrology, Univ. Warsaw, Poland.

Analcime crystals appear in a number of different environments. They are divided, correspondingly to their formation conditions, into five groups: P-type (primary analcimes), H-type (hydrothermal analcimes), S-type (sedimentary analcimes), M-type (metamorphic analcimes), L-type (formed by exchange conversion of leucite). Inclusions trapped in analcimes are seldom investigated due to "leakage," which in turn may be caused by likely interaction between framework water and the water from FI.

The aim of our experiments was to crystallise H-analcimes under various kinetic conditions and to investigate I trapped in them. The experiment was performed in a standard cold seal vessels. Three kinds of I were formed: (A) single-phase FI; (B) two F phases with very small bubbles (3-5 vol %); and C two F phases with big bubbles (25-30 vol %). Types A and B occur deeply inside crystals. Type C occupies area near the crystal surface. Cryometric measurements have given the equivalent of NaCl value respectively 8 wt % for A and B type, 5 wt % for C type.

During the heating, inclusions A were decrepitating at various T, or bubbles were formed in them at T = 130-250°C, which did not disappear during further T increase. Inclusions B homogenised at T = 110-120°C, when the heating process proceeded quickly. Along with slow heating the bubbles were growing in the I without any homogenisation. Inclusions C manifested similar behaviour. Fast heating was causing their homogenisation at T = 310-370°C. During the slow heating they were not becoming homogenised. The bubbles volume in them was constantly increasing reaching 70 vol % of the total volume of I.

Sodium concentration obtained by means of cryometric method from the A and B-type I fits exactly to the maximum sodium contents in the solution after full plagioclase release. Knowing the Tt and Pt we could evaluate the Th data. Quick homogenisation of the B-type prevents the inclusion from leaking. Moving the Th value along 10 wt % NaCl isochore we receive, at 2 kb, almost exactly Tt = 285-295°C. Slow homogenisation causes visible leakage, more pronounced in the C-type inclusion than in the A and B-types. Kinetics of the water escaping from an inclusion into structure depends on sodium site position. Because of the irregular and slightly zoned sodium distribution in investigated analcimes, the leakage is more visible in inclusion C and less in inclusion A and B. (From authors' abstract by E.R.)

SLOBODNIK, M., MUCHEZ, Ph. and VIAENE, W., 1995, Formation conditions of Pb-Zn mineralizations in the Bohemian Massif, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 323-325. First author at Dept. Geology and Paleontology, Masaryk Univ. Brno, Czech Republic.

Hydrothermal mineralizations in Frasnian limestones of the southern part of the Moravian Karst and in the Tournasian limestones of the Ostrava region have been investigated and compared with MVT mineralizations in eastern Belgium. Sphalerite and ferroan calcites associated with sulphides in the Moravian karst and Ostrava region formed at a T ~50°C and <94°C respectively, from F with a salinity between 11.7 and 23.1 eq. wt % NaCl. The O isotopic composition of the ambient F was low ($\delta^{18}O \leq 5.2‰$ SMOW), indicating a meteoric origin of the ambient F. After the sulphide mineralization, low salinity water migrated through the carbonates. The MVT mineralization in Belgium formed from a F with similar features. They had a meteoric origin and flow of these waters was gravity-driven and took place from the uplifted parts of the Variscan orogen towards the foreland basin. (Authors' abstract)

SMELIK, E.A., 1995, Fluid channelization at the submicroscopic scale in exsolved orthoamphiboles: Eur. J. Mineral., v. 7, p. 825-834.

Describes the details of F infiltrating crystals along microstructures. (H.E.B.)

SMIRNOV, S.Z. and ISHKOV, Yu.M., 1995, Ore forming elements in fluids of granite pegmatites (the Kent massif pegmatites, Central Kazakhstan, as example), *in* N.V. Sobolev et al., eds., Contributions to Experimental and Genetic Mineralogy, v. 11, p. 44-49 (in Russian).

Includes a table of five "laser spectral analyses" of FI from pegmatitic quartz for Be, B, Mn, Fe and Cu. (E.R.)

SMIRNOV, V.K., SOBOLEV, A.V., BATANOVA, V.G., PORTNYAGIN, M.V., SIMAKIN, S.G. and POTAPOV, G.V., 1995, Quantitative SIMS analysis of melt inclusions and host minerals for trace elements and H_2O (abst.): Eos, v. 76, no. 17, p. S270. First author at Inst. Microelectronics, IM RAS, Yaroslavl, Russia.

Quantitative SIMS analysis of glasses and pyroxenes for Ti, Sr, Zr, Y, Nb, Ba, La, Ce, Nd, Sm, Eu, Gd, Dy, Er, Yb, Hf and H_2O was developed on Cameca IMS-4F ion microprobe in IM RAS. The methodic was set for O^- primary beam using idea of energy filtering (Shimizu and Hart, 1982). The strong linear correlations between measured isotope to Si ratios and corresponding element concentration to SiO_2 content ratios were obtained for 16 standards of well characterized glasses, Ca-pyroxenes and garnets covered most range for incompatible elements concentrations in igneous rocks. H_2O measurements were calibrated using range of natural and artificial glasses with H_2O concentrations between 0.1 and 10 wt %. The obtained data on standards show the polynomial fit with two degrees which reproduces all measured standards with accuracy >20% relative and in most cases >10% relative. The background level of H_2O estimated by measurement of Mg olivine was <100 ppm.

The established analytical procedure supported by original software package includes five cycles of measurements in the mass range between 1 and 180. Individual counting time for each mass is monitored automatically dependent on the concentration level and stability of signal. Typical run conditions are as follows: ion source energy offset -50 eV, energy slit width 50 eV, primary beam current 1-10 nA, primary beam energy 14.5 keV, primary beam diameter 10-20 micrometers.

The accuracy of routine measurements estimated by reproducibility of standards is >20% relative for all concentrations down to 0.01 ppm level for trace elements and down to 500 ppm level for H_2O. Detection limits are estimated to be down to 0.001 ppm for trace elements and down to 100 ppm for H_2O. (Authors' abstract)

SMITH, G.R., JURINAK, J.J., TANJI, K.K. and BURAU, R.G., 1995, Applications of a Pitzer equations-based model to hypersaline solutions: Chemical Equilibrium and Reactions Models, SSSA Spec. Publ. 42, p. 113-141.

SMITH, M.P., 1995, Modelling of fluid evolution on the basis of crush leach analyses of fluid inclusions from the Cligga Head greisen related Sn-W deposit, S.W. England (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 237-238. Author at Dept. Earth Sciences, Univ. Leeds, Leeds LS2 9JT, UK.

FI from the Cligga Head Sn-W deposit have been studied both microthermometrically and using crush leach analysis. The Cligga Head hydrothermal F had salinities from 5 to 12 wt % NaCl eq. and was dominated by Na-K-Fe-Ca chloride brines, with significant F, B and SO_4 contents. The ratios of Br to Cl in the F are comparable to those of modern volcanic fumarole gases. The molal Na/K ratio varies from ≈4 to 10. The ratios of Ca and Fe to K also show some variation, showing a slight increase with the Na/K ratio.

The composition of F in equilibrium with a model granite assemblage was calculated from 600 to 300°C and 1 kb P, and the composition of F in equilibrium with model greisen was calculated from 400 to 300°C.

The modeled F compositions in terms of Na-K-Fe are compared with the composition of FI leachates in Figure 1. It can be seen that the ratios of Na/K in the FI are comparable with those from the model. The Fe contents are higher in the FI than in the modeled F >600°C, but not as high as those predicted from a greisen mineral assemblage. The Ca contents of all the I F are higher than any of the modeled F compositions.

The re-equilibration of an aqueous chloride-bearing F with the granite at progressively lower T can explain the cation composition of FI from greisen related quartz veins at Cligga Head if mixing between F of different degrees of re-equilibration occurred. The anion content of the crush leach analyses of quartz from Cligga Head is consistent with resurgent boiling of granite as source for the F salinity. (From author's abstract by E.R.)

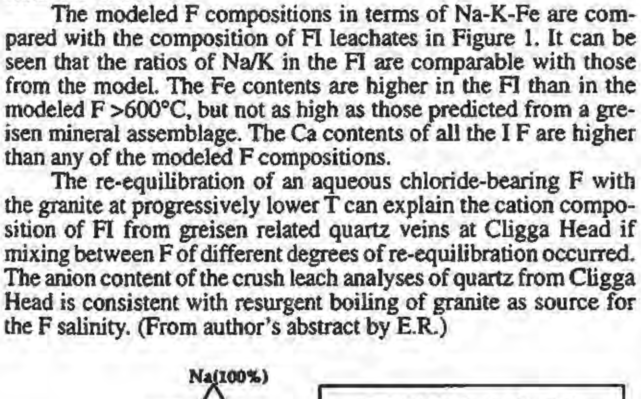


Figure 1:-Comparison ofthe Na-K-Fe content of fluid inclusions and modelled fluids at 1kbar and 300-600°C.

SO, C.-S., DUNCHENKO, V.Y., YUN, S.-T., PARK, M.-E., CHOI, S.-G. and SHELTON, K.L., 1995, Te- and Se-bearing epithermal Au-Ag mineralization, Prasolovskoye, Kunashir Island, Kuril Island arc: Econ. Geol., v. 90, p. 105-117. First author at Dept. Geology, Korea Univ., Seoul 136-701, Republic of Korea.

Au-Ag-Te-Se-bearing epithermal mineralization at Prasolovskoye, NW Kunasbir Island, Kurils, occurs along fault zones developed within a circular intrusive zone in Miocene to Quaternary age volcanic rocks. The ores show complex textures and mineralogy and can be divided into three stages based on tectonic fracturing and mineral associations: pyritic (I), polymetallic (II), and Au-Ag (III). Stages I and II occur as hydrothermal replacement zones, veins, and breccias and are base metal sulfide rich without economic Au and Ag grades. FI and S isotope data indicate that stages I and II formed from relatively high T (≤340°C) F with sal. of 1.2 to 5.5 wt % NaCl eq.

FI data indicate that the main Au-Ag-Te-Se mineralization during substage IIIC occurred between 150° and 245°C from low-salinity (0.4-1.6 wt % NaCl eq.) F. Au deposition was most likely the result of boiling of hydrothermal F. Measured and calculated O and H isotope compositions of stage III F ($\delta^{18}O$ = -4.7 to -9.4‰; δD = -80 to -83‰) indicate meteoric water dominance during the Au-Ag-Te-Se mineralizing event. (From authors' abstract by E.R.)

SO, C.-S., YUN, S.-T., PARK, M.-E., 1995, Geochemistry of a fossil hydrothermal system at Barton Peninsula, King George Island: Antarctic Sci., v. 7, p. 63-72. First author at Dept. Earth and Environmental Science, Korea Univ., Seoul 136-701, Korea.

A fossil hydrothermal system on Barton Peninsula, King George Island, Antarctica, formed a series of Pb-Zn- and pyrite + native S-bearing epithermal quartz ± calcite veins, filling fault-related fractures in hydrothermally altered volcanic rocks of Eocene age. The Pb-Zn veins occur within argillic hydrothermal alteration zones, whereas the pyrite + native S veins are found within advanced argillic alteration zones. FI data indicate that the vein formation occurred at T between ~125° and 370°C (sphalerite deposition formed at 123-211°C) from F with salinities of 0.5-4.6 wt % eq. NaCl. Equilibrium thermodynamic interpretation of mineral assemblages indicates that the deposition of native S in the upper and central portions of the hydrothermal system was a result of the mixing of condensates of ascending magmatic gases and meteoric water giving rise to F which had lower pH (<3.5) and higher fugacities O and S than the Pb-Zn-depositing F at depth. The $\delta^{34}S$ values of sulphide minerals from the Pb-Zn veins ($\delta^{34}S$ = -4.6 to 0.7‰) are much higher than the values of pyrite and native S from the pyrite + native S veins ($\delta^{34}S$ = -12.9 to -20.1‰). This indicates that the F depositing native S had higher sulphate/H_2S ratios under higher fO_2 conditions. S isotope compositions indicate an igneous source of S with a $\delta^{34}S_{\Sigma S}$ value near 0‰, probably the Noel Hill granodiorite. Measured and calculated $\delta^{18}O$ and δD values of the epithermal F ($\delta^{18}O_{water}$ = -6.0 to 2.7‰, δD water = -87 to -75‰) indicate that local meteoric water played an important role for formation of Pb-Zn and native S-bearing quartz veins. (Authors' abstract)

SO, C.-S., YUN, S.T. and SHELTON, K.L., 1995, Mesothermal gold vein mineralization of the Samdong mine, Youngdong mining district, Republic of Korea: Mineral. Deposita, v. 30, p. 384-396. First author at Dept. Geology, Korea Univ., Seoul 136-701, Korea.

Mesothermal Au mineralization is situated in massive quartz veins ≤1.2 m wide which fill fault fractures within upper amphibolite to epidote-amphibolite facies, Precambrian-banded biotite gneiss. The veins are mineralogically simple, consisting of Fe- and base-metal sulfides and electrum, and are associated with weak hydrothermal alteration zones (<0.5 m wide) characterized by silicification and sericitization. FI data and equilibrium thermodynamic interpretation of mineral assemblages indicate that the quartz veins were formed at T between 425 and 190°C from relatively dilute aqueous F (4.5-13.8 wt % eq. NaCl) containing variable amounts of CO_2 and CH_4. Evidence of F unmixing (CO_2 effervescence) during the early vein formation indicates approximate P of 1.3-1.9 kb, corresponding to minimum depths of ≈5-7 km under a purely lithostatic P regime. Au deposition occurred mainly between 345 and 240°C, likely due to decreases in S activity accompanying F unmixing. The $\delta^{34}S$ values of sulfide minerals (-3.0 to 5.3‰), and the measured and calculated O-H isotope compositions of ore F ($\delta^{18}O$ = 5.7 to 7.6‰; δD = -74 to -80‰) indicate that mesothermal Au mineralization at the Samdong mine may have formed from dominantly magmatic hydrothermal F, possibly related to intrusion of the nearby ilmenite-series, "Kimcheon Granite" of late Jurassic age. (From authors' abstract by E.R.)

SOBOLEV, A.V., 1995, Melt inclusions as a source of principal petrologic information (abst.): Eos, v. 76, no. 17, p. S266. Author at Vernadsky Inst. Geochemistry, RAS, Kosigin str 19, Moscow 117975, Russia.

Three main subjects were addressed in particular: (1) geochemistry of primary M; (2) primary volatile contents in magmas; and (3) direct evidence for natural occurrence of ultramafic M.

(1) Widely accepted idea of general mixing of primitive M in the mantle assumes very rare natural occurrence of unmodified primary M. However, massive ion probe studies of MI in high Mg-olivines from MORB (EPR, MAR), Iceland, subduction-related environments (Troodos, Cyprus) and mantle plumes (Hawaii, Reunion) show that few to 10% of measured populations could be treated as unmixed or moderately mixed nearly primary M while the rest are well mixed samples close in composition to bulk rocks or glasses. Nearly primary M show extremely large range in in-

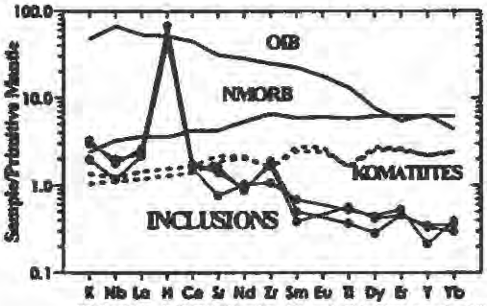
compatible element concentrations from ultra-enriched to ultra-depleted and suggest very efficient element fractionation during melting. These data argue for mantle under MOR and above SZ as effectively open system for the M fractions of 1-3 wt % and suggest that magma-generating mantle columns commonly exceed 50 km in thickness. All this information is completely missed in rocks and glasses.

(2) Massive ion probe studies of MI for H_2O suggest that typical level of H_2O concentration in primary subduction-related magmas (boninites and tholeiites) should be ~2-3 wt % which is two to three times higher than could be expected from H_2O contents in evolved but fresh submarine glasses. Decoupling of H_2O and trace elements of similar incompatibility (K, La, Ce) observed in depleted MI suggests active role of F (either H_2O or CO_2) in H_2O transportation in both suprasubduction and mid-oceanic ridge mantle.

(3) There is no reported rock which represents quenched ultramafic L of Phanerozoic age with MgO >18 wt %. However, MgO-rich (≤29 wt % MgO) I in Cr-spinels from low-Ca boninites (Papua New Guinea) and Siberian meimechites display olivine spinifex structure indicative of quenching of ultramafic M. These data provide direct evidence for very high T achieved in the magma-generating zones of Phanerozoic mantle. (From author's abstract by E.R.)

SOBOLEV, A.V., KAMENETSKY, V.S. and CRAWFORD, A.J., 1995, Very hot H_2O-bearing Phanerozoic mantle: Evidence from ultramafic melt inclusions in phenocrysts from Papua-New Guinea boninite (abst.): Eos, v. 76, no. 17, p. S270. First author at Vernadsky Inst. Geochemistry, Kosigin St. 19, Moscow 117975, Russia.

Extremely high T for magma-generating zones (1700-1800°C) is widely accepted as unique feature of an Archean mantle. This has been proved by presence of high-Mg (≤29 wt % MgO) and high-T melts known as peridotitic komatiites (e.g., Nisbet et al., Lithos, 30, 291-307, 1993) with so-called olivine spinifex structure. In this paper we report the direct evidence of ultramafic composition (≤29 wt % MgO) of the M parental for low Ca boninites from Cape Vogel, Papua New Guinea. Such M with olivine spinifex structure were found as I in chrome-spinel phenocrysts (up to Cr/Cr+Al = 0.95) and have been reconstructed from MI in olivine (Fo94). The composition of these M measured by ion and electron probes corresponds to H_2O bearing strongly refractory boninite. This M originated by multistage melting of harzburgitic source under influence of H_2O-bearing subduction related component at high mantle T (~1600°C). Strong relative enrichment of primary M in LREE and Nb and high T suggest the influence of plume component in the origin of low-Ca boninites. (Authors' abstract)



PM, OIB, NMORB after Sun & McDonough, 1989, komatiites after McDonough & Ireland, Nature, 365,1993.

SOLER, A., DELGADO, J., ARCOS, D., CARDELLACH, E. and AYORA, C., 1995, The diverse types of Au mineralization in the Pyrenees and their significance in the evolution of Hercynian orogen, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 71-74. First author at Dept. Cristallografia, Mineralogia i Dipòsits Minerals, Univ. Barcelona, Spain.

Several forms of arsenopyrite-Au bearing assemblages are found in the Hercynian terrane of Central and Eastern Pyrenees. Mineralizing F were equilibrated with the enclosing rocks as shown by the lack of wall-rock alteration and the presence of gangue minerals similar to those of the regional rocks (chlorite + quartz + muscovite). From the chemistry of the F at least two solutions have been recognized: a CO_2-rich low salinity (6% wt NaCl eq.) F, present in the synfoliation veins and a CO_2-free and high salinity (≤30% wt NaCl eq.) F found in the post-foliation deposits. Ore deposition took place ~500°C and 5 kb in the synfoliation veins and ~350°C and 2 kb in the post-foliation veins and skarns. The late Hercynian uplift of the metamorphic terrane caused a steep rise in the thermal gradient (from 25 to 50°C/km), the expansion of pore F, and its migration into faults and thrusts. The drop in the P-T conditions caused the unmixing of a CO_2-rich phase from the original CO_2-$NaCl$-H_2O F. The remaining brine was able to keep metals in solution and precipitate them in faults and thrusts mainly as result of a T decrease. In the case of the skarns, the F were mobilized because of the thermal gradient related to the contact metamorphism. (From authors' abstract by E.R.)

SOLOMON, Mike, 1994, Meteoric fluids and sulphur in tin-tungsten deposits with special reference to carbonate replacement types (abst.), *in* D.R. Cooke and P.A. Kitto, eds., Contentious Issues in Tasmanian Geology: A Symposium: Geol. Soc. Australia, Tasmania Div., Abstracts, no. 39, p. 91-92.

Presents published FI data in support of paragenesis. (H.E.B.)

SPEISER, A., HEIN, U.F. and PORADA, H., 1995, The Kansanshi Copper Mine (Solwezi Area, northwestern Zambia): Geology, wall-rock alteration and fluid inclusions, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 389-392. Authors at Inst. Geologie und Dynamik der Lithosphäre, Göttingen, Germany.

At Kansanshi, Zambia, Cu-quartz veins are hosted by Katangan metasediments. Epithermal mineralisation precipitated from complex Na-Ca-Cl-H_2O-CO_2-(CH_4) brines which were modified *in situ* during F-rock interaction. P-T conditions of ore formation are 230°C < T < 310°C and 1200 bar < P << 2500 bar, respectively. (Authors' abstract)

SPENCER, R.J., ROBERTS, S.M. and YANG, W., 1995, Paleoclimate data from fluid inclusions in salt: examples from the Qaidam Basin, China, and Death Valley, United States (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 239. Authors at Dept. Geology and Geophysics, Univ. Calgary, Calgary, Alberta T2N 1N4, Canada.

Salt deposits hold great potential to supply unique data for the interpretation of past climate. One of the most exciting developments in paleoclimate research is the analysis of trapped atmospheric gases in polar ice allowing records of climate and climate forcings, based on analyses of stable isotopes and atmospheric gases, to be obtained from the same samples. Because of this, ice cores are now considered to contain some of the best paleoclimate records available.

Like ice, salt deposits contain direct samples of the ancient hydrosphere and atmosphere as FI in evaporite minerals.

A late Pleistocene/Holocene mid-latitude paleoclimate record [but no data] is presented for the high elevation Qaidam Basin on the Qinghai-Tibet Plateau. Major element and stable isotope compositions of surface brines, preserved, along with atmospheric gases, as FI in salt, are used to construct the record which covers the last 54 ka. Preliminary data from a core trough Death Valley, California, covering the last 200 ka are also presented. (From authors' abstract by E.R.)

See also FIR, v. 27, p. 139-140. (E.R.)

SPIRAKIS, C.S. and HEYL, A.V., 1995a, Interaction between thermally convecting basinal brines and organic matter in genesis of Upper Mississippi Valley zinc-lead district: Trans. Inst.. Min. Metall. (Sect. B: Appl. Earth Sci.), v. 104, p. B37-B45.

The modified basinal brines, containing partly oxidized S species, scavenged metals from basement rocks and sediments and transported them through the host rock, which contained local concentrations of organic matter. Thus, all components of the mineralizing F (NaCl, H_2O, heat, S and metals) were obtained within the ore district, obviating the need to invoke long-distance transport; the siting of mineral districts was related to the locations of faults through U- and Th-enriched granites beneath sediments containing basinal brines, and the locations of ore deposits within these districts were controlled by the locations of concentrations of organic matter. (From authors' abstract by E.R.)

SPIRAKIS, C.S. and HEYL, A.V., 1995b, Evaluation of proposed precipitation mechanisms for Mississippi Valley-type deposits: Ore Geol. Rev., v. 10, p. 1-17. First author at U.S. Geol. Surv., MS 929, DFC, Lakewood, CO 80225.

The mechanism of precipitation is an important aspect of any genetic model for MVT deposits. Yet most of the precipitation mechanisms for minerals in the MVT association have serious flaws. Solution mixing would require an unlikely series of solutions to account for the various minerals in the ores, and it does not account for the universal occurrence of organic matter in the ores nor for the oxidation state of S in pyrite in the ores. Sulfate reduction addresses some of these problems, but is inconsistent with kinetic data and could not be reversed to account for the oscillations between precipitation and dissolution of sulfide minerals in the ores. CO_2 effervescence does not address the precipitation of most minerals in the ores, and all of the evidence for effervescence may be explained in other ways. Cooling of the mineralizing solution could precipitate many minerals, but FI data suggest that, in many deposits, the solution did not cool significantly as any particular stage formed. A credible genetic model also must explain why all of the minerals precipitated at the same sites; any combination of the above mechanisms which suggests that unrelated mechanisms occurred at the same sites by coincidence is unlikely.

The most reasonable scenario is that a hot, thiosulfate-bearing mineralizing solution reacted in various ways with organic matter at all sites of mineralization to precipitate the ore minerals. The organic matter acted as a reductant, source of CO_2, source of organic acids, and a substrate for bacterial metabolism of thiosulfate in various stages of mineralization. Thus, organic matter links all stages of the mineralization to the same sites. (Authors' abstract)

SPIRO, B., GIZE, A., FIRST, D. and HERRINGTON, R., 1995, Organic matter in the Láhoca-Recsk Cu-Au-S deposit, Inner West Carpathian Arc, Hungary, *in* Pasava, Kříbek and Žák, eds., Mineral Deposits: Balkema, Rotterdam, p. 807-810. First author at NERC Isotope Geosciences Laboratory, Keyworth, Nottingham, UK.

Within and around these epithermal Cu-Au-S deposits there is a widespread occurrence of hydrocarbons. Petrographic evidence indicates at least three episodes of hydrocarbon emplacement, two of the episodes having different thermal maturity. petrographic evidence also suggests that oil emplacement postdated the main sulphide formation. (From authors' abstract by E.R.)

SPIRTEL, F.M., NIELSEN, R.L. and CHRISTIE, D.M., 1995, Anomalous low Na MORB magmas: Evidence for depleted MORB or analytical artifact? (abst.): Eos, v. 76, no. 17, p. S269. Author at COAS, Ocean. Admin. 104, Oregon State Univ., Corvallis, OR 97331.

During the last decade, variations in the Na content of MORB magmas have become central to several new models of magma genesis and mantle flow. We have relied on Na numbers even though such determinations are known to be prone to Na-loss during microprobe analysis. Our studies of MI have led to an examination of Na loss during analysis of quench halos in basaltic glass.

We were alerted to this problem while working with partially crystalline MI in MORB plagioclase. Traverses across such I revealed zones of apparently extremely low Na2O content which we subsequently [were] able to attribute to extremely rapid Na loss from zones of fine quench crystallization. Within each glass pillow rind, such quench halos typically become increasingly abundant away from the outer surface. They are generally irregular to spherical masses, made up of intergrowths of crystals with interstitial residual M, commonly nucleated on quench crystallites or microphenocrysts. When they are visible, analysts routinely avoid such halos, but they are very difficult to see in reflected light. To investigate the significance of this phenomenon we examined a suite of plagioclase phyric MORB glasses recovered from the East Blanco Depression, by R. Embley and Wilson.

In all cases the Na loss from the quench halo was dramatically faster than for the host glass. For example, the results for a 30 micro beam and 30 nA beam demonstrate that almost half of the Na is lost from the quench halo in the first minute, whereas the Na loss from the host glass over the same time period is negligible. In fact, the Na is lost >120 times faster than the quench halo than from the host glass. The rate of Na loss from such patches is so rapid, that the averaging of a single point of this type with 3-5 nearby normal glass analyses will reduce the average Na_2O for that sample by 20-30%, with no effect on the other elements. (Authors' abstract)

SRIKANTAPPA, C., LAKSHMEESHA, B. and RAITH, M., 1995, Shear related gold mineralization during retrogression of the Nilgiri granulites, south India (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 288-289. First author at Dept. Geology, Manasagangotri, Univ. Mysore 570 006, India.

Numerous Au-quartz veins are hosted by retrogressed enderbites and basic granulites. During the retrogression, pore F trapped in the granulites evolved from a near peak metamorphic high density CO_2 F (1.15 to 1.08 g/cc) to a late, low density CO_2 F in the intensely retrogressed rocks (0.88 to 0.86 g/cc). In the Au-quartz veins, in contrast to the high density CO_2 F in the granulites, mixed CO_2-H_2O and low density CO_2 (0.90 to 0.86 g/cc) F predominate.

Based on structural and petrographic observations, the ore assemblages as well as the chronology and compositional characteristics of FI, it is envisaged that the transport and deposition of Au took place during shear deformation. The Au mineralization occurred at a late stage (2-3 kb and 280 to 340° following uplift and cooling. (From authors' abstract by E.R.)

SPRY, P.G. and THIEBEN, S.E., 1995, The geology and geochemistry of Cretaceous-Tertiary alkaline igneous-related epithermal Au-Ag telluride mineralization of Montana (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-100. Authors at Dept. Geological and Atmospheric Sciences, 253 Science I, Iowa State Univ., Ames, IA 50011.

FI studies suggest that Au mineralization was deposited from low-T (130°-270°C), moderately saline (1-2 eq. wt % NaCl), nonboiling, CO_2-poor, near neutral pH, relatively oxidizing F. T as high as 420°C have been reported from contact metamorphic ores and the Golden Sunlight deposit. O and H isotope studies support the concept that Au-Ag telluride mineralization was deposited from meteoric water (Landusky-Zortman) or by mixing of magmatic and meteoric waters (Gies, Golden Sunlight). S isotope data suggest a variety of magmatic and/or sedimentary S sources. Alkaline igneous-related Au telluride deposits in Montana, some of which contain molybdenite (Landusky-Zortman, Beal) or, as in the case of Golden Sunlight which is telescoped upon a porphyry Mo system, are thought to represent one end-member of a continuum with porphyry Mo deposits. (From authors' abstract by H.E.B.)

STAUDT, W.J., 1995, Sulfate, sodium and chloride incorporation into sedimentary carbonate minerals: Unpub. PhD thesis, SUNY at Stony Brook, Stony Brook, New York, 164 p.

Indexed under FI. (E.R.)

STEFANI, A.B., 1995, Characterization of the spatial and temporal distribution and genetic relationship of dolomitization, secondary porosity and MVT mineralization, upper Knox Group, central Tennessee: Implications for development of basinwide flow systems: Unpub. Masters thesis, Univ. California, Riverside, CA, 157 p.

Systematic shifts in $\delta^{18}O$ values of intermediate and late dolomite cements, combined with variation in FI Th suggest that diagenetic F T increased during intermediate dolomitization, peaked during MVT mineralization (sphalerite, 114.9°C and fluorite, 109.6°C) and declined during late calcite (92.3°C). FI data also indicate that F associated with MVT mineralization were hot brines (fluorite, 109.6°C, 21 eq. wt % NaCl). Bitumen associated with dolomites and hydrocarbons in FI in sphalerite and barite indicate an association of diagenetic F with migration of hydrocarbons. (From author's abstract by E.R.)

STEL'MACHONOK, K.Z., 1995, Near-simultaneous formation of single-system veinlets in a molybdenum stockwork orebody at the Dzhida deposit, Transbaykalia: Dokl. Ross. Akad. Nauk, v. 341, no. 3, p. 399-402 (in Russian).

Analyses of 10 FI, from various stages, for Mo, Cu, Ag, Fe, Mn and W are reported. (E.R.)

STERN, W.B., MULLIS, Josef, RAHN, Meinert, SUN, Muyuan and FREY, Martin, 1995, On the shape of the first 'illite' X-ray diffraction-reflection, crystallinity, and incipient metamorphism: Revista Geol. Chile, v. 22, p. 127-135.

Uses FI data to help calibrate method. (H.E.B.)

STERNER, S.M., HALL, D.L. and KEPPLER, Hans, 1995, Compositional re-equilibration of fluid inclusions in quartz: Contrib. Mineral. Petrol., v. 119, p. 1-15. First author at Bayerisches Geoinst., Univ. Bayreuth, Postfach 10 12 51, D-95440 Bayreuth, Germany.

Compositional modifications to salt-water FI in quartz were observed following exposure to disequilibrium conditions in a series of laboratory experiments in which samples containing I of known composition were annealed at 3 kb and $600 \leq T \leq 825°C$ in the presence of F having different compositions for time intervals ranging from a few days to one month. The behaviors of both synthetic and natural FI were studied. The synthetic samples were reequilibrated under $P_{int} = P_{conf}$ conditions to minimize stress in the crystal surrounding the I, and were subjected to both $f_{H2O}^{int} > f_{H2O}^{conf}$ and $f_{H2O}^{int} < f_{H2O}^{conf}$. After reequilibration for four days at $T \geq 600°C$, most I displayed significant compositional changes *without decrepitation*. Salinity variations as large as ≈25 wt % were inferred for brine I exposed to $f_{H2O}^{int} \neq$ for f_{H2O}^{conf} for 16 days at 825°C. The majority of our observations are consistent with the net diffusion of water toward the reservoir having the lowest μH_2O. The behavior of *natural* salt-water FI during reequilibration was generally consistent with corresponding observations on synthetic samples. Additionally, it is evident that although applied stress can significantly enhance the reequilibration rate, strain in the crystal host around the I resulting from large P differentials between the internal and confining F is not a necessary prerequisite for compositional change. Finally, because significant compositional changes can be induced in brine I in quartz during short-term exposure to non-equilibrium conditions at $600 \leq T \leq 825°C$ in the laboratory, it is likely that similar changes may result at much lower T during exposure of natural rocks to non-equilibrium conditions over geologic time. (From authors' abstract by E.R.)

STEVENS, G., 1995, Shear-zone-hosted gold along the southern margin of the Limpopo Belt: A metamorphic perspective on the origin of the mineralising fluids: Univ. Witwatersrand, Econ. Geol. Research Unit Information Circ. No. 295, 26 p. Author at Economic Geology Research Unit, Dept. Geology, Univ. Witwatersrand, P/Bag 3, WITS 2050, South Africa.

Numerous small Au mines and prospects are localised on the Hout River Shear Zone and related structures that developed during southwards thrusting of the granulite grade southern Marginal Zone of the Limpopo Belt over the lower grade rocks of the Kaapvaal Craton. Petrographic evidence from the mineralised sites suggests that thrusting and mineralization occurred under amphibolite-grade conditions, i.e., during the retrograde path in the granulites, and close to the peak of metamorphism in greenstones on the craton. Thus, the mineralization is an integral part of the tectonometamorphic cycle that produced, and then partially exhumed, the granulites. FI studies suggest that mineralization was associated with the mobilization of low aH_2O, CO_2-rich F along the uplift-related shear zones. However, the entire southern portion of the Southern Marginal Zone records the retrogression of former granulite-facies mineral assemblages by interaction with a F of similar composition. This does not represent the general infiltration of the terrane by a carbonic F of external origin. Rather, the F are of internal origin and resulted from the oxidation of biogenic graphite through interaction with H_2O-rich F derived from crystallizing, *in situ* anatectic leucosomes. In this study it is proposed that the evacuation of this internally derived retrograde F along active shear zones resulted in the associations observed at the sites of mineralization. (Author's abstract)

STILLINGER, F.H., 1995, A topographic view of supercooled liquids and glass formation: Science, v. 267, p. 1935-1939.

Various static and dynamic phenomena displayed by glass-forming L, particularly those near the so-called "fragile" limit, emerge as manifestations of the multidimensional complex topography of the collective potential energy function. These include non-Arrhenius viscosity and relaxation times, bifurcation between the α- and β-relaxation processes, and a breakdown of the Stokes-Einstein relation for self-diffusion. This multidimensional viewpoint also produces an extension of the venerable Lindemann melting criterion and provides a critical evaluation of the popular "ideal glass state" concept. (Author's abstract)

Pertinent to understanding the glassy state of many frozen high-Ca, Mg brine I. (E.R.)

STIX, John, GAUTHIER, Gilles and LUDDEN, J.N., 1995, A critical look at quantitative laser ablation ICP-MS analysis of natural and synthetic glasses: Canadian Mineral., v. 33, p. 435-444. Authors at Dept. Géologie, Univ. Montréal, Case postale 6128, Montreal, Quebec H3C 3J7, Canada.

In this paper, we examine techniques and problems of quantitative laser-ablation ICP-MS analysis for natural and synthetic glass samples and discuss internal standardization, use of calibration curves, and single-standard calibration. Internal standards are used to normalize raw intensities and are generally a low-abundance isotope of a major element in the samples. For zoned minerals, internal standards are used that show small compositional variations. Calibration curves are necessary to define the ICP-MS response over a range of concentrations and are constructed using a series of geochemical reference standards of similar composition to the unknown materials to be analyzed. A series of calibration curves for mafic-ultramafic and felsic glasses are presented, which generally show linear behavior. However, Zr, Y, and Ce calibrations are nonlinear and exhibit higher relative intensities for these elements at higher concentrations. This nonlinearity may be the result of (1) large ranges in concentrations or (2) matrix effects involving Fe and total trace-element content in the glasses. Calibrations using a single geochemical reference standard can be attempted only if the calibration curves are linear and pass through the origin, and if the reference standard and the samples have similar compositions. (Authors' abstract)

STIX, John, LAYNE, G.D. and SPELL, T.L., 1995, The behavior of light lithophile and halogen elements in felsic magma: Geochemistry of the post-caldera Valles Rhyolites, Jemez Mountains Volcanic Field, New Mexico: J. Volcanol. and Geothermal Res., v. 67, p. 61-77. First author at Dept. Géologie, Univ. Montréal, Case postale 6128, Montreal, Quebec H3C 3J7, Canada.

The data suggest that (1) a magmatic F phase continuously extracted Cl from F-saturated magmas and (2) some of the magmatic Cl lost could have been incorporated into the Valles hydrothermal system. (From authors' abstract by E.R.)

STOWELL, H.H. and LESHER, C.M., 1995, A review of metamorphic lode gold mineralization in the Southern Appalachian Blue Ridge, Alabama and Georgia (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 116.

Indexed under FI. (E.R.)

STRAUB, K.T., YEATS, C.J., BROWN, P.E. and HAGEMANN, S.G., 1995, Preliminary fluid inclusion investigation of the composite VHMS- and lode-gold style Archean deposit at Mt Gibson, Western Australia (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-66.

The Mt Gibson Au and base-metal deposits are located in the southern portion of the Archean Yalgoo-Singleton greenstone belt in the Murchison Province of the Yilgarn Craton, Western Australia. Detailed petrographic and structural studies indicate that base-metal and Au mineralization is likely composite in nature, introduced initially by volcanic hosted massive sulfide (VHMS) mineralization processes and subsequently overprinted by a characteristic lode-Au style of mineralization. Au mineralization is inferred to have been introduced pre- to syn- tectonic and pre- to syn- amphibolite facies metamorphism.

Microthermometry of P FI is quartz reveals at least three FI types: (I) $CO_2 \pm H_2O \pm$ salt, (II) $CO_2 \pm CH_4$ and (III) $H_2O \pm$ salt ± gas. Type I inclusions are found mostly adjacent to sulfides in samples showing a marked lode-Au style mineralization. Type II and III inclusions are present in samples displaying both VHMS and lode-Au styles of mineralization. CO_2 densities in Type I inclusions range from 0.80-0.90 g/cc. Most of these I decrepitated between 230° and 298°C. Type II inclusions have eq. CO_2 densities between 0.73 and 1.13 g/cc with XCH_4 content varying from <0.01 to 0.11. Total Th range from 131° to 350°C. Type III inclusions can be subdivided into two populations: (A) FI whose dms are most likely halite and sylvite (Te ranges from -14.0° to -24.9°C); and (B) complex FI with ≤5 dms containing aqueous, gaseous and uncertain salt components (Te ranges from -40.0° to -81.0°C). Salinity estimates for population A are from 0.1 to 49 eq wt % NaCl and have bulk densities of 0.9 to 1.1 g/cc. Final homogenization in these I occurs between 140° and 425°C. Population B is characterized by the final melting of ice between +38.0° and -45.0°C. The unusually high melting T in population B are from 180° to >600°C (homogenization by either L or V disappearance or by salt dissolution).

These preliminary FI data indicate that both moderate to high salinity F and low XCH_4 F were likely associated with both stages of mineralization at the Mt Gibson deposits. The salinity estimates are unusually high for both VHMS and lode-Au styles of mineralization suggesting a magmatic source for the high salinity F. (Authors' abstract)

STRONG, D.F., 1995, Some geochemical petrological aspects of mineral deposits: Warta Geologi, Newsletter Geol. Society Malaysia, v. 21, no. 2, p. 81-82.

Indexed under FI. (E.R.)

STUART, F.M., BANKS, D.A. and BURGESS, R., 1995, Determination of halogen ratios in fluid inclusions: Inter-laboratory calibrations and application to mantle volatiles (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 347.

The relative abundances of Cl, Br and I in FI are routinely determined by; (i) inductively coupled plasma atomic emission spectrometry and (ii) neutron irradiation/noble G mass spectrometry, but to date little attempt has been made to cross-calibrate the two methods. To rectify this, and identify standard material, we have used both techniques to determine halogen ratios in FI extracted by crushing four natural and three synthetic quartz samples which display Br/Cl and I/Cl which vary over 2 orders of magnitude. Preliminary results demonstrate that Br/Cl are consistent within 20% and I/Cl are consistent within a factor of 8 between the two methods. The poor consistency of I/Cl may be due to resonances in the neutron absorption cross-section of ^{127}I for epithermal neutrons. In an allied experiment we are currently determining which of the standard ^{40}Ar-^{39}Ar irradiation monitors are most applicable monitors to use in this regard.

Preliminary results from a study of CO_2-dominated F trapped in lherzolite xenoliths from the European sub-continental mantle have constant Br/Cl which are higher (by a factor of 2) than bulk Earth. This may reflect a recycled component in the host magma. The low I content of the F precludes accurate measurement of I/Cl. (From authors' abstract by E.R.)

STUART, F.M., BURNARD, P.G., TAYLOR, R.P. and TURNER, G., 1995, Resolving mantle and crustal contributions to ancient hydrothermal fluids: He-Ar isotopes in fluid inclusions from Dae Hwa W-Mo mineralisation, South Korea: Geochim. Cosmochim. Acta, v. 59, p. 4663-4673. First author at Dept. Geology, Univ. Manchester, Manchester M13 9PL, UK.

He and Ar isotopes from FI in individual colour zones (B, C, D, and E) of a large scheelite crystal from the 88 Ma Dae Hwa W-Mo deposit, South Korea, trace the source and history of the ore F. A gradual decrease of the F $^{3}He/^{4}He$, $^{3}He/^{36}Ar$, and $^{40}Ar/^{36}Ar$ from the core to the edge of the scheelite reflects the progressive dilution of a magmatic F by meteoric water and is consistent with the previously observed decrease of $\delta^{18}O(H_2O)$ and FI Th (Shelton et al., 1987). The covariation of FI He-Ar isotope systematics with $\delta^{18}O$ and Th defines a magmatic component with $^{3}He/^{4}He = 1\text{-}2 \times 10^{-6}$, $^{3}He/^{36}Ar > 0.01$, and $^{40}Ar/^{36}Ar > 1000$. Anomalously high He and Ar isotope ratios in zone D F represents undiluted magmatic noble G. This may reflect local variation in the magmatic G flux or G loss due to boiling of the hydrothermal F prior to mixing with magmatic G.

He and Ar isotope systematics constrain mantle and crustal components in the hydrothermal F. $^{40}Ar/^{3}He$ (4.5×10^4) are close to the mid-ocean ridge basalt value, implying that ^{40}Ar is mantle in origin. Radiogenic isotope ratios of the mantle endmember ($^{40}Ar/^{4}He = 0.69 \pm 0.06$) are similar to contemporary geothermal F. The coincidence of mantle-derived He and Ar in the F is strong evidence that mantle melting during Late Cretaceous subduction triggered the crustal melting responsible for granite formation. $^{40}Ar/^{4}He$ of the meteoric fluid (0.007 ± 0.001) is far lower than the crustal production ratio (0-2) implying an origin in crust <200°C. (Authors' abstract)

STUART, F., TURNER, G. and TAYLOR, R., 1994, He-Ar isotope systematics of fluid inclusions: Resolving mantle and crustal contributions to hydrothermal fluids, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 261-277. First author at Geology Dept., Manchester Univ., Manchester M13 9PL, UK.

Using the noble G isotopes to trace the provenance and interaction histories of ancient F has largely been overlooked. Studying FI-hosted noble G isotopes runs into the potentially significant problems of diffusive loss and the addition of *in situ* components. These can be overcome by crushing minerals with low diffusivities and low radioelement contents thereby allowing He (Ne) and Ar to trace F that may be $>10^4$ Ma.

He and Ar isotopes from FI in individual zones of scheelite ($CaWO_4$) from the 88 Ma Dae Hwa W-Mo deposit, S. Korea, identify two trapped F components: a magmatic F (ultimately mantle-derived) and a crustal-radiogenic F. $^{3}He/^{4}He$, $^{3}He/^{36}Ar$ and $^{40}Ar/^{36}Ar$ decrease from the core to the edge reflecting the mixture of a ^{3}He-rich magmatic F with ancient meteoric F with low $^{3}He/^{4}He$ and $^{40}Ar/^{36}Ar \sim 385$. This is consistent with FI Th, $\delta^{18}O$ and δD variations. The $^{3}He/^{4}He$, $^{3}He/^{36}Ar$ and $^{40}Ar/^{36}Ar$ of F trapped in one of the outer zones are significantly higher than the other zones and represent an influx of a less diluted magmatic F, perhaps tapped by fracturing during mineralisation. Both ^{40}Ar and ^{3}He are transferred into the crust by melting of the subcontinental mantle. Radiogenic isotope ratios of the end-member F are consistent with a direct mantle origin for the noble G in the magmatic component ($^{40}Ar/^{4}He = 0.67$). This suggests that Cretaceous granite magmatism in Korea occurred in response to basaltic intrusion or underplating of mantle melts. The meteoric F end-member has $^{40}Ar/^{4}He = 0.007$, requiring it to have originated in shallow crust where radiogenic ^{40}Ar has largely been retained by K-bearing minerals. (Authors' abstract)

STUDENT, J.J. and BODNAR, R.J., 1995b, The preservation of magmatic volatiles in naturally decrepitated melt inclusion halos (abst.): Eos, v. 76, no. 17, p. S268. Authors at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Silicate M and FI in quartz phenocrysts from hypabyssal porphyritic quartz latite dikes at Red Mountain, AZ, provide insights into magmatic volatile evolution and MI decrepitation processes. The MI may be classified based on shape, presence or absence of a shrinkage bubble, whether the I is devitrified or not, and the presence of satellite M and/or aqueous I. Trapped solid I are also abundant in the phenocrysts and often contain an attached melt.

MI >90 µm have decrepitated naturally. The ruptured MI preserve magmatic volatiles in decrepitation microfractures. Decrepitation was caused by isothermal decompression of the host melt during upward movement and injection of the dikes. The microfractures are the result of brittle failure caused by tension and occur as subspherical planes radiating from MI walls. Formation of the magmatic volatile is the result of decompression degassing of the MI upon rupture. Theoretical calculations by Tait (1992) indicate that the size of the original MI can be related to its integrity during internal overpressure. MI <90 µm in diameter show no decrepitation, whereas larger I within the same phenocryst are ruptured. The size of unruptured MI indicates 100 MPa internal overpressure, suggesting that melt entrapment within the quartz phenocrysts occurred at least 3 km below the point of rupture. The rupture event released both melt and magmatic volatiles. The melt was still molten at the time of rupture, as revealed by S MI within the decrepitation microfractures. In most instances, the exsolved volatile consists of low density V, but mixtures of low-density V and NaCl-rich L are not uncommon. Opaque dms are present in some low-density V I. This textural evidence suggests that ruptured melt and associated FI can be used to constrain P-T histories during magmatic F evolution in mineralized systems. (Authors' abstract)

STUDENT, J.J. and BODNAR, R.J., 1995b, Synthetic silicate melt inclusions in the H_2O saturated haplogranite system at 760°C and 800°C at 200 MPa: experimental techniques and fluid inclusion microthermometry (abst.): Eos, v. 76, no. 46, p. F683.

Silicate MI in rock forming minerals provide critical information for understanding melt petrogenesis. Partial melting experiments have recently been conducted in order to characterize the nature of entrapped MI in quartz using standard synthetic FI techniques. Experiments were conducted in the H_2O-saturated haplogranite system (Ab-Qtz; Ab-Or-Qtz; Or-Qtz) within the quartz stability field at 200 MPa and 760 and 800°C using standard cold seal vessels. The starting aqueous F composition was 10 wt % NaCl. These parameters were chosen to simulate conditions inferred for the formation of MI which have been found in quartz phenocrysts from calc-alkaline rocks associated with porphyry Cu systems.

Aqueous FI and sheets of silicate melt with some isolated MI were trapped as SI within fractures in the quartz core, and as primary MI in quartz overgrowths. The quench core glass was fused to quartz cores and contains glass, aqueous FI, feldspar crystallites, and quartz together with feldspar crystals in miarolitic-type cavities. Average salinities of aqueous I determined by freezing point depression range from 8 wt % for I in the Or-Qtz system, to 12 wt % for I trapped in the Ab-Qtz system. Isochores for aqueous I in the quartz pass through experimental run P-T conditions. A range of salinities in aqueous I from single samples may reflect entrapment of aqueous I before equilibrium between the melt and aqueous phase had been established. This effect may be evidenced by an increase in salinities in later trapped FI due to the loss of H_2O from the aqueous F to the melt. Homogenization of silicate MI trapped within quartz, determined using standard heating stage techniques, produced total Th in excess (≤40°C) of the maximum run conditions. (Authors' abstract)

STUSSI, J.M., ROYER, J.J., DUBOIS, M. and CHEILLETZ, A., 1995, Petrology of the monzogranitic geothermal site at Soulz-Sous-Forêts. (Rhine Graben, France) (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 299.

The European experimental HDR geothermal site, logged from 1400 to 2227m (ESPI well), is composed of a porphyritic biotite, hornblende, monzogranite.

FI study on primary quartz gives evidence for two F generations: (i) high T (>350°C) and low salinity (<4-5 wt % NaCl eq.) aquo-carbonic F; (ii) medium T (180- 280°C) and salinity (2-7.5 wt % NaCl eq.) aqueous F. These F characteristics suggest hydrothermal circulation at the postmagmatic stage. It is consistent with the $\delta^{18}O$ (+9.4 to +13.8) enrichment of the granite feldspar (Fouillac and Genter, 1991), suggesting that the alteration processes occurred at a low water/rock ratio, probably during the cooling of the granite. (From authors' abstract by E.R.)

SUBÍAS, I., FANLO, I. and FERNÁNDEZ-NIETO, C., 1993, F-Zn-Pb vein mineralization of Las Marmoleras (Western Pyrenees; Huesca Province): Geological, mineralogical and geochemical characterization: Acta Geol. Hispanica, v. 28, p. 49-61 (in Spanish, English abstract).

The Marmoleras F-Zn-Pb mineralizations occur as vein developed in the facies Larrue limestones or in the contact between the former and the Sia facies; the quoted facies, Upper Devonian in age, suffered contact metamorphism. These veins are located in the Valle de Tena (Spanish Western Pyrenees). Some of the veins crosscut diabasic dikes of Permian age. Two different phases of ore deposition have been distinguished: phase I, definite sulphide assemblage, sphalerite + galena + pyrite + chalcopyrite; phase II, sphalerite + galena + tetrahedrite + green fluorite + white fluorite. Sericite and chlorite were formed as hydrothermal alteration in the diabasic dikes.

FI in sphalerite II homogenize at 272.2°C and have sal. 9.2 wt % NaCl. I in fluorite homogenize at 167.3°C and have salinities of 14.9 wt % eq. NaCl. Te in both minerals are <-21.1°C, indicating that the trapped F are polysaline. There is a decrease in Th with increasing salinity from sphalerite II to fluorite. Moreover, salinity decreases from green fluorite to white one.

Mineral assemblages combined with FI and geochemical data indicate that S and O fugacities decrease with increasing paragenetic time. Under these conditions, and as suggested by available experimental data, metals were most likely transported as chloride complexes while F did as NaF^0 o CaF^+.

The S isotopic compositions of disseminated pyrite in the Upper Devonian metasediments is ca. +12‰. These values are similar to those from Palaeozoic metasediments of the eastern Pyrenees. The $\delta^{34}S$ values of ore sulphides have a wide range between -1.0 and +8.8‰. The calculated $\delta^{34}S\Sigma$ values of ore F vary from +1.1 to +11.1‰, suggesting a mixing process which involves S from the Palaeozoic sedimentary rocks and S from an igneous source.

Rare earth distribution studies allow us to define two different types of fluorite on the basis of their total REE content. The REE content of the first type is ca. 100 ppm, and its chondrite normalized curves illustrate strong LREE enrichment, suggesting an early crystallization. Type 2 fluorites display ligand-rich REE normalized curves produced by an enrichment in HREE. The Tb/Ca and Tb/La ratios display an horizontal trend that can be interpreted as a remobilization trend. In short, geochemical investigations on the fluorites from Las Marmoleras allow us to deduce that type 1 fluorites can be considered as a precursor for the type 2 ones. (Authors' abstract)

SUBÍAS, I. and FERNÁNDEZ-NIETO, C., 1995, Hydrothermal events in the Valle de Tena (Spanish Western Pyrenees) as evidenced by fluid inclusions and trace-element distribution from fluorite deposits: Chem. Geol., v. 124, p. 267-282. Authors at Cristalografia y Mineralogía, Univ. Zaragoza, P. San Franciso s/n, E-50009 Zaragoza, Spain.

This paper provides further evidences from fluorite and calcite geochemistry and from FI studies for the origin of the Valle de Tena fluorite deposits. There are two kinds of fluorite mineralizations: (1) vein-type and (2) carbonate-hosted.

Microthermometrical measurements on two-phase, H_2O-rich I with high L to V ratios yield Th ranging from 100° to 200°C for the two deposit types. Salinities range from 4.0 to 11.6 eq. wt % NaCl for carbonate-hosted deposits and from 12.5 to 21.3 eq. wt % NaCl for vein mineralizations.

The FI, geochemical, geologic and preliminary stable isotope data support two temporally distinct hydrothermal systems accounting for the fluorite formation and suggest a sedimentary basin source for the ore F. High-salinity F (basement brines) are involved in the formation of the vein-type deposits, whereas the subsequent carbonate-hosted mineralizations were formed by mobilization of the fluorite veins by formation waters. (From authors' abstract by E.R.)

See also next item. (E.R.)

SUBÍAS, I., FERNÁNDEZ-NIETO, C. and MORITZ, R., 1995, Strontium isotope geochemistry of fluorite deposits from the Valle de Tena (Western Pyrenees): Possible sources of mineralizing components, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 83-86. First author at Cristalografia y Mineralogía, Univ. Zaragoza, Spain.

Th for three different veins all 110-220°C; sal. 4-21 wt %. See also previous item. (E.R.)

SUDO, Masafumi, OHTAKA, Osamu and MATSUDA, J.-I., 1994, Noble gas partitioning between metal and silicate under high pressures: The case of iron and peridotite, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 355-372.

SUENO, Shigeho, 1995, High energy ion beams: Useful probes for mineral chemical analysis: Eur. J. Mineral., v. 7, no. 6, p. 1273-1297. Author at Inst. Geoscience, Univ. Tsukuba, Tsukuba, 305 Japan.

The bombardment of a MeV-range high-energy ion beam on a target material induces many types of particles and radiation. The detection of these emissions makes possible a wide variety of analytical methods suitable for chemical analysis of minerals. These ion beam analyses, e.g., PIXE, RBS, NRA, PIGE, PAA, have many advantages in comparison with electron beam probe analytical methods such as EPMA, TEM and SEM. For example, ion beam analysis (IBA) has unique capabilities for trace element analysis, light element analysis, depth profile analysis, external beam analysis, channeling analysis, ion beam induced luminescence, subsurface FI analysis and accelerator mass spectroscopy. The basis of each analytical technique and recent progress of mineralogical applications are reviewed. (Author's abstract)

Uses literature data. (E.R.)

SUGISAKI, Ryuichi and NAGAMINE, Koichiro, 1995, Evolution of light hydrocarbon gases in subsurface processes: Constraints from chemical equilibrium: Earth Planet. Sci. Lett., v. 133, p. 151-161.

SUN, Fengyue and SHI, Zhunli, 1995, The relationship between lamprophyres and some hydrothermal deposits: Implications for a differentiation model of mantle-derived C-H-O fluids: Contrib. Geol. and Miner. Resources Research, v. 10, no. 2, p. 72-81 (in Chinese, English abstract). First author at Changchun College of Geology, PR China.

On regional scale, calc-alkaline lamprophyres are related to hydrothermal deposits temporally and spatially, while they are independent in small scale. On the basis of analysing the geological features of lamprophyres and hydrothermal deposits and the activity of mantle-derived C-H-O F, the authors have proposed the differentiation model of the mantle-derived C-H-O F with respect to the formation of lamprophyres and mineral deposits. When the high-T dense mantle-derived C-H-O F that contain a large amount of major and minor elements move upwardly into the lower crust, differentiation takes place, due to P drop or other changes, forming a Mg- and Fe-rich volatile-saturated silicate L phase and a Si- and alkalis-rich C-H-O F phase. The former migrates upwardly and emplaces in the upper crust to form lamprophyre dikes, and the latter takes part in some hydrothermal mineralization. (Authors' abstract)

SUN, H. and HUFF, W.D., 1995, Tectonomagmatic setting of the Osmundsberg K-bentonite (Lower Silurian) in northwestern Europe: IUGG XXI General Assembly, Absts. Week A, Geophysics and the Environment, p. A439. Authors at Dept. Geology, Univ. Cincinnati, Cincinnati, OH 45221.

Electron microprobe analyses of M (glass) I in volcanic quartz from the Osmundsberg K-bentonite show clearly that the pre-eruptive magma responsible for the Osmundsberg ash-fall event was a high-silica rhyolite (avg. value of $SiO_2 = 77.7\%$ on an anhydrous basis) and peraluminous ($(Na_2O + K_2O + CaO)/Al_2O_3 = 0.90$ on a molar basis). Data points of MI compositions are close to calc-alkali rhyolite on K_2O-CaO-Na_2O ternary plot (molecular proportions) of average volcanic rocks. The chemical composition of MI of the Osmundsberg K-bentonite is comparable to those of MI from Mount Pinatubo eruption and Taupo volcanic center. Both of them have a tectonic setting of island arc. Bulk samples of the Osmundsberg K-bentonite plotted on magmatic discrimination diagram indicate a calc-alkaline source and a destructive plate margin tectonic setting. (From authors' abstract by E.R.)

SUN, Xianru, LI, Yuansheng, DONG, Shuwen, ZHANG, Yong and HUANG, Dezhi, 1995, A fluid inclusion study of ecologite in the Dabieshan region: Acta Mineralogia Sinica, v. 15, no. 3, p. 352-359 (in Chinese, English abstract). First author at Inst. Geological Science, Anhui Province, Hefei 230001, PR China.

This paper deals with FI in eclogite from the Dabieshan region, Anhui, The FI are composed predominately of NaCl-H_2O, H_2O and NaCl-CO_2-H_2O [and] were entrapped during the amphibolite- and greenschist-facies regressive metamorphism. From the peak stage of metamorphism to the late stage of regressive metamorphism the composition of FI shows an evolution trend from oxidizing to reducing. The discovery of MI provides with [indicates?] partial anatexis. FI studies have shed much light on the possible uplifting P-T-t path of ecologite in the Dabieshan region—a process of isothermal depressurization. (Authors' abstract)

SUN, Zhanxue, LI, Xueli, SHI, Weijun and LIU, Jinbui, 1995, Hydrogeochemical studies of the Xiazhuang uranium ore-forming hydrothermal system, South China, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 657-660. Authors at East China Geological Inst., Fuzhou, Jiangxi, PRC.

Researches of chemical and isotopic composition of I, and I thermometry show that the T of F in the Xiazhuang fossil hydrothermal system varies from 320°C to 210°C for the pre-metallogenic epoch, 200°C to 160°C for the metallogenic epoch, and 200°C to 100°C for the post-metallogenic epoch, respectively. For the ore-forming solution, the P ranges from 25×10^5 Pa to 600×10^5 Pa, and the water types mainly belong to $SO_4 \cdot F \cdot HCO_3$ - K·Ca·Na or F·SO_4 - K·Na types. Evidences demonstrate that the ore-forming F is of meteoric origin, and the uranium mineralizations resulted from depressurization, T decreasing, and degassing in the discharge zone of the system. (Authors' abstract)

SUSHCHEVSKAYA, N.M., PEIVE, A.A., TSEHONYA, T.I., SKOLOTNEV, S.G. and KONONKOVA, N.N., 1995, Petrology and geochemistry of magmatic series of the active parts of the Romanche and St. Paul faults and conjugate Middle-Atlantic Ridge: Geokhimiya, no. 5, p. 697-719 (in Russian, English abstract).

New data on the composition of chilled glasses were studied by use of computer modeling (COMAGMAT). The petrological and geochemical segmentation of three oceanic crust blocks divided by latitudinal depressions is revealed. (From authors' abstract by E.R.)

SUSHCHEVSKAYA, T.M., DURISOVA, J., EROKHIN, A.M., KNJAZEVA, S.N., KOKINA, T.A., KALINICHENKO, A.M., LOKHOV, K.I. and PRISJAGINA, N.I., 1995, Chemical characteristics of mineral-forming media of cassiterite-quartz deposits from fluid inclusion data: Geokhimiya, no. 6, p. 809-828 (in Russian, English abstract).

Bulk analytical methods of FI studies in minerals of pre-ore and post-ore mineral assemblages from the vein-greisen type Iul'tin (Chukotka), Cinovec and Krupka ore deposits (Krusné Hory Mountains ore region, Czech Republic) were used. The FI data were interpreted as an evidence of the formation of ores after the T was decreased up to 400°C. The deposition of Sn-W ores was a result of heterogenisation of low mineralised aqueous-CO_2 solutions. The composition of ore-forming solutions is characterised by the following properties: predominance of NaCl ≤1 M concentration; increased role of fluorine and Li, the latter in the case of Krusné Hory Mountains; high S (S(II) content $\leq 10^{-1.2}$ M and As $\leq 10^{-1.7}$. Increased alkalinity and oxidation of mineral-forming solutions are considered as the favouring factors of Sn-W ore deposition. Both chemical processes are interpreted as a result of the local F boiling as well as by mixing of magmatic F of long living hydrothermal systems with infiltration waters of meteoric origin. (From authors' abstract by E.R.)

SUSHCHEVSKAYA, T.M., IGNAT'YEV, A.V., SPASENNYKH, M.Yu., DEVIRTS, A.L., LAGUTINA, Ye.P. and VELIVETSKAYA, T.A., 1994, The origin of the mineralizing fluids at the Iul'tin Sn-W deposit based on oxygen- and hydrogen-isotope data: Dokl. Ross. Akad. Nauk, v. 339, no. 3, p. 391-395 (in Russian).

See next item. (E.R.)

SUSHCHEVSKAYA, T.M., SPASENNYKH, M.Yu. and IGNATYEV, A.V., 1995, The Iultin tin-tungsten deposit: Nature of ore-forming fluids based on oxygen isotope data, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 543-545. First author at Vernadsky Inst. Geochemistry and Analytical Chemistry, Moscow, Russia.

Data on ^{18}O depletion using numerical modeling of water-rock interaction revealed the pattern of F movement and permitted an estimate of the total amount of meteoric water involved. (From authors' abstract by E.R.)

See also previous item. (E.R.)

SUSHCHEVSKAYA, T.M., YEROKHIN, A.M., KHITAROV, D.N. and BALITSKAYA, L.V., 1992, The correspondence between the chemical composition of aqueous extracts from inclusions in minerals and the composition of the mineral-forming medium: Dokl. Ross. Akad. Nauk, v. 323, no. 6, p. 1174-1179 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 324, no. 4, p. 175-xxx, 1994).

Abstract in FIR, v. 25, p. 209-210. (E.R.)

SUSTAVOV, O.A., 1995, Deformation of veined quartz during gold mineralization in black-shale suites (Kular District, Eastern Yakutia): Russian Geology and Geophys., v. 36, no. 4, p. 76-81 (in English).

Indexed under FI. (E.R.)

SWEENEY, R.J., PROZESKY, V. and PRZYBLOWICZ, W., 1995, Selected trace and minor element partitioning between peridotite minerals and carbonatite melts at 18-46 kb pressure: Geochim.

Cosmochim. Acta, v. 18, p. 3671-3683.

SYMMES, G.H. and FERRY, J.M., 1995, Metamorphism, fluid flow and partial melting in pelitic rocks from the Onawa contact aureole, Central Maine, USA: J. Petrol., v. 36, p. 587-612.

SZABÓ, CS. and BODNAR, R.J., 1995a, Carbon dioxide, silicate melt and sulfide melt inclusions in mantle metasomatized peridotite xenoliths from the Nógrád-Gömör volcanic field, northern Hungary/southern Slovakia (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 240-241. Authors at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

See next item. (E.R.)

SZABO, Cs. and BODNAR, R.J., 1995b, Chemistry and origin of mantle sulfides in spinel peridotite xenoliths from alkaline basaltic lavas, Nógrád-Gömör Volcanic Field, northern Hungary and southern Slovakia: Geochim. Cosmochim. Acta, v. 59, p. 3917-3927. Authors at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Monosulfide solid solution sulfide blebs in the metasomatized xenolith developed their compositions and textures as a result of mantle metasomatism. Sulfides in the protogranular/porphyroclastic, equigranular, and recrystallized xenoliths represent immiscible melts trapped during partial melting event(s) in the mantle. (From authors' abstract by E.R.)

SZABÓ, Cs. and BODNAR, R.J., 1995c, Silicate-rich metasomatic melt in the upper mantle beneath the Nógrád-Gömör Volcanic Field, northern Hungary/southern Slovakia: Evidence from silicate melt inclusions (abst.): Eos, v. 76, no. 17, p. S268. Authors at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Extensive studies have shown that chemical heterogeneities in upper mantle peridotites can be related to mantle metasomatic alteration associated with F of variable composition. Cr-diopside peridotite xenoliths hosted in alkaline basalt from the Nógrád-Gömör Volcanic Field (NGVF), northern Hungary/southern Slovakia, are excellent materials to study mantle metasomatic products and metasomatic F. These xenoliths (protogranular to porphyroclastic and equigranular spinel lherzolite-spinel websterite series and secondary recrystallized dunite-spinel lherzonite series) show evidence of both modal and cryptic metasomatism as evidenced by amphibole and phlogopite and enrichment in LREE.

Both xenolith groups contain various types of FI, including pure CO_2, sulfide melt, and multiphase silicate MI. This latter type is composed of glass + CO_2 ± silicate, oxide, apatite and sulfide dms. These I have trapped and preserved the mantle metasomatic agent(s). Two types of silicate melts (andesitic and basaltic) are identified as potential metasomatic agents. Both melt compositions are characterized by high concentrations of alkalies, Al_2O_3, CO_2, halogens (F, Cl), high Mg# (~80), and probably elevated H_2O contents. MI with andesitic composition are much more common than those with basaltic composition in the NGVF xenoliths. The source of the andesitic melts is interpreted to be the Mio-Pliocene subduction-related magmas occurring along the Carpathian Belt that includes the NGVF. These andesitic melts are probably also responsible for formation of mantle metasomatic minerals such as phlogopite and amphibole. MI with basaltic composition, recognized only in one nodule, suggest a genetic relationship with the host alkaline basalt lavas. However, magmas of the host alkali basaltic lavas, which sampled the previously metasomatized mantle, caused only minor metasomatism. (Authors' abstract)

TABIBIAN, Mamoud and BARKER, Colin, 1995, Prediction and analysis of gas composition in the Arkoma Basin (abst.): AAPG Bull., v. 79, no. 9, p. 1408. Authors at Occidental Petroleum, Bakersfield, CA.

The Arkoma Basin is an overmature, G-dominated basin that straddles the Arkansas-Oklahoma border. It developed from an initial rifting phase, with subsequent continental collision and Ouachita thrusting on the southern margin. Burial histories were developed for locations in the Wilburton, Red Oak, and Bonanza Fields based on published well data. These were combined with thermal histories and used to calculate present-day vitrinite reflectance values. (R_o). The models were adjusted until calculated and observed R_o values agreed. With this information for the T at any time during basin evolution a thermodynamics program was used to calculate G composition. This free energy-minimization program takes F composition, rock mineralogy (≤25 phases), P, and T as input, and calculates the G composition for the thermodynamically stable assemblage. The predicted G composition for the Arbuckle Formation at Wilburton was dominantly CH_4, while at Bonanza (where T have been higher) it was mainly CO_2. Actual G compositions were obtained by analyzing G trapped in FI in fracture-filling calcite cements in the Arbuckle. This was done using a pair of computer-controlled, high-speed mass spectrometers that analyzed the G burst released as each individual I was ruptured by heating in vacuum. G analysis takes 25 msec and up to several hundred I can be analyzed using a 10 mg sample. Calcites from the Arbuckle dolomites at Wilburton were dominated by CH_4, while those from Bonanza contained mainly CO_2. This study confirmed by analysis the G compositions predicted by thermodynamic calculations. (Authors' abstract)

TAGUCHI, S., TAKAGI, H., MURAOKA, H. and UCHIDA, T., 1995, Relation between fluid inclusions and alteration in geothermal field (abst.): Abstracts (FIR) of 1995 Annual Mtg., Geothermal Research Soc. Japan (in Japanese).

Fracture measuring system has been developed by NEDO in a framework of a project entitled "Development of Exploration Methods for Fractured Reservoirs," which includes FI study using laser Raman microscopy (LRM). Here, we report results of FI study by LRM and microthermometry and the relation to distribution of alteration minerals in the fields. LRM used in this study is Ramanor T64000 made by Jobin Yvon, and the detection limits for N_2, CO_2, CH_4 and H_2S are 0.35, 0.55, 0.15 and 0.21 bars, respectively. Samples are collected from wells of N_2-YT-1 and N_2-YT-2 drilled at Kokonoe-Cho, Oita Prefecture. No G were detected in samples from YT-1. CO_2 and H_2S G were detected in quartz at depth from 510 m of YT-2. In this sample, L-rich and V-rich I were observed, indicating boiling at trapping stage, and these G are exclusively detected in V-rich I. The ratio of H_2S/CO_2 is different in each I for 0, 0.42, 0.63 and 0.91, indicating dynamic F evolution at generation stage. Tm(ice) of L-rich I at a depth of 510 m of YT-2 is -0.2°C, while that of V-rich I is <-0.4°C. Dissolved G as well as dissolved salts contribute to low Tm(ice) of G-rich I. When the difference of 0.2°C in Tm(ice) between L-rich and V-rich I attributes to dissolved G, the amount of G is estimated at 0.1 mol/kg·H_2O. FI in samples from a depth of 1554.29 m of YT-2 are L rich. Tm(ice) of the sample ranges from 0 to -0.5°C and [no] G were detected. In YT-2, acid alteration minerals such as alunite and kaolin are observed at depths between 170 and 250 m. This alteration zone is considered to be formed by strong acid F which is generated by mixing between oxidized groundwater and H_2S G separated by boiling from F at deep portions. This is the first time that H_2S G was detected in FI at depths below acid alteration zone. G separated by boiling at depths are considered to rise up quickly, concentrate near water table in the subsurface, and form acid alteration zone. (Authors' abstract, translated courtesy M. Sasaki)

TAHERI, J. and BOTTRILL, R., 1994, Nature and origin of gold mineralization, Mangana-Forester area, northeastern Tasmania (abst.), *in* D.R. Cooke and P.A. Kitto, eds., Contentious Issues in Tasmanian Geology: A Symposium: Geol. Soc. Australia, Tasmania Div., Abstracts, no. 39, p. 73-74. Authors at Mineral Resources Tasmania, PO Box 56, Rosny Park Tasmania 7018, Australia.

Au-bearing quartz veins occur in a NNW-trending belt and are hosted by the Mathinna Beds in NE Tasmania. The Mathinna Beds are turbidite-deposited sedimentary rocks which have been metamorphosed to lower greenschist facies and comprise mainly slates (carbonaceous in part) and quartz wackes. The Au-bearing quartz veins were formed from two distinct types of F viz.:

(a) H_2O-CO_2 (CH_4)-rich, low salinity F at T ~300°C [FI data]. The ore-forming F are characterised by isotopically heavy and consistent values for the early and intermediate quartz veins, ranging from 9.2 to 11.4‰. The data are compatible with metamorphic F derived from devolatization of deep-seated metasediments at the greenschist-amphibolite facies boundary. Deeply convecting, chemically modified meteoric F probably also played a role in the formation of the ore-forming solutions. The metamorphic F appear to be responsible for the formation of the vast majority of the Au-lode deposits, which are characteristically low in Sn and W, generally <10 ppm.

(b) CO_2-poor F of possibly lower Tf showing isotopically lighter O values (6.9-9.0‰), similar to the isotopic composition of F responsible for the greisenization of granites. The quartz veins exhibit different mineralogy in containing wolframite and tourmaline and are anomalous in Sn and W (10-990 ppm). The results are indicative of the involvement of granitic intrusions in the formation of some particular Au-bearing deposits. (From authors' abstract by H.E.B.)

TAKAGI, H., HAYASHI, M., TAGUCHI, S., SANADA, K., UCHIDA, T. and MURAOKA, H., 1995, Changes in homogenization temperatures of fluid inclusions with overheating (abst.): Abstracts (FIR) of 1995 Annual Mtg., Geothermal Research Soc. Japan (in Japanese).

Th of FI, especially in calcite and anhydrite, often change by stretching when the I are overheated above Th. Calcite and anhydrite are common hydrothermal minerals in geothermal systems and important for geothermal resource survey. In this study, the authors confirmed the change of Th by overheating in order to establish a Th measurement method for calcite and anhydrite from geothermal systems. Studied calcite and anhydrite were from geothermal wells at Kokonoe-Cho, Oita Prefecture. Th of I in calcite rose by overheating >25°C, and all the I were decrepitated by overheating of 250°C. Th of some I in anhydrite rose by overheating of 75°C, and the I were completely decrepitated by overheating of 225°C. These indicate that I in anhydrite are more resistant to stretching by overheating than those in calcite, and that overheating for Th measurement of I in calcite must be avoided. (Authors' abstract, translated courtesy T. Sawaki)

TAKAOKA, Nobuo, 1994, Enrichment and fractionation of noble gases in bubbles, in J. Matsuda, ed., Noble Gas Geochem. Cosmochem.: Terra Scientific Pub. Co., Tokyo, p. 23-29. Author at Dept. Earth and Planetary Sciences, Fac. Sci., Kyushu Univ., Fukuoka 812, Japan.

A model calculation is given to interpret an enormous enrichment of Xe abundance and a low Ar-Xe ratio, which have been found in the Yamato-74063 Acapulco-type meteorite, in terms of a bubble hypothesis [i.e., FI]. Because of preferential concentration of noble gases in a G phase, the local Xe abundance is greatly enhanced as bubble volume increases. The local Ar/Xe ratio decreases rapidly with the increasing bubble volume and approaches the Ar/Xe ratio in bubbles. With these signatures, we can interpret the large enrichment in trapped G and the large elemental fractionation in the Yamato-74063 meteorite. However, data on solubilities (or Henry's constants) and closure T of Ar and Xe are not available for silicate crystals such as pyroxene. We need those data for a quantitative discussion. (Author's abstract)

TAKAOKA, Nobuo and YOSHIDA, Yo-ichi, 1991, Noble gas composition in unique meteorite Yamato-74063: Proc. NIPR Symp. Antarct. Meteorites, v. 4, p. 178-186. First author at Dept. Earth and Planetary Sciences, Fac. Sci., Kyushu Univ., Fukuoka 812, Japan.

Unique meteorite Yamato-74063 contains large amounts of trapped heavy noble G whereas it is depleted in trapped He and Ne. The concentration of trapped ^{36}Ar is comparable with that of E- and C-chondrites and ureilites. Trapped ^{132}Xe is unusually abundant. Y-74063 contains a very high concentration of radiogenic ^{129}Xe. Trapped $^{20}Ne/^{36}Ar$ is low and similar to that of ureilites. Trapped $^{36}Ar/^{132}Xe$ of 32 ± 4 is lower than that of any meteorites ever reported. The trapped G may be mixtures of an Ar-depleted component and the "sub-solar" or "Ar-rich" component isolated in E-chondrites. The cosmic-ray exposure age is 6.2 ± 0.4 Ma. Gas-retention ages are calculated to be $<3.7 \pm 0.2$, and 4.8 ± 0.4 Ga from radiogenic ^4He and ^{40}Ar, respectively. The K-Ar age older than the age of the solar system may [be] attributed to chemical inhomogeneities resulting in an exceptionally high K concentration of the investigated sample. The G-retention ages, the large amounts of radiogenic ^{129}Xe and the trapped noble G indicate that the meteorite was a closed system for the noble G since crystallization. (Authors' abstract)

TAKAOKA, Nobuo, MOTOMURA, Yoshinobu, OZAKI, Kota and NAGAO, Keisuke, 1994, Where are noble gases trapped in Yamato-74063 (unique)?: Proc. NIPR Symp. Antarct. Meteorites, v. 7, p. 186-196. First author at Dept. Earth and Planetary Sciences, Fac. Sci., Kyushu Univ., Fukuoka 812, Japan.

Yamato-74063, a primitive achondrite with affinities to Acapulco, has been analyzed for noble G isotopes by laser ablation mass spectrometry. Some grains released huge amounts of trapped Xe as well as trapped Ar and Kr. Among them, an orthopyroxene grain containing abundant I of tiny metal spherules released equally large amounts of Xe gas found for C residues of ureilites and carbonaceous chondrites, with $^{36}Ar/^{132}Xe = 11$. In contrast, other grains including silicates, Fe-Ni metal and troilite released negligible amounts of trapped G. Mineralogical studies of polished thin sections, prepared from the same chip as was analyzed for noble G, indicate that the silicate grains containing the tiny metal I also contain abundant tiny voids, one to several µm across. Originally these voids must have been filled with G and/or F. We propose bubbles as a candidate of hosts that trap large amounts of noble G in the silicate. With data on noble G behavior in bubbles, although available only for andesite melt, the extremely low $^{36}Ar/^{132}Xe$ ratio in the silicate phase of Y-74063 can be understood in terms of the bubble hypothesis. (Authors' abstract)

TAKASHI, Miyano, 1995, Phase equilibria in a binary H_2O-CO_2 fluid mixture at $P_{solid} > P_{total}$ fluid and charnockitization in the fracture system: Sci. Rept., Inst. Geosci., Univ. Tsukuba, Sec. B, v. 16, p. 1-28.

The F in a non-ideal binary H_2O-CO_2 mixture for charnockigization and formation of the orthoamphibole isograd in the Limpopo belt, southern Africa, appear to have a wide compositional range and rather H_2O-rich at $P_s > P_f$, although they are CO_2-rich ($X(H_2O) < 0.2$) at $P_s = P_f$. This may account [for] various compositions of FI in quartz in the related rocks. In consequence of crystallization of minerals in the fracture zones, it is considered that "fluid path" exists as repetitive cycles of decreasing and increasing P_f above the depth of a P-T path during the crustal uplift, and that it has played an important role to stabilize orthopyroxene in charnockite-enderbite suites and pelitic granulites. (From author's abstract by E.R.)

TAKESHITA, Toru, 1995, Dynamic analysis of deformed quartz grains from the folded Middle Miocene Momonoki Subgroup of central Japan: Origin of healed microcracks: Tectonophysics, v. 245, p. 277-297.

TALNIKOVA, S., BARASHLOV, Y. and PANKOV, V., 1995, Fluid component in Yakutian diamonds of different paragenesis (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 242-243. First author at Inst. Geosciences, Yakutsk, Russia.

From a series of 20 analyses from the literature (methods unstated here), the authors show that: (1) diamonds of eclogitic paragenesis fall into two groups in terms of G composition: primarily CO_2 and CO_2 -aqueous; (2) CO_2 -aqueous F in diamonds of eclogitic paragenesis is more oxidized than that in diamonds of ultrabasic association. (E.R.)

TANAKA, T. and MARIKO, T., 1995, Chemical composition of the fluid inclusion in skarn minerals from the Tochibora and Maruyama deposits of the Kamioka mining district (abst.): J. Soc. Resource Geol., v. 45, no. 4, p. 287 (in Japanese).

TARKIAN, M. and BRESKOVSKA, V., 1995, Mineralogy and fluid inclusion study of the Zidarovo copper polymetallic deposit, eastern Bulgaria: N. Jb. Miner. Abh., v. 168, p. 283-298.

The Zidarovo polymetallic deposit is genetically related to trachyandesites and trachybasalts of Upper Cretaceous age. Four stages of vein type ore mineralization have been established: (1) quartz-pyrite; (2) Cu-Bi-Au; (3) hematite-chlorite; (4) galena-sphalerite and Au.

FI in quartz show gradually decreasing Tf from early (371-310°C) to late (292-197°C) stage of mineralization. The lowest T (150-120°C) were obtained for sphalerites of stage four. The overall low salinities of the F (on average: 4.0 eq. wt % NaCl) suggest that meteoric water was involved in mineralization. The possibility of interactions between ascending hydrothermal F and dilute meteoric waters is supported by geological features and mineralogical data which indicate a shallow depth of mineralization. (From authors' abstract by E.R.)

TARKIAN, M. and KOOPMANN, G., 1995, Platinum-group minerals in the Santo Tomas II (Philex) porphyry copper-gold deposit, Luzon Island, Philippines: Mineral. Deposita, v. 30, p. 39-47. Authors at Inst. Mineralogy and Petrology, Univ. Hamburg, Grindelallee 48, D-20146 Hamburg, Germany.

Mineralized quartz diorites of the Santo Tomas II porphyry Cu-Au deposit, carry high Au contents (avg.: 1.8 ppm) as well as 160 ppb Pd and 38 ppb Pt. Polyphase FI in quartz veinlets, associated with a PGM-bearing bornite-chalcopyrite-magnetite assemblage, are characterized by high salinity (35 to >60 eq. wt % NaCl) and high Tt (between 380 and 520°C). They may represent primary magmatic-hydrothermal F, which have been responsible for the transport of Pd, Pt and Au as chloride complexes. (From authors' abstract by E.R.)

TAYLOR, B.E., 1995, Isotopic composition of S. American meteoric waters: New δD and δ^{18}O maps with implications for hydrothermal deposits and Andean tectonics: (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 467.

Indexed under FI. (E.R.)

TAYLOR, B.E., LEITCH, C.H.B., TURNER, R.J.W., LYDON, J.W. and WATANABE, D.H., 1995, Stable isotope geochemistry of the Sullivan Pb-Zn deposit, Kimberley, British Columbia (abst.): GAC/MAC Annual Meeting, 17-19 May 1995, Canada, Abstracts, p. A-103. First author at Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, Canada.

O, H and C isotopes in ores, wall rocks and FI of the Proterozoic Sullivan Pb-Zn deposit record aspects of the deposit's genesis and, primarily, subsequent modification during gabbro sill emplacement and metamorphism. The most striking O isotope characteristic is the large range in δ^{18}O of wall rocks (4 to 14‰) controlled by cross-cutting, post-ore stage mineral assemblages: chlorite-pyrite (3.5 to 7), albite-chlorite (6 to 10), and quartz-muscovite-(calcite) (11 to 14). The range of δD for most chlorite- or muscovite-bearing rocks is -70 to - 50‰; tourmalinites have δD values ~-50‰. δD values as low as -100‰ do occur in micaceous rocks of the North Star Hill area. Some minor subsequent disturbance of primary δD values is suggested for the micaceous rocks. O and H isotope data are consistent with alteration of the shallowly buried deposit by slightly modified sea-water at ~250°C during gabbro dike and sill emplacement. The isotopic compositions of the whole rocks remained largely undisturbed during later metamorphism and deformation, even through meteoric waters (probably Tertiary: δD = -140 to -118) are found in S FI. Unlike continental or arc-related magmatic hydrothermal system, wall rocks of the Sullivan deposit and rocks in North Star-Sullivan corridor lack distinct O isotope zoning patterns related to ore deposition owing to relatively low reactivity of the host rock, and their low isotopic contrast with the hydrothermal F.

The isotopic composition of calcite varies with occurrence. Trace to minor interstitial calcite in ore and waste beds has a narrow of δ^{18}O (most 12.1 to 12.7) but a relatively large range of δ^{13}C (-11.1 to -3.3). The data indicate that most of the interstitial calcite in bedded ore and intervening waste bands has equilibrated O isotopes with the same F (permissibly seawater at ca. 165°C primary?). Coarse calcite associated with porphyroblastic pyrite has lower δ^{18}O (ca. 9.0) that possibly reflect the later, higher T albitic alteration. (Authors' abstract).

TEMPLETON, A.S., CHAMBERLAIN, C.P., CRAW, Dave and KOONS, P.O., 1995, Mixing between mid-crystal fluids and basinal waters during recent uplift of the Southern Alps, New Zealand (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-454.

Hydrothermal activity occurs in regions of both high and low uplift rate in the Southern Alps, New Zealand. We have obtained T estimates and δ^{18}O and δ^{13}C data from minerals precipitated in Late Cenozoic faults to show a two phase modification of metamorphic F during slow uplift (1-2 mm/yr) as the central Southern Alps are thrust over an intermontane basin. Our data demonstrate the mixing of metamorphic F and topographically driven meteoric waters during the early stages of uplift, followed by a second mixing of these evolved F with diagenetically modified basinal waters at the latest stages of basin development.

FI, δ^{18}O of quartz-calcite mineral pairs, and vitrinite reflectance values of preserved organic matter yield F T of ~300°C in post-metamorphic veins and much cooler T between 250°C and 50°C in active faults surrounding and within the MacKenzie basin. F-mixing phase I is characterized by the dilution of deep metamorphic F by ≤40% meteoric water at 300°C. The presence of meteoric water is shown by an excursion from calcite δ^{18}O values of 11‰-15‰ to lighter values of 6‰-10‰. Calculated F compositions are depleted by 4‰ to 7‰ in δ^{18}while δ^{13}C values remain invariant. Phase II occurs at shallow levels, where the evolved midcrustal waters are further diluted by a low δ^{13}C F. The isotopic composition of 75 carbonates precipitated in active structures such as the Ostler_ fault, where recently uplifted low-grade metamorphic rock have overridden orogenic gravels in the MacKenzie basin, all fall on a mixing line between two endmembers. Calcites formed at the higher T of 250°C yield δ^{18}O values of ~8‰ and δ^{13}C ~-12‰, whereas calcites precipitated at T as low as 50°C yield δ^{18}O values of ~22‰ and δ^{13}C~20‰. We interpret the simultaneous cooling of the F, depletion in δ^{13}C values and enrichment in $\delta 1^{8}$O values in the calcites as the combined result of infiltration of cold basin-derived waters into a near-surface hydrothermal reservoir and expulsion of midcrustal F into the adjacent basin. (Authors' abstract)

TERNES, Kim and NABELEK, P.I., 1995, Fluid inclusion evidence of the evolution of magmatic fluids in the Harney Peak leucogranite, Black Hills, South Dakota (abst.), *in* M. Brown and P.M. Piccoli, eds., The Origin of Granites and Related Rocks, Third Hutton Symp., College Park, Maryland, Aug. 26-Sept. 2, 1995: U.S. Geol. Surv. Circ. 1129, p. 144-145. Authors at Dept. Geological Sciences, Univ. Missouri, Columbia, MO 65211.

Experimental and theoretical studies have shown that magmatic F have strong influence on the phase equilibria of granitic systems. The speciation of magmatic F can be determined by microthermometric FI analyses; however, to date most studies have focused on altered granites where the bulk of the magmatic F stage has been overprinted by externally derived F. This study has been undertaken to obtain direct FI evidence for the composition and evolution of F in a crustally-derived magmatic system. The Proterozoic Harney Peak peraluminous leucogranite [was] influenced by magmatic F on crystallization of the granite, [as] demonstrated by prominent local granite-pegmatite layering and chemical heterogeneities. Previous stable isotope study of the granite has shown that the granite has not interacted with non-magmatic F since its crystallization (Nabelek et al., 1992). Therefore, any I found in the HPG are of magmatic origin and offer a direct sampling of magmatic F associated with a naturally occurring granitic system.

P and S FI were analyzed in tourmaline and quartz. The PI consist of variable H_2O-CO_2-NaCl-(CH_4) mixtures. The CO_2-rich I are less salty and yield higher isochore T (calculated using the model of Brown and Lamb, 1989). The range of P FI compositions is ascribed to Rayleigh exsolution of the magmatic F which should lead to early CO_2-rich F due to the low solubility of CO_2 in high-silica magmas. The calculated isochore T of the most H_2O-rich PI are below the granite solidus. However, they may be in error because it was assumed that the only solute is NaCl. Tm(ice), birefringent dxls, phase-equilibria considerations, and alpha-track mapping of B and Li distribution in thin sections, all indicate that K, Li, B and other solutes must be additional constituents in the I.

Using published solubility models for H_2O and CO_2 in granitic M, the initial volatile content of the HPG of ~5.3 wt % H_2O ($X^m(H_2O) = 0.45$) and 650 ppm CO_2, was calculated using the computer program DEGAS (Holloway and Blank, 1994). It is suggested that saturation of the HPG M at 3.5 kb with a CO_2-rich F, that is represented by I with the lowest XH_2O of 0.20, increased the liquidus T and partially quenched the M, producing the aplitic segregations of the sills which comprise much of the granite. With further degassing, Rayleigh fractionation produced more H_2O-rich F which resulted in lowering of the solidus and crystallization of pegmatitic segregations. At subsolidus T the magmatic F unmixed into H_2O-NaCl and CO_2-CH_4 F which were trapped as SI. This study demonstrates the strong influence of mixed F-species on phase equilibria of granitic magmas and provides the first direct evidence for the solubility of volatile species in a natural granite system. (From authors' abstract by E.R.)

THIEBEN, S.E. and SPRY, P.G., 1995, The geology and geochemistry of Cretaceous-Tertiary alkaline igneous rock-related gold-silver telluride deposits of Montana, USA, in Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. xxx-xxx. Authors at Dept. Geological and Atmospheric Sciences, Iowa State Univ., Ames, IA.

Epithermal Au-Ag telluride deposits in Montana are spatially and genetically related to the regional Great Falls Tectonic Zone as well as to alkaline igneous intrusive rocks. A variety of mineralisation styles are present and are characterised by the elemental signature Au + Ag + Te ± F ± V ± Bi ± Mo. FI studies suggest that Au mineralisation was deposited from low-T (130°-270°C), moderately saline (1-12 eq. wt % NaCl), non-boiling, CO_2-poor, near neutral pH, relatively oxidising F. O and H isotope studies support the concept that Au-Ag telluride mineralisation was deposited from meteoric water or by mixing of magmatic and meteoric waters. S isotope data suggest a variety of magmatic and/or sedimentary S sources. Alkaline igneous-related telluride deposits are thought to represent one end-member of a continuum with porphyry molybdenum deposits. (Authors' abstract)

THIÉRY, R., KERKHOF, F. van den and DUBESSY, J., 1994, V-X properties of CO_2-CH_4-N_2 fluids in fluid inclusions (abst.): 15th Mtg. of Earth Sciences [15^e Réunion des Sciences de la Terre], 26-28 April 1994, Nancy, France, p. 50.

The determination of the molar volume (V) and the composition (X) of paleofluids trapped in FI is an essential step in the reconstruction of lithospheric paleocirculations. The combined use of analytical methods as microthermometry and Raman microspectrometry permits obtaining these V and X parameters, provided that the volumetric properties and the phase transitions of these F are well known. As there are not many experimental data, it is necessary to use thermodynamic models which are adjusted at the experimental points. The V-X properties of CO_2-CH_4-N_2 F are described here with good precision in the whole P-T-V-X domain from -170°C to +31.1°C. Instead of using a single equation of state to model all P-T-V-X properties of the F, two models have been applied successively. The first model is the equation of Soave-Redlich-Kwong, which interconnects the P-T-X properties of phase equilibria of a single F phase (L and/or V, in the presence or not of crystals of solid CO_2). The calculation of the parameters of this equation has been modified in order to obtain a good reproduction of experimental P-T-X data in the critical domain. The second model is the Lee-Kesler correlation, which gives precise data on the volumetric properties (V) of non-polar F in function of their P-T-X properties. V-X diagrams, well suited for the study of FI, have been established for the three binary systems CO_2-CH_4, CO_2-N_2 and CH_4-N_2. Also discussed are the conditions for the appearance of a metastable L-L-V immiscibility <-90°C for CO_2-CH_4 F with low N_2 contents. (Authors' abstract, translation courtesy Dr. E.A.J. Burke)

THOMAS, R., 1995a, The importance of fluid and melt inclusion studies for ore deposit research: Considerations from a Freiberg point of view: Results of Ore Deposit Research, Contributions to the Honorary Colloquium on the Occasion of the 65th Birthday of Prof. Ludwig Baumann, p. 202-212 (in German).

THOMAS, R., 1995b, Assessing the water content in rhyolitic, granitic and pegmatitic melts using melt inclusion homogenization data: Method-results-problems (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1. Note: Late(?) two-page abstract, unpaginated and not bound in Abstracts volume.

A review of work on a variety of MI. Thomas (1994, Eur. J. Min., v. 6, p. 511-535) presented a new and simple method for the estimation of the H_2O content (eq. wt %) in hydrous silicate melts using homogenization measurements on MI in rock-forming minerals in volcanic as well as in plutonic rocks. The time- and diffusion-controlled quenching technique is based on the melt kinetics of the glassy or crystallized MI and uses as algorithm a combination of the Stokes-Einstein equation and Shaw's viscosity calculation, together with data for the T, I diameter, run time, and I chemistry. Using this method we obtain, beside the H_2O content of the silicate melt, additional information: viscosity of the melt, the solidus- and the minimum Th, which can be considered to a rough approximation as the Tt of the MI or the liquidus T, as well as model data about the P evolution.

The goal of this contribution is to present results about the H_2O content in silicate melts from MI studies of rhyolites, granites, F-rich granites and pegmatites. The accuracy of the method, the possibility of diffusive loss of H_2O and the modification of the melt composition by post-entrapment processes are critically assessed. (From author's abstract by E.R.)

THOMAS, R., 1995c, Assessment of water content in granitic melts using melt inclusion homogenization data: Method - results - problems (abst.), *in* M. Brown and P.M. Piccoli, eds., The Origin of Granites and Related Rocks, Third Hutton Symp., College Park, Maryland, Aug. 26-Sept. 2, 1995: U.S. Geol. Surv. Circ. 1129, p. 145-146.

See previous item. (E.R.)

THOMPSON, J.F.H., editor, 1995, Magmas, Fluids and Ore Deposits: Mineralogical Assoc. Canada Short Course Series, v. 23.

Individual pertinent abstracts entered in this volume. (E.R.)

THOMPSON, T.B., 1995, Characterization of alkaline rock-related mineralization in the Nogal Mining District, Lincoln County, New Mexico—A discussion: Econ. Geol., v. 90, p. 983-987.

A discussion based in part on the interpretation of FI evidence, of Douglass and Campbell, 1994, FIR, v. 27, p. 33. (E.R.)

TITOV, A.V., 1995, The petrology of early Cretaceous monzonitic volcanic-plutonic rocks from southern Pamir (based upon thermobarometric and isotopic data: Unpub. dissertation, 112 p. plus 22 tables, 34 figures and 90 references. Abstracted by David A. Vanko from 20-p. dissertation précis, in Russian, published by Geological Inst. SO RAN, Novosibirsk, CIS.

Th of MI, electron microprobe analyses of minerals and MI, and radiogenic isotopic data are used to develop a model for the petrogenesis of this within-continent monzonitic (latitic) volcanic-plutonic association. Th data from MI yield the following ranges of magma liquidus T: andesitic and trachyandesitic basalt - 1180-1200°C; two-pyroxene quartz latite - 1140-1160°C for clinopyroxene and bytownite phenocrysts, 1100-1080°C for labradorite rims, and 1050-1090°C for groundmass feldspar; hornblende-quartz latite - 980-1020°C; trachyte and trachyandesite - 960-930°C; quartz-porphyry and rhyolite - 640-670°C. Early phenocrysts have dense CO_2 FI; data indicate two levels of crystallization at ~6 kb for andesitic basalt and ~3.5-3.7 kb for quartz-latite and second-generation phenocrysts in andesitic basalt. Th of MI in basic hypabyssal rocks are: phenocrysts - 1120-1150°C; interstitial quartz - 700-720°C. Th of MI in granitic rocks - 680-720°C. Post-granitic diorite-porphyry dikes contain quartz + garnet: Th of MI in quartz ranges from 1000°C to 720°C, and the composition of garnet varies systematically with the Th of MI in coexisting quartz.

TIVEY, M.K., 1995, The influence of hydrothermal fluid composition and advection rates on black smoker chimney mineralogy: Insights from modeling transport and reaction: Geochim. Cosmochim. Acta, v. 59, p. 1933-1949.

TKACHENKO, S.I. and SHMULOVICH, K.I., 1992, Liquid-vapor equilibrium at 400 to 600°C in aqueous systems containing NaCl, KCl, $CaCl_2$, and $MgCl_2$: Dokl. Ross. Akad. Nauk, v. 326, no. 6, p. 1055-1059 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 327A, no. 9, p. xxx-xxx, 1994).

TODOROV, T., LILOV, P., SHUMLIANSKI, V., FOMIN, J., ZAGNITKO, V., IVANTISHINA, O. and BEZUGLAIA, M., 1995, Isotope-geochemical characteristics of the main endogenous ore deposits in Western Carpathians: Geol. Soc. Greece, Sp. Publ., No. 4, p. 853-854.

Th and O isotope data from FI are given. (H.E.B.)

TOMILENKO, A.A., CHEPUROV, A.I. and SHEBANIN, A.P., 1995, Cryometric studies of fluid inclusions in natural diamonds (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 244-245. Authors at Inst. Mineralogy and Petrography, Univ. pr. 3, 630090 Novosibirsk, Russia.

Series of monophase transparent inclusions have been found during optical studies of flat-parallel plates made of single-crystals of natural diamonds from the placers of northeastern Siberian Platform. They are located in healed cracks, which are not exposed at the crystal surface. The inclusions are flattened and have the shape of isometric plates with the elements of diamond cutting mainly of faces {111}. The size of inclusions range from a few [i.e., facets?] to 35 mkm [µm?].

The optical, cryometric and Raman-spectroscopic investigations allowed us to establish three types of liquid inclusions in diamonds. On cooling, a solid phase (phase A) has Tn <-50°C in the I type inclusions, which turns into a thin isometric plate. Cooling up to -120°C of the liquid, left after formation of phase A, results in precipitation of one or several solid phases (phase B). On slight heating they rather quickly recrystallize into one crystal. Phase B may occupy ≤20-30 vol % of the vacuole volume. Further cooling to -196°C leads to no other changes. Slow heating of the sample results in the beginning of melting first of phase B, which is already observed at ~-75°C. Tm B is -66°C. Further heating leads to gradual melting of phase A, with Tm A -42°C. Similar values of Tm B and triple point for pure CO_2 (-56.6°C) and peculiar features of its behavior on cooling and heating suggests that phase B is most likely a solid CO_2. Melting of phase B at lower T as compared to the T of triple point for pure CO_2 seems to be affected by nitrogen. The presence of nitrogen in the I type inclusions was confirmed by Raman spectroscopy. Tm A (-42°C) and peculiar features of behavior of phase A at low T suggest the presence of some amount of hydrocarbons along with CO_2 and nitrogen in the I type inclusions.

FI of types II and III are similar in appearance to type I inclusions and are localized within one healed crack. On cooling to -120°C one or a few solid phases precipitate, which are similar to phase B in type I. According to the results of cryometric and Raman-spectroscopy analyses, the composition of type II is a mixture of CO_2 and nitrogen.On cooling type III to -110°C, only one solid phase is precipitated, which commonly occupies ≤75-80% of vacuole volume. Further cooling to -196°C does not result in any changes in inclusions. On heating, gradual melting of the solid phase occurs in the range from -58 to -36°C. No vibrational lines of Raman spectra typical of N_2, CO, CH_4 and hydrocarbons heavier than CH_4, which have vibrational lines in subregions 800-1200, 1400-1600 and 2800-3200 cm-1, were observed. In terms of cryometric characteristics, this solid phase similar to phase A of type I type, whose lower Tm in the type I seems to be affected by CO_2 and nitrogen. The results of cryometric and Raman-spectroscopic studies allow us to suggest that type III inclusions contain mainly hydrocarbons (?), whose Raman-activity is extremely low.The presence of the types II and III within one crack suggest that these inclusions were most likely formed as a result of necking down of the type I.

The observed FI are located in the cracks, and their preservation occurred after crystallization of diamonds. At the same time, the healed character of cracks undoubtedly indicates that during preservation of inclusions there existed conditions (T, P and X of medium) required for crystallization of diamond. The latter is confirmed by the presence of a negative diamond cutting in the appearance of inclusions, their necking down and recrystallization of diamond sites around inclusions. (From authors' abstract by E.R.)

TOMILENKO, A.A. and KOVYAZIN, S.V., 1995, Interaction of melt inclusion substance and host synthetic periclase on heating (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 246-247.

A series of experiments on heating of MI of complex composition in synthetic periclase to various T showed diffusion of Fe from the I into the host. Such diffusion must be considered when estimating the initial composition of MI in natural minerals of deep-seated xenoliths. (E.R.)

TORAMARU, Atsushi, 1995, Numerical study of nucleation and growth of bubbles in viscous magmas: J. Geophys. Res., v. 100, p. 1913.

TORGERSEN, Thomas, DRENKARD, Stefan, STUTE, Martin, SCHLOSSER, Peter and SHAPIRO, A.M., 1995, Mantle helium in ground waters of eastern North America: Time and space constraints on sources: Geology, v. 23, p. 675-678.

Mantle He in continental environments is generally considered to be the result of active volcanism and/or active extension. The latest episodes of volcanism in NE North America are the track of the New England hotspot (95-190 Ma) and the closure of the Iapetus sea (before 300 Ma). Thus, the identification of mantle He in young ground waters of central New England is counter to the conventional wisdom. On the basis of evaluation of He evolution in emplaced magmas, we postulate an "aged" mantle source for the excess He component in ground waters of central New England that is either (1) a local, near-surface-emplaced, G-rich magma that has retained significant volatiles (e.g., in FI) or (2) a deeply emplaced G-rich magma with high initial $^3He/^4He$ 10^{-5} and He transport (with dispersion) through the crust over time. This G-rich initial condition may support the concept of a volatile-enriched mantle wedge and thus explain the increased buoyancy flux of the New England hotspot as it traversed eastern North America, as has been suggested by others. (Authors' abstract)

TOROK, K., 1995a, $CaCl_2$-rich fluid inclusions in the garnet bearing gneiss of the Ko-hegy quarry, Sopron (W-Hungary) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 248-249. Author at Eötvos L. Univ. H-1088 Budapest Múzeum krt. 4/A, Hungary.

The studied garnets are a low grade orthogneiss group, which suffered Alpine metamorphism. The rock consists of potash feldspar, almost pure albite, quartz, phengitic muscovite, biotite, grossularite and almandine-rich garnet and accessory zircon and apatite. Quartz veins either parallel with foliation or crosscutting it are abundant.

Two phase, L and rich aqueous inclusions were measured from the matrix albite and the quartz vein cutting the foliation. Inclusions in the vein were trapped along healed fractures that can be followed through the entire 5-6 mm wide track.

Three types of I were found:

Type I. Primary, in core of matrix albite together with solid inclusions of phengitic muscovite. Solid and FI are absent from the clear rim of the albite. The inclusions contain medium salinity (10.9 - 12.4 NaCl eq. wt %) aqueous solution with Th from 178.4 to 217.2°C. Though the I are quite small (<8-10 microns), Te = -28 to -35.4°C.

Type II. Inclusions along healed fractures in quartz veins; sal. = 7.1-12.4 NaCl eq. wt %. Th = 85.4 to 176.0°C.

Type III. Similar to Type II but Te = -65.6 to -45.5°C, and Tm ice = -40 to -17.2°C. The calculated salinity is between 20 and 28 $CaCl_2$ eq. wt %. Th similar to type II, range 60.7 to 170.8°C.

One phase aqueous inclusions in quartz, associated with type II and III inclusions, fail to heterogenize even at -150°C. This can be attributed either to metastability or show that trapping of inclusions continued at low T as well.

Type II and III inclusions occur together in the same textural position or along parallel healed fractures which suggest that these two distinct F may have been coeval and existed together without mixing for a long time. Other geobarometers indicate peak metamorphic conditions of ~8-10 kb P at ~500°C. The isochores of the Type I primary inclusions in the matrix albite indicate lower P, 5-6 kb at 500°C. Type II and III inclusions in quartz vein crosscutting the foliation may belong to the retrograde phase. (From authors' abstract by E.R.)

TÖRÖK, K., 1995b, Garnet breakdown reaction and fluid inclusions in a garnet-clinopyroxenite xenolith from Szentbékkálla (Balaton-Highland, Western Hungary): Acta Vulcanol., v. 7, p. 285-290. Author at Dept. Petrology and Geochemistry, Eötvös Univ., Múzeum krt. 4/A H-1088 Budapest, Hungary.

Garnet breakdown reaction and FI were studied in a garnet clinopyroxenite xenolith from Szentbékkálla, Balaton Highland, to determine its metamorphic and F evolution. Although the garnets have high pyrope content (66.5-68.2%), the xenolith is not an eclogite, because its clinopyroxene is sodian-aluminian augite, poor in jadeite (6.5-11.2%) and rich in Ca-Tschermak (14.9-17.7%) component. This is typical for garnet clinopyroxenites. Garnet-clinopyroxene geothermometry yields 1069-1100°C for the xenolith at 1.5 GPa P. Mg-rich garnets of the xenolith are partly or fully replaced by Al-rich orthopyroxene + spinel + anorthite symplectite.

This reaction marks a P drop (<1.5 GPa) and an increase in the T (~1200°C) which may be due to upwelling of hot mantle material and uplift of the upper mantle.

Secondary CO_2 ± silicate MI can be divided into two generations. The first (type 1), higher density generation was trapped below the stability field of the Mg-rich garnet, at the same time as symplectite formation. These I were trapped in the uppermost mantle, between 43 and 35.3 km depth, assuming 1200°C T and 3.0 g/cm^3 density for the overlying rock column. The CO_2 F may be related to the updoming of the mantle. The type II, low density CO_2 I generation may have been trapped during the transport in the basaltic magma in the depth range of 13.6 to 10.4 km.

The calculated depths are similar to those of ultramafic xenoliths from the same locality, which implies that garnet clinopyroxenite coexists with ultramafic rocks beneath the region. Considering the calculated depth of origin of the garnet clinopyroxenite and the depth of trapping of the high density I, the upper mantle sequence may have been uplifted ~7-15 km. (Author's abstract)

TÖRÖK, K. and DE VIVO, B., 1995, Fluid inclusions in upper mantle xenoliths from the Balaton Highland, Western Hungary: Acta Vulcanol., v. 7, p. 277-284. First author at Dept. Petrology and Geochemistry, Eötvös Univ., Múzeum krt. 4/A H-1088 Budapest, Hungary.

FI in olivines, orthopyroxenes and clinopyroxenes of seven ultramafic xenoliths and a single pyroxene megacryst from two localities (Szentbékkálla, Szigliget) of the Transdanubian Volcanic Region (TVR, Western Hungary) were measured in order to achieve better understanding of F migration and processes connected with it in the upper mantle beneath the region. CO_2 and silicate melt are the most abundant species in the I. These two components can be observed both as pure I and mixed in any proportion. In addition, sulfide globules occur as solid I. A reconnaissance study on silicate MI yielded Th between 1160' and 1230°C. Extension of the TI, range towards higher T is expected because of the upper T limit of the apparatus.

The measured FI contained essentially pure CO_2 with melting points between -56.4- and -57.5°C and occasionally various amounts of silicate glass and in some cases sulfide and other dms. Most of the I homogenized into L, covering a wide Th interval between -42.9 and +30.8°C. However, a few I homogenized to V phase between + 27.5 and + 30.5°C. This wide Th interval yields a density ranging from 1.13 to 0.28 g/cm^3. Assuming a Tt of 1100°C, the P ranges between 1190 MPa and 240 MPa for I homogenizing to the L phase and 120-90 MPa for those homogenizing to the V phase. These P intervals mean 40.3-8.1 km and 3.8-3.1 km depth, respectively assuming 3.0 g/cm^3 density for the overlying rock column. The continuous Th interval with several peaks may indicate multiple trapping events or/and the continuous decrepitation and redistribution of older I during ascent of the xenoliths in the basaltic magma. Some other consequences such as implications for a relative rapid uplift in certain intervals of depth (from 31.2 km to 24.3 km and from 8.1 km to the surface) are also discussed in detail. (Authors' abstract)

TOURET, J.L.R., 1995a, Brines in granulites: the other fluid (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 250-251. Author at Dept. Petrology and Isotope Geology, Free Univ., De Boelelaan 1085, 1081HV Amsterdam, The Netherlands.

Carbonic F are not the only F remnants preserved in granulites. Traces of high-salinity, NaCl-rich brines have also been observed in I from a great number of granulite occurrences. These are much less obvious than CO_2-rich I and they can easily remain unnoticed if not systematically searched for: because of the steep slope of any brine isochore, the internal P in an inclusion occurring at peak conditions will be systematically much lower than external P during most retrograde regional P-T paths. The inclusion will collapse, leaving only a small aggregate of microcrystals within an irregular, squeezed cavity.

Many examples of these brine I have been observed in different regions, some Archean, many Proterozoic, e.g., in Southern Norway. They occur in various lithologies, but mostly in pre-metamorphic, supracrustal remnants which have remained perfectly preserved despite the high metamorphic grade and a most complicated history. At least three major types of preferred environments have been identified:

(1) Detrital sediments, which in Southern Norway could represent remnants of former evaporites (Bjordammen near Kragero, Bamble sector).

(2) Various lithologies, such as cordierite-anthophyllite rocks, which could derive from hydrothermal, sea-floor type alteration of basaltic lavas. This type of environment includes the well-known skarns occurring in the vicinity of Arendal (Southern Norway). Skarns would be the product of isochemical recrystallization of hydrothermally altered sea-floor carbonates.

(3) Acid volcanics (metarhyolites) and shallow intrusives, high grade equivalents in the Bamble sector of some of the low-grade Telemark supracrustals (Norway).

The striking relationship between the brine I and these different supracrustal lithologies show without any ambiguity that the brines are remnants from pre-metamorphic F, still present despite the most complicated regional P-T evolution. It is also obvious that F presently trapped in I represent only a small fraction of the F which have been present in the rocks since their deposition at the Earth's surface. During prograde, peak and retrograde metamorphism, most of the brines have been remobilized and transported on various distances, either locally or regionally. These brines must play an important role in controlling the chemical potential of alkalies during granulite metamorphism. They are the best candidates for explaining the complexities of LILE-element behaviour at the boundary of granulite metamorphism: either depletion (regional scale) or, on the contrary, increase (LILE-repletion) during the metasomatic transformation of metapelite into charnockite in the so-called "incipient charnockites" of Southern India and Sri-Lanka. (From authors' abstract by E.R.)

See also next item. (E.R.)

TOURET, J.L.R., 1995b, The role and nature of fluids in the continental lower crust: Memoir Geol. Soc. India, v. 34, p. 143-160.

A review. See also previous time. (E.R.)

TOURET, J.L.R. and HUIZENGA, J.M., 1995, Fluid in metamorphic shear-zones (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 114.

Knowing precisely the nature and amount of F in shear zones is a difficult problem. It can be approached from mass balance calculations or theoretical studies on F-mineral equilibria, but the direct study of F remnants preserved in FI remains an essential source of information. However, the repeated deformation introduces great complexities, notably through possible episodes of F immiscibility and selective leakage of the most mobile components, e.g., water. A good knowledge of these processes is essential for estimating how much F can be present at depth and for interpreting the possible geophysical signature of deep shear-zones. (From authors' abstract by H.E.B.)

TRAN, T.H., PANINA, L.I. and 10 others, 1995, Magnesian-ultrapotassic magmatic rocks and lamproite problems in northwestern Vietnam: J. Geol., [Vietnam] Series B, no. 5-6, p. 412-419 (in English).

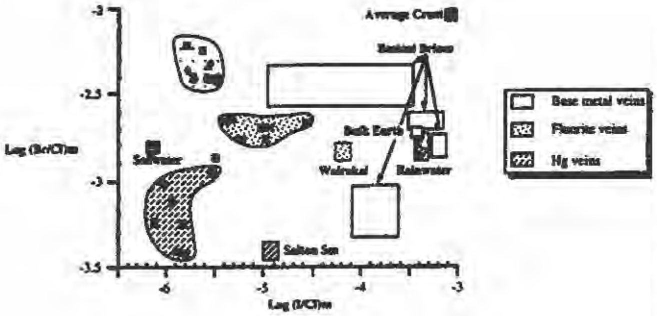
Indexed under FI. (E.R.)

TREIMAN, A.H., 1995, Ca-rich carbonate melts: A regular-solution model, with applications to carbonatite magma + vapor equilibria and carbonate lavas on Venus: Am. Mineral., v. 80, p. 115-130.

Pertinent to the occurrence of immiscibility in terrestrial carbonate magmas. (E.R.)

TRITLLA, J., CANALS, A., BANKS, D. and CARDELLACH, E., 1995, Evaporite-related fluids and ore deposition during Mesozoic rifting in eastern and northeastern Spain (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 252-253. First author at Earth Sciences Dept., Univ. Leeds, UK.

Low T veins in the Pyrenees and the Catalonian Coastal Ranges range from Pb-Zn-(Ba)-rich veins to fluorite-rich veins with variable amounts of barite. All these deposits have a low Tf (between 75 and 200°C), the presence of complex polysaline F ($NaCl-CaCl_2-KCl-(MgCl_2)$) with salinities between 12 to 22 wt % eq NaCl, and a clear relationship with the Pretriassic paleosurface. Similar ore deposits in the Eastern part of the Iberian Ranges contain Hg sul-



fides and sulfosalts. The solutions associated are polysaline (NaCl-$CaCl_2$-KCl), with Tf between 230 and 280°C and sal. from 18 to 35 wt % eq NaCl.

Halogen crush-leach analyses were performed using the method of Yardley et al (1993). The total chloride concentration was derived from the estimates of the sal. obtained from microthermometry. Halogen ratios have been determined in quartz, calcite, dolomite, sphalerite and fluorite samples.

Base-metal and barite vein F have Br/Cl and I/Cl ratios greater than those of seawater but lie close to the seawater evaporation line. Deviations from this line, in terms of the iodine content, could quite easily be due to analytical uncertainties in the analysed data, where discrepancies of a factor of 2 or 3 would not be unreasonable at these low levels. Of greater importance is the Br/Cl ratio which shows that these F are similar to brines where the F is the "bittern" remaining after halite has precipitated from evaporated seawater.

Br/Cl ratios in fluorite veins are slightly higher than the seawater mean ratio, suggesting that these waters were marine waters that suffered some degree of evaporation before entering in the hydrothermal system. I/Cl ratios are also higher than seawater and can be explained by the circulation of these solutions through rocks rich in I as, for example, the enclosing granitic rocks.

F trapped in dolomite and quartz from the carbonate-hosted Hg veins have Br/Cl ratios lower than and I/Cl ratios similar to seawater. These data suggest that the solutions can be related either with magmatic brines, even though the low iodine concentration in these F is not compatible with this hypothesis, or with secondary brines produced by leaching of halite-bearing evaporites. Both the very high salinity of the FI (33% NaCl eq.) and the presence of Triassic evaporite layers, with gypsum and halite pseudomorphs, within the upper Buntsandstein facies and the basal levels of the Muschelkalk facies, support the latter hypothesis.

Stable isotope data and FI studies show that these veins formed by the mixing of subsurface, metal-rich brines with surficial waters either marine (Catalonian Coastal Ranges deposits) or that had interacted with evaporites (Pyrenees and Espadán deposits). The ultimate source for the subsurface brines would be evolved basinal brines that had interacted with the basement lithologies.

So, there is a common main mechanism of formation for these ore deposits, which is related with deep crustal circulation of F beneath subsiding basins in Mesozoic times. The differences between deposits are due to the importance of the regional geothermal anomaly and the local availability of one or another element. (From authors' abstract by E.R.)

TRUMBULL, R.B., 1995a, Tin mineralization in the Archean Sinceni rare element pegmatite field, Kaapvaal craton, Swaziland: Econ. Geol., v. 90, p. 648-657. Author at GeoForschungsZentrum Potsdam, Federal Republic of Germany.

Primary Sn mineralization at the Sinceni West deposit consists of cassiterite in late-stage pegmatite units of sugary albite, associated with mica-tourmaline metasomatic selvages in the host rock. The albitic units are interpreted as the products of late residual melt, and the metasomatic selvages reflect F exsolution from the melt at the latest stage of pegmatite consolidation. (From author's abstract by E.R.)

Quotes FI data of Trumbull (1995b) (next item). (E.R.)

TRUMBULL, R. B., 1995b, A fluid inclusion study of the Sinceni rare-element pegmatites of Swaziland: Mineral. Petrol., v. 55, p. 85-102. Author at GeoForschungsZentrum Potsdam, Federal Republic of Germany.

FI were studied from two groups of pegmatite minerals. One (schorl, garnet, quartz, beryl) represents the main stage of crystallization and the second (cassiterite, schorl-dravite, elbaite) formed in late-stage, mineralized units.

Three F types were recognized. Type I fluid is aqueous and moderately saline with very low CO_2 contents. It forms S or PS I in the main-stage minerals and PI in late-stage elbaite, schorl-dravite and cassiterite. Type 2 fluid is carbonic, mixed H_2O-CO_2, and it forms SI in main-stage quartz and beryl which were trapped at the solvus conditions (~325°C), well below the pegmatite solidus. Type 3 fluid is aqueous, highly saline, and contains cubic daughter salts. It occurs as S or PS I in main-stage quartz.

Isochore trajectories and independent P-T information show that inclusions of type I fluid in the main-stage minerals cannot be primary although many look to be so. Type I fluids were exsolved at a late stage of pegmatite consolidation, forming SI in main-stage minerals and PI in tourmaline and cassiterite from mineralized units. Evidence is inconclusive whether type 2 and 3 fluids represent evolved type I fluid or are external fluids. (Author's abstract)

See also previous item. (E.R.)

TSUNODA, Kenro and SHIMIZU, Masaaki, 1995, Mineralization of the Suehiro vein of the Otome deposit, Yamanashi Prefecture, Japan: Resource Geol., v. 45, p. 111-120 (in Japanese, English abstract). First author at Dept. Earth Sciences, Yamanashi Univ., Kofu 400, Japan.

Metallic mineralization in the Suehiro vein and its neighbouring veins of the Otome deposit was described. The metallic minerals of the Suehiro vein and its neighbouring veins are ferberite, pyrrhotite, less pyrite, chalcopyrite, sphalerite, molybdenite 2H, goethite, arsenopyrite, cubanite, Ag, Sb-bearing cosalite, bismuthinite, native bismuth, ingodite, Bi-bearing boulangerite, izoklakeite, etc.

The mineralization sequence at Otome can be divided into three stages, based on microscopic observation, EPM analyses and FI data: Stage I (W mineralization), Stage II (sulphides and sulphosalts), and Stage III (hematite and goethite). Further, the stage II is subdivided into three substages. The FI Th ranged from 350° to 250°C for stage I, from 330° to 150°C for stage II and <150°C for stage III.

T and S activities of stage II mineralization at Otome are estimated as 330° to 150°C, and -11 to -20 in log aS_2 (atm), based on the FeS contents of sphalerite, mineral assemblages and FI data. (Authors' abstract)

TURNER, P., BURLEY, S.D., REY, D. and PROSSER, J., 1995, Burial history of the Penrith Sandstone (Lower Permian) deduced from the combined study of fluid inclusion and palaeomagnetic data: Geol. Soc. [London] Special Pub. 98, p. 43-78.

TÜYSÜZ, Necati, SADIKLAR, Burhan, ER, Murat and YILMAZ, Zeki, 1995, An epithermal gold-silver deposit in the Pontide Island arc, Mastra Gümüshane, northeast Turkey: Econ. Geol., v. 90, p. 1301-1309. First author at Dept. Geology, Black Sea Technical Univ., 61080 Trabzon, Turkey.

FI from the early-stage quartz are solely L filled. No evidence of L CO_2 was found in the I. No P corrections were made on the Th. The Th obtained from the first-stage quartz range from 340° to 240°C with a mode at 270°C, whereas those from the second-stage range from 260° to 160°C with a mode at 230°C. First stage salinities ranged from 5.3 to 10.9 wt % NaCl eq. with an average of 8.4 wt % NaCl eq. The second stage ranged from 4.1 to 8.6 wt % NaCl eq. with an average of 6.9 wt % NaCl eq. The coexisting two-phase I suggest that Au-bearing F was boiling from ~240°C and mineralization took place mainly at Th between 220° to 240°C, whereas Ag deposition peaked at somewhat higher T and salinities. The Th of the FI within the zone of Au mineralization suggest depths of formation, assuming hydrostatic condition on the boiling point with a depth curve of not greater than 350 m below the paleosurface. (From authors' text by E.R.)

UCHIDA, E., GORYOZONO, Y., NAITO, M. and YAMAGAMI, M., 1995, Aqueous speciation of iron and manganese chlorides in supercritical hydrothermal solutions: Geochem. J., v. 29, p. 175-188.

ULLMAN, W.J., 1995, The fate and accumulation of bromide during playa salt deposition: An example from Lake Frome, South Australia: Geochim. Cosmochim. Acta, v. 59, p. 2175-2186.

ULMER, Peter and TROMMSDORFF, Volkmar, 1995, Serpentine stability to mantle depths and subduction-related magmatism: Science, v. 268, p. 858-861.

URABE, T. and 29 others, 1995, The effect of magmatic activity on hydrothermal venting along the superfast-spreading East Pacific Rise: Science, v. 269, p. 1092-1095.

Plumes with high ratios of volatile (^{3}He, CH_4, and H_2S) to nonvolatile (Mn and Fe) species marked where hydrothermal circulation has been perturbed by recent magmatic activity. The high proportion of volatile-rich plumes observed implies that such episodes are more frequent here than on slower spreading ridges. (From authors' abstract)

VAGGELLI, G. and FRANCALANCI, L., 1995, Silicate-melt inclusions in mafic enclaves of post-minoan dacitic lavas from Santorini, Greece: Physico-chemical conditions of parental magmas: Plinius, no. 14, p. 295-297. Authors at Dip. Scienze della Terra, Univ. Firenze, Italy.

Primary silicate-MI in olivine and clinopyroxene, from mafic enclaves in post-minoan dacitic lavas of Santorini, have been analyzed in order to characterise the physico-chemical conditions of the host magmas and to infer the composition of the parental magmas.

Microthermometric investigation provides Th ranging from 1230±5°C to 1280±5°C. The Th, corresponding to the disappearance of the shrinkage bubble and/or of the last crystal within the silicate-MI, were used as T of quenching.

Electron microprobe analyses were performed both on homogenised and unheated silicate-MI hosted by clinopyroxene and olivine. The unheated I show an extremely evolved composition with respect to the homogenised. The high silica content of unheated I is accompanied by high alumina, alkali and Cl, and by low CaO, MgO, FeO, TiO_2. As the crystallisation of the host phase and dms (clinopyroxene + Fe-Ti oxides) may be responsible for the composition of these residual glasses, the presence of S globules in the unheated I may explain the decrease of S from the homogenised to the unheated I.

Homogenised silicate-MI in olivine are characterised by a silica content from 48.7 to 52.3 wt %, and by FeO and MgO values from 8.6 to 10.6 and from 5.3 to 7.4 wt %, respectively. The FeO/MgO ratio between the host olivine and the entrapped silicate 'liquid is around 0.3, both indicating crystal/liquid conditions of equilibrium and supporting the hypothesis that the homogenised compositions are not affected by post-entrapment crystallization. A significant correlation between the Th and the geochemical features of homogenised I does exist. In particular, the T decrease is accompanied by an increase in silica, alumina, alkali, Cl and S and by a decrease of CaO, FeO, MgO and TiO, contents. In respect with the mafic enclave compositions, the homogenised I have comparable contents of CaO, and K_2O, lower silica and alumina, and higher FeO, MgO, TiO_2 and Na_2O. Thus, these MI have the least evolved compositions among all the post-minoan magmas.

The chemical compositions of homogenised I in clinopyroxene, corrected for the host phase interaction, are more evolved than the olivine-hosted homogenised I, suggesting that clinopyroxene was a later phase in the magma crystallization.

The chemical variations of olivine-hosted homogenised I indicate that magmas were evolving by fractional crystallization of only femic phases. No plagioclase crystallisation can be inferred, at least in these early stages. The exclusive crystallization of olivine, [that] probably occurred at high P, drives the L composition to high alumina contents till a huge amount of plagioclase starts to crystallise, forming the typical plagioclase-rich calcalkaline rocks. (From authors' abstract by H.E.B.)

VALBRACHT, P.J., HONDA, M., STAUDIGEL, H., McDOUGALL, I. and TROST, A.P., 1994, Noble gas partitioning in natural samples: Results from coexisting glass and olivine phenocrysts in four Hawaiian submarine basalts, *in* J. Matsuda, ed., Noble Gas Geochemistry and Cosmochemistry: Terra Scientific Publishing Co. (TERRAPUB), Tokyo, ISBN 4-88704-114-4, p. 373-381. First author at Research School of Earth Sciences, The Australian Nat'l Univ., ACT 0200, Canberra, Australia.

Mass spectrometric abundance determinations of all five noble G in fresh glass and coexisting olivine phenocrysts from four Hawaiian submarine basalts resulted in olivine/glass abundance ratios less than unity. These data provide strong support for some laboratory experiments indicating that noble G behave as moderately incompatible elements during crystallization of olivine. Preferential partitioning of the noble G into the melt and G phase during magmatic processes involving olivine are likely to have enhanced the degassing of the noble G from the solid Earth. (Authors' abstract)

VALLEY, J.W. and GRAHAM, C.M., 1995, Processes of hydrothermal water/rock exchange: ion microprobe and laser analysis of $\delta^{18}O$ in quartz from Skye Valley (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-36.

O isotope analysis of quartz and feldspar separates, and of whole rock powders show that the Maol na Gainmhich granite (MNGG), Isle of Skye, Scotland, underwent hydrothermal interaction with heated meteoric water. The results prove that microcracks in quartz provided permeability for meteoric waters, and that recrystallization healed cracks facilitating exchange. Thus F flow was highly heterogeneous and channeled at the 10-100μm scale. (From authors' abstract by H.E.B.)

VANKO, D.A. and BROWN, P.E., 1995, Papers presented at PACROFI V, Fifth biennial Pan-American Conference on research on fluid inclusions, held in Cuernavaca, Morelos, Mexico, May 19-21, 1994: Introduction: Geochim. Cosmochim. Acta, v. 59, p. 3883-3885.

Most of these are the full papers for abstracts presented in FIR, v. 27. (E.R.)

VANKO, D.A. and CAPPS, R.C., 1995, History of fluids in the basement, Savannah River Site, South Carolina: Vein mineralogy and fluid inclusions (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 2, p. 94. First author at Dept. Geology, Georgia State Univ., Atlanta, GA 30303.

Drill cores from the Savannah River Site in South Carolina provide samples of the local Paleozoic crystalline basement. The history of F-rock interaction is revealed through vein mineralogy, textures, crosscutting relationships, mineral chemistry, and FI characteristics.

Hole DRB-1 penetrates ~1000 ft of greenschist to amphibolite grade meta-igneous rocks having upper level plutonic and porphyritic mafic and felsic protoliths. Numerous veins include several generations of quartz-, calcite-, and zeolite-bearing veins. Veins are 0 to 40 mm wide (majority 0.5-5 mm wide). Nearly every 6-ft interval contains several veins, with some intervals containing numerous veins forming a network.

Early vein types contain quartz, feldspar, epidote, chlorite, or calcite. Latest veins contain drusy quartz, calcite, zeolite, pyrite, hematite, or clay.

Cathodoluminescence (CL) reveals at least two types of sparry calcite in composite veins: layers that contain spectacular fine CL color banding, and other layers composed of homogeneous calcite.

FI observed in quartz include (1) a primary population of three-phase FI with aqueous and carbonic L plus V; (2) a population of three-phase FI with L, V, and a tiny birefringent dxl; (3) a possibly primary population of L+V FI with 5-10 vol % V; and (4) numerous S FI with L or L+V and very small V bubbles. FI in calcite are L or L+V with 0 to 10 vol % V; they appear to be mostly secondary, although some calcite contains euhedral growth zones outlined by lines of solid and FI. Preliminary FI Th in calcite range from ~100°-160°C. (Authors' abstract)

VARELA, M.E. and BENGOCHEA, A.L., 1991, Magmatic inclusions in rhyo-dacite intrusives from the mining district Los Manantiales of Chubut: Asociacion Geol. Argentina, Rev., v. XLVI, p. 295-298 (in Spanish, English abstract).

Silicate MI represent microsystems that preserve unique information on the physicochemical conditions of the magma at the moment when the I were formed. Detailed petrographic studies of MI, their characterization of post-trapping evolution and microthermometric studies at high T provide information on the chemistry of M. (Authors' abstract)

VARELA, M.E., BJERG, E.A. and LABUDIA, C.H., 1995, Fluid inclusion evolution in upper mantle xenoliths from Patagonia, Argentina (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 256-257. Authors at Dept. Geologia, Univ. Nacional del Sur, San Juan 670, (8000) Bahia Blanca, Argentina.

FI in ultramafic xenoliths hosted by Pliocene-Pleistocene alkaline basalts from the Somoncura Massif, Northern Patagonia, provide an estimation of the depth/P at which they were captured by the hosting alkaline basalts and their ascent history. The xenoliths were classified as spinel lherzolites and harzburgites with protogranular and porphyroclastic textures.

FI were classified according to their occurrence, shapes and Th as "early" and "late" CO_2 I. Different amounts of these I are present in olivine, orthopyroxene and clinopyroxene. Because olivine is easily plastically deformed during eruption, a phenomenon that leads to incorrect density and P estimations, thermometric analyses were done only when these minerals showed only minor deformation. All the studied FI showed type H3 microthermometric behaviour [see Kerkhof FIR, v. 23, p. 84, and FIR, v. 22, p. 190], where $L+V > L$ or $L+V < V$ are the final phase transitions having Ti and final Tm at or close to the same T (-56.6°C) which is characteristic of pure CO_2 I. This allows the F density determination using molar volume-T data on the two-phase regions of pure CO_2.

Early CO_2 FI have Th L varying from -35°C to 0°C. Late CO_2 I have Th L between 12°C and 23°C and Th V within a narrow range: 21°C-25°C. The Tm CO_2 of 140 I range from -56.6°C to -59.2°C, with a mean value of -57.1°C.

Glass + CO_2 I in olivine and clinopyroxene crystals exhibit Tm at -57°C, and no other transition phases were observed up to room T due to a continue and progressive darkening of the bubble. This phenomenon impeded the visualization of the Th. Tp was calculated assuming a Tt of ~1200°C and analytical and experimental data for pure CO_2 systems. Tp for early CO_2 I varies from 6.8 kb to 11.6 kb (ρ CO_2 0.9 g/cm^3-1.09 g/cm^3). For late inclusions Tp varies from 4 kb to 5.4 kb (ρ CO_2 0.74 g/cm^3-0.84 g/cm^3) and 0.65 kb to 0.8 kb (ρ CO_2 0.20 g/cm^3-0.24 g/cm^3). The CO_2 density distribution for early I indicates a minimum depth of origin for the studied xenoliths in the range 21 km-35 km. The observed difference in CO_2 densities in late I may indicate two stages in the ascent of these nodules. One episode occurred in the range 14-17 km and the second one, indicated by late CO_2 FI that have Th V, took place in the range 2.4-3 km. Taking into account that these processes were registered in all the studied xenoliths of this area, it is suggested that this evolution is valid on a regional scale in the central part of northern Patagonia. (From authors' abstract by E.R.)

VARELA, M.E. and GREGORI, D.A., 1995, Fluid circulation path in a volcanic-hosted polymetallic deposits, Angela Mine Argentina (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 258-260. First author at Dept. Geologia-CONICET, Univ. Nacional del Sur, San Juan 670 (8000) Bahia Blanca Argentina.

The mineralization, disseminated in veins, consists of pyrite, sphalerite, galena, chalcopyrite, tetrahedrite and pyrrhotite. FI studies were carried out on quartz and sphalerite. Three main types of FI are present: Type I: Two-phase L-rich. Type II: Two-phase V rich. Type III: Polyphase with L, V bubble and dms. In them, the dm/FI volume ratio varies markedly. Towards upper levels the abundance of type III increase gradually, suggesting that mineralizing solutions could be enriched in carbonates, silica, Al, Na and probably K. Type I FI abundances in ore shoots duplicate or triplicate those in poorly mineralized zones. Type II FI are more abundant in ore shoots, their presence is constant throughout them from deeper levels towards surface. The coexistence of P or PS L-rich and V-rich inclusions in the different levels of the Angela Mine could be considered a strong evidence of two-phase conditions due to boiling at the time of trapping. Th ranges from 288 to 338 (type Ia) and 376 to 395 (type II). Sal. ranges from 3.3 to 5.68 % NaCl eq. The analysis of these data suggests a depth of formation fluctuating between 1200 and 1500 m.

The FI studies indicate that boiling may be considered as the principal ore depositional mechanism. Salinity and Th diminish from deeper levels (105-120) to the level 60 and increase from this level towards surface. An important feature to be noted is the absence of evidence for boiling at the level 60.

The Th isotherms indicate that the minimum T are restricted to intermediate levels.

The Th data of P FI of the veins are similar to those Th of the S FI in the quartz phenocrysts of the rhyolitic dykes. These data indicate that the hydrothermal F have maintained broadly the same characteristics during the intrusion of rhyolitic dykes and deposition of ores. The different lines of evidence show that the fine-grained andesite at the intermediate levels acted as an semipermeable media changing the F evolution and therefore variation in mineral deposition. Above intermediate levels mineralizing F were mixed and diluted with lower T F. Below this level, the presence of the higher T and salinities indicate that mixing and dilution were more restricted. (From authors' abstract by E.R.)

VAVELIDIS, M., 1995, Framboidal pyrite from the Kuroko-type barite mineralization of the Katsimouti area, Milos Island, Greece: Chem. Erde, v. 55, p. 281-294. Author at Dept. Mineralogy, Petrology and Economic Geology, Univ. Thessaloniki, Greece.

The presence and morphology of framboidal pyrite in the barite mineralization of the Katsimouti area, Milos island, is studied for the first time. Microprobe analyses of framboidal and first generation pyrite indicate significantly higher arsenic contents when compared to the second generation pyrite. Th of FI in barite, which is closely intergrown with the framboidal pyrite, show peak T between 280°C and 320°C. The Th of I in sphalerite, which formed after framboidal pyrite, range between 180°C and 220°C. (Authors' abstract)

VAVELIDIS, M., SCHMIDT-MUMM, A. and MELFOS, V., 1995, Microthermometric investigations in the Bi-Te-Ag bearing Cu-mineralization of Panagia area, Thasos Island, Greece (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 261-261. First author at Aristotle Univ. Thessaloniki, Greece.

Samples that were used were undeformed, I-rich transparent quartz (Q1). Three types can be distinguished, with 60-70 vol % V. G1 is three-phase and contains $CO_2(g)$-$CO_2(l)$-$H_2O(l)$, all primary. G2 (less common) is L-rich ($H_2O(g)$-$H_2O(l)$). G3 is made up by large (<200 μm) irregularly-shaped cavities, which often appear empty. Freezing of these I showed that they contain CO_2. G1 I freeze at -45°C (aqueous phase) and -100°C (CO_2 phase). Tm CO_2 vary from -56.7 to -56.6°C near the triple point of CO_2. Tm ice was observed from -7.6 to -7.2°C, Tm clath. occurs between +7.8 and +8.9°C (mainly +8.2°C). This corresponds to a total sal. of 3.7 to 6.5 wt % NaCl eq. Th CO_2 +23.6 to +31.1°C, to L or V. Th tot of the mixed I occurs from 313 and 360°C with a maximum at 320 to 330°C [in L or V?]. G2 freeze at ~-45°C and have Te of -24 to -18°C, which indicates that the solution contained mainly NaCl. Tm ice (-1.9 to -2.0°C) correspond to a sal. of 3.5 wt % NaCl eq. Th vary between 229 and 305°C, with a maximum at 290 to 300°C. In only two cases we observed T at 190°C. G3 Tm (-56.6°C) revealed a pure CO_2 phase. Th between +27.3 and +31.5°C in L or V. FI measurements from younger clear quartz (Qz) showed similar results.

G1 represents the main mineral-forming F. G2 could be generated through phase separation in the H_2O-CO_2-NaCl system. This phase separation is further evidenced by the presence of the G3 I and implies gas saturation of the H_2O-CO_2-NaCl I. Under these conditions the Tf of the investigated mineralization can be reliably estimated from the Th of the CO_2-H_2O I. The isochores for the system were calculated [and yielded] a derived P of 500 bars. This is in good agreement with the estimate derived from intersection of the isochores of G2 and G3 I, which reveals 340 to 360°C and 500 to 700 bars. Tt of the CO_2-H_2O-NaCl I range from 320 to 340°C, which is in good agreement with the formation of framboidal pyrite during the early stages of mineralization. The mineralization formed later than the last metamorphic event, in agreement with the microscopic study that shows that investigated quartz is undeformed. (From authors' abstract by E.R.)

VEKSLER, I.V. and SOKOLOV, S.V., 1995, Evolution of carbonatitic melts in ultramafic-alkaline intrusions: Evidence from melt inclusions study (abst.): Eos, v. 76, no. 17, p. S270. First author at Vernadsky Inst. Geochemistry, RAS, Kosigin str 19, Moscow 117975, Russia.

Composition and origin of carbonatitic M are subjects for long-lasting debates. Natrocarbonatites of Oldoinyo-Lengai—the only undoubted example of volcanic carbonatites—are compositionally in drastic contrast to all known plutonic carbonatites. Intrusive carbonate rocks could be strongly altered by metasomatic and hydrothermal processes and their bulk chemistry may not represent the M composition.

MI trapped by rock-forming minerals seem to us to be the only reliable samples of carbonatitic L. We have studied mineralogy, Th and bulk chemistry of MI in forsterites, apatites, dolomites, wollastonite, baddeleyite and zircon from several carbonatitic intrusions (Kola Peninsula and Polar Siberia). Selected samples represent different types of intrusive carbonatites. According to geological data they correspond to different stages of the formation of carbonatite bodies. The Th of the I vary from 920-860°C for early apatate, 800-770°C for forsterite, to 580-500°C for dolomite. Electron microprobe analyses of homogenized I show broad variations in their compositions from high-Ca to peralkaline ones. The data on MI suggest that natrocarbonatites may be not uncommon late-stage products of the evolution of mantle-derived silicate-carbonate M parental for ultramafic- alkaline intrusions. (Authors' abstract)

VELASCO, F., TORNOS, F., PESQUERA, A., and PEÑA, A., 1995, Metamorphic hydrothermal fluids in tonalite-hosted copper-gold vein mineralization, Mina Sultana (Cala, Huelva, Spain) (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 263-264. First author at Dept. Mineralogía y Petrología, Univ. País Vasco. 48080 Bilbao, Spain.

The Sultana Cu-Au deposit is composed of an early fine-grained and tectonized quartz ± pyrite assemblage followed by comb quartz grown on open spaces with polymetallic ore. The host tonalites show a pervasive silicification, ankeritization, sericitization, chloritization as well as local tourmalinization.

FI in the late quartz related with the Cu-Bi-Au-rich mineral assemblage are likely primary. Three apparently synchronous types can be recognized. Type I consist of an aqueous solution with ≤2 dms, halite and sylvite. Type II also includes CO_2-rich, L and V phases. Type III is CO_2-rich, locally with a subordinate aqueous phase (± dxls).

Microthermometric results are shown in Table 1 [deleted]. Most of the phase changes are difficult to recognize, but several modifications could be recorded. First melting temperatures (T1f) [i.e., Te?] range between -54.1 and -21.2°C, suggesting that the aqueous phase belongs to the H_2O-$CaCl_2$-NaCl ± KCl system. The melting temperature of hydrohalite (Tmhh) suggests sal. between 9.6 and 19.2 wt % $CaCl_2$ eq. Minimum NaCl sal. range between 8.1 and 18.8 wt %, but the Tm NaCl indicate NaCl contents ≤50 wt % and total sal. between 18 and 70 wt %. However, preliminary Cryo-SEM-EDS analysis (Ayora & Fontarnau, 1990, FIR, v. 23, p. 8) show that the $CaCl_2$ content is significantly lower than expected by microthermometric results, close to 0.5 wt %. Recalculated sal. are thus between 8 and 51 wt %, K/Na ratios are very low (<0.07), and the presence of dxls of sylvite can be due to a salting-out effect. Appreciable amounts of $MgCl_2$ and $FeCl_2$ were not detected. The discrepancies between microthermometric and analytical data suggest a high degree of metastability in these complex Ca-bearing FI.

$TmCO_2$ and $ThCO_2$ show that CH_4 and/or N_2 are present in important amounts. Microthermometric measurements suggest that XCO_2/XCH_4 ratios range from 0.04 to 0.12 in type II and III. Guessed XCO_2 values are 0.10-0.23 for type II and 0.30-0.70 for type III. Tm clath are hardly seen, and the observed values are probably influenced by other gases. Most FI decrepitate before final Th, but the mode of recorded T ranges from 310 to 380°C. Mass spectrometry of bulk samples show that CH_4/CO_2 ratios are higher than measured ones in the range of 0.13-0.22. CO and H_2 are present in significant proportions, whereas XN_2 is negligible. As a whole, the coexistence of the three types of FI is consistent with the presence of an immiscibility process related to the vein opening. Th and independent geothermometers agree with the H_2O-CO_2-salt solvus for P close to 1-1.5 kb. For the measured XCO_2, F immiscibility would produce a CO_2-poor NaCl-rich brine and a CO_2-phase with >70% molar CO_2. Nevertheless, the FI interpretation is not straightforward. Extreme members of the immiscibility process are the type I and the more V-rich type III fluid inclusions. However, type II can represent the original and unmixed F, but also trap different proportions of unmixed F. The same holds true for the more H_2O-rich type III inclusions. The fluid composition, the P-T conditions of trapping, the geologic setting and the available stable isotope data suggest that hydrothermal F are equilibrated with nearby metamorphic rocks, probably the Precambrian black shales, which invaded the system. F unmixing produce an alkalinization of the system and dramatic lowering of the fS_2, leading to the precipitation of metals transported by thiosulphide or weak acid complexes, but inhibiting the precipitation of metals transported as chloride complexes. These veins share many of the characteristics of mesothermal Au deposits, but are developed in a postorogenic and extensional setting. (From authors' abstract by E.R.)

VIGGIANO, J.C., 1995, Fluid inclusion studies in Mexican geothermal fields: An underestimated matter (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 286-287.

A review of what types of information can be obtained from FI studies, and a listing of which types of data are available (including unpublished data) on seven geothermal systems. (E.R.)

VIKENTYEV, I.V., 1995, Metamorphic structures and remobilization of metals in massive sulfide deposits of shear zones of the Urals and Altai, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 913-916. Author at Inst. Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Russian Acad. Sci., Moscow, Russia.

Dynamometamorphic structures are abundant in the ores and host rocks of deposits in mobile belts. Metal remobilization took place mainly by diffusion and hydrothermal transport during peak metamorphic and retrograde phases of the main period of folding. Most of the massive metamorphic sulfides precipitated from concentrated solutions rich in carbonic acid at T = 150-350°C (≤700°C) and P = 0.5-3 kb (≤5 kb) for various deposits. (Authors' abstract)

VINDEL, Elena, LOPEZ, J.A., BOIRON, M.-C., CATHELINEAU, M. and PRIETO, A.C., 1995, P-V-T-X-fO_2 evolution from wolframite to sulphide depositional stages in intragranitic W-veins: An example from the Spanish Central System: Eur. J. Mineral., v. 7, p. 675-688. First author at Dept. Cristalografía y Mineralogía, Univ. Complutense, 28040 Madrid, Spain.

The relative P-T-X conditions of the deposition of wolframite and sulphides in quartz veins have been investigated using representative W-polymetallic sulphide veins hosted by peraluminous granites in the central domain of the Spanish Central System. Ore-bearing quartz veins fall into two groups: W-veins (wolframite-bearing quartz veins with minor amounts of sulphides) and sulphide (S) dominated veins (wolframite free). The two vein types (S and W) have similar orientation, silicate and sulphide mineralogy. A multidisciplinary approach based on a detailed FI analysis in relation with a paragenetic reconstruction of vein fillings suggests a similar genesis and F history, as follows:

(i) an early F stage, lacking in S-veins, characterized by CO_2-H_2O-NaCl rich V is at the origin of a strong K-mica alteration of the granite wall-rock, and of vein filling by milky quartz (QI) - phengite I - (wolframite), at ~130 ± 20 MPa and 525 ± 25°C;

(ii) A second stage characterized by H_2O-CO_2-CH_4-NaCl F with a low volatile-phase density, at the origin of the deposition of: (a) saccharoidal quartz (QII) (+ phengite II and minor amounts of scheelite in W-veins), and then (b) a chlorite-sulphide (pyrrhotite, sphalerite and galena) assemblage. A progressive decrease of the CO_2 content in F is recorded, CH_4 being the major volatile species in the latest I spatially associated with sulphides. P is ~130 ± 30 MPa, and T decreases from 380° to 330°C throughout the course of the F trapping.

(iii) later F inputs in the veins are shown by two types of S aqueous FI in healed microfissures, which display moderate Th (160°-220°C) and salinities.

The two main stages (wolframite, then sulphides) are characterized by a nearly isobaric cooling and dilution of volatile-rich F. The X-fO_2 evolution indicates that F chemistry was probably controlled during the first stage by graphite-F equilibrium, implying a F source external to the granite (surrounding metamorphic series).

The sulphide stage, which is ubiquitous in most W deposits, appears clearly in this example as the latest stage of a primary hydrothermal cycle involving volatile-bearing F, and is not disconnected from the W stages. (Authors' abstract)

VITYK, M.O. and BODNAR, R.J., 1995a, Do fluid inclusions in high-grade metamorphic terranes preserve peak metamorphic density during retrograde decompression?: Am. Mineral., v. 80, p. 641-644. Authors at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

It is often assumed that FI in quartz do not maintain their density if they experience internal P 2 kb in excess of confining P. However, results of a long-term (180 d) laboratory experiment simulating a nearly isothermal decompression P-T path showed that two of 160 I recorded the original density. These two I thus maintained ~2 kb internal overpressure for the duration of the experiment without modification. Comparison with results reported in the literature reveals that a small percentage of FI in quartz from high-grade metamorphic rocks maintain peak densities during retrograde uplift. These I represent outliers in Th histograms and are often ignored during data interpretation. (Authors' abstract)

VITYK, M.O. and BODNAR, R.J., 1995b, Textural evolution of synthetic fluid inclusions in quartz during reequilibration, with applications to tectonic reconstruction: Contrib. Mineral. Petrol., v. 121, p. 309-323. Authors at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Experimental reequilibration of synthetic 10 wt % NaCl-H_2O I in natural quartz reveals that reequilibration textures show distinct differences depending upon the P-T path followed by the I after formation. These differences combined with other geological information may be used to determine whether the sample (rock) followed a dominantly isothermal or isobaric P-T path following entrapment. The intensity and style of I reequilibration features is related to the direction and magnitude of the departure of the P-T path from the original isochore for the I. Thus, FI reequilibration textures not only permit inclusionists to determine whether the rocks followed an isothermal or isobaric retrograde P-T path, but also the magnitude of departure of this path from one that is isochoric. (Authors' abstract)

See also next item. (E.R.)

VITYK, M. and BODNAR, R.J., 1995c, Experimental re-equilibration of synthetic fluid inclusions: potential effects of time and loading rates (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 265-266.

See adjacent items. (E.R.)

VITYK, M.O. and BODNAR, R.J., 1995d, Experimental reequilibration of synthetic fluid inclusions: effect of brittle deformation and chemical gradients (abst.): Eos, v. 76, no. 46, p. F706.

Important questions remain concerning the use of FI from deformed metamorphic rocks. Specifically, are histograms of microthermometric data for I from the deformed rocks unique in shape and/or other features? Are these histograms significantly different from those of undeformed samples? Long-term (from 180 to 360 days) reequilibration experiments using synthetic 10 wt % NaCl-H_2O I formed at 700°C and 5 kb in natural quartz may provide some insight into these questions. Our observations suggest that a nearly symmetrical histogram with low data variability is characteristic for FI gradually reequilibrated under conditions of internal overpressure. Conversely, I from samples subjected to brittle deformation by shock-induced fracturing of the host produce a specific multi-modal distribution with high variability of Th. This distribution may be attributed to selective decrepitation and/or stretching of the I during fracturing.

In order to more closely simulate natural P-T histories, we have conducted a series of retrograde P-T experiments involving F of different composition (CO_2, CO_2-H_2O, H_2O, NaCl-H_2O). The goal of this phase of the research is to evaluate structural and chemical interactions between different FI populations trapped at different times and P-T conditions. For simple, 8 and 30 day duration experiments using 20 wt % NaCl-H_2O synthetic I in natural quartz conducted at 700°C and 5 kb (Pint = Pconf) in pure CO_2 demonstrates that >70% of the I have maintained their original composition after reequilibration. After this experiment, the I showed a broad range of salinities (from the original 20 wt % NaCl to very high salinity F). Those I that showed a salinity change also showed detectable CO_2 after the experiment. Broad ranges in salinities of apparently coeval I have also been documented for many metamorphic terrains. Although the variability in natural samples could reflect actual variation in the F composition with time, laboratory experiments suggest that selective compositional reequilibration by reactivization of microcracks is a possible explanation. (Authors' abstract)

VITYK, M.O. and BODNAR, R.J., 1995e, Experimental simulation of retrograde decompression: Preservation of fluid inclusion densities in high-grade metamorphic terranes (abst.): Eos, v. 76, no. 17, p. S290. Authors at Dept. Geological Sciences, Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

FI analyses of high-grade metamorphic rocks often demonstrate that some I (commonly <1% of all I measured) show isochores which project through peak metamorphic P-T conditions. In some cases, these results have been interpreted to indicate that the I represent "peak metamorphic inclusions" which have survived retrograde cooling events and have maintained their original density. In other instances, investigators have suggested that the I could not have maintained their original density, owing to the high internal overpressures (>1 kb) generated during retrogression.

Synthetic FI in natural quartz were used to monitor changes in I characteristics during retrograde decompression. FI were taken along identical decompressional P-T paths (from 700°C and 5 kb to 625°C and 2 kb) to simulate retrograde P-T conditions in high-grade metamorphic environments. By changing the confining P in our experiments in ~0.7 kb increments over three weeks duration, we found that a large percentage of aqueous synthetic I in quartz maintained 2 kb of internal overpressure for 7 d without changing volume. These results differ from previous experimental studies involving instantaneous loading at conditions of high internal overpressure, where I maintaining their original density have not been reported. Our experimental data further indicate that a small percentage of aqueous synthetic I (two out of 160 I measured) preserve their original density, even when subjected to internal overpressures of ~2 kbar for as long as 180 d. Based on these results and comparison with naturally modified I, we suggest that FI data from high grade metamorphic rocks may be interpreted to indicate that some of the I have maintained peak metamorphic densities over geological time. Thus, if these I can be identified and measured, they provide valuable information concerning the physical and chemical environment at peak metamorphic conditions. (Au-

WADA, H. and SANTOSH, M., 1995, Stable isotopic characteristization of metamorphic fluid processes in the Kerala Khondalite Belt, south India: Memoirs - Geol. Soc. India, v. 34, p. 161-172.

WADA, N., MATSUDA, J. and OZIMA, M., 1995, Noble gas isotopic compositions in cubic diamonds: modern mantle component trapped in fluid inclusions (abst.): Eos, v. 76, no. 46, p. F643.

It has been reported that coats of cubic diamonds contain mantle-derived F as sub-micrometer I, which are the probable host phase of noble gases. Since the coats are supposed to be rather young from the nitrogen aggregation state, the cubic diamonds could be the good samples to estimate the noble gas state of the modern upper mantle.

Isotopic and elemental compositions of noble gases in cubic diamonds from Zaire were analyzed. Noble gases in the cubic diamonds are supposed to be primary of a trapped origin, since the amounts of noble gases produced in situ by the decay of radionuclides or by the reaction with cosmic-ray were estimated to be small. $^{3}He/^{4}He$ ratios are higher than the atmospheric ratio and similar to typical values observed in MORB (mid-oceanic ridge basalt). $^{20}Ne/^{22}Ne$ ratios range from the atmospheric ratio to 11, and $^{21}Ne/^{22}Ne$ ratios of initially trapped Ne in diamonds are inferred to be larger than those in MORB. $^{129}Xe/^{130}Xe$ ratios are higher than the atmospheric ratio by ≤10%, due to the decay of extinct ^{129}I in the mantle. $^{131\text{-}136}Xe$ also show a slight deviation, which can be attributed to spontaneous fission of ^{238}U or ^{244}Pu. (Authors' abstract)

WAKITA, H., FUJII, N. and TOKUYAMA, E., 1991, Survey of the deep crust: Report of the Superdeep Well at the Kola Peninsula:

Kagaku, v. 62, p. 141-148 (in Japanese).

Eudialyte in alkaline rock from the Kola Peninsula contains gaseous I that are composed mainly of CH_4, C_2H_6, other hydrocarbons (C_3-C_6), H_2, with small amounts of He, CO and CO_2. C isotope ratios ($\delta^{13}C$) of the I gases are nearly equal to those in mantle, not to organic matter. The I data are from the literature. (Abstract courtesy T. Sawaki)

WALDERHAUG, Olav, 1995, Discussion of 'Evidence for resetting of fluid inclusion temperatures from quartz cements in oilfields' by Osborne and Haszeldine (1993): Marine and Petroleum Geol., v. 12, p. 559-561. Author at Rogaland Research, PO Box 2503, Ullandhaug, 4004 Stavanger, Norway.

In a thought-provoking paper, Osborne and Haszeldine (1993) concluded that Th for aqueous I in quartz overgrowths are largely reset due to stretching of the I when the I are heated to T above their entrapment T. However, their data may be interpreted differently, and several other data sets do not support their conclusions. (Author's abstract)

A discussion of paper by Osborne and Haszeldine (FIR, v. 26, p. 129-130). See also Worden et al. (1995) and Osborne and Haszeldine (1995a,b), this volume. (E.R.)

WALKER, F.D.L., LEE, M.R. and PARSONS, Ian, 1995, Micropores and micropermeable texture in alkali feldspars: Geochemical and geophysical implications: Mineral. Mag., v. 59, p. 505-534. Authors at Dept. Geology and Geophysics, Univ. Edinburgh, W. Mains Road, Edinburgh EH9 3JW, Scotland.

SEM and TEM show that normal, slightly turbid alkali feldspars from many plutonic rocks contain high concentrations of micropores, from ~1 µm to a few nm in length, typically 0.1 µm. There may be 10^9 pores mm^{-3} and porosities as high as 4.75 vol % have been observed, although ~1% is typical. Only "pristine" feldspars, which are dark coloured when seen in the massive rock, are almost devoid of pores. Although the presence of F in pores cannot usually be demonstrated directly, crushing experiments have shown that Ar and halogens reside in F. Apart from rare, primary pores in pristine feldspar, pore development is accompanied by profound recrystallization of the surrounding microtexture. These "unzipping" reactions result from F-feldspar interactions, at T <450°C in hypersolvus syenites and T <350°C in a subsolvus granite, and are driven by elastic strain-energy in coherent cryptoperthites and in tweed textures.

Intracrystal porosity is a non-trivial feature of a large volume of the middle and upper crust. The importance of pores in the following fields is discussed: $^{39}Ar/^{40}Ar$ dating and "thermochronometry"; O exchange; Rb and Sr diffusion; weathering; experimental low-T dissolution; development of secondary porosity and diagenetic albitization; leachable sources of metals; nuclear waste isolation; deformation; seismic anisotropy; electrical conductivity. Important questions concern the T range of the development of the textures and their stability during burial and transport into the deeper crust. (From authors' abstract by E.R.)

WALTER, A.-V., FLICOTEAUX, R., PARRON, C., LOUBET, M. and NAHON, D., 1995, Rare-earth elements and isotopes (Sr, Nd, O, C) in minerals from the Juquiá carbonatite (Brazil): Tracers of a multistage evolution: Chem. Geol., v. 120, p. 27-xx.

WANG, Baoqing, 1995, Calcite fill on the top of Ordovician paleokarst in Liulin, Shanxi: Geol. Review (Dizhi Lunping), v. 41, no. 5, p. 473-479 (in Chinese; English abstract). Author at Xi'an Petroleum Inst., Xi'an, Shaaxi, PRC.

Paleokarst is well developed in the upper most first submember of the Ordovician Majiagou Formation ($M5_1$) in Liulin, Shanxi. The pores, cavities and fractures are filled with abundant freshwater granular and mosaic calcite. In light of the C and O isotopic composition, Th and salinity of FI and characteristics of cathodoluminescence, the calcite fillings are grouped into the early-stage fill and the late-stage fill.

The values of $\delta^{13}C$ and $\delta^{18}O$ of the early-stage calcite fill, which are similar to those of micrite and dolomite, range from -7.710‰ to 0.575‰, and from -9.753‰ to -7.124‰ with means of -3.722‰ and -8.766‰, respectively. The values of $\delta^{13}C$ and $\delta^{18}O$ of the late-stage calcite fill, which are obviously lower than those of micrite and dolomite, range from -16.595‰ to -5.699‰ and from -18.95 ‰ to -12.678‰ with means of -9.374‰ and -15.108‰, respectively. The Th of FI range from 76-239°C, and the salinity of FI range from 0.8-9.0%. The Th and salinity of FI in the early-stage calcite fill, which are lower than those in late-stage calcite fill, are <95°C and 2%, respectively. The early-stage calcite fill has strong cathodoluminescence, while the late-stage one has no luminescence. Luminescence intensity is the function of activators or sensitizers such as Mn^{2+}, Pb^{2+}, Cu^{2+}, Zn^{2+} and Cr^{3+} and quenchers such as Fe^{2+}, Ni^{2+} and Co^{2+}. (Author's abstract)

WANG, Dawei, ZOU, Zhiping and LI, Shaoxiong, 1995, On geological features and genesis of the Gongpoquan copper deposit, Gansu, China: Northwest Geoscience (Xibei Dizhi Kexue), v. 16, no. 1, p. 115-122 (in Chinese, English summary).

Indexed under FI. (E.R.)

WANG, Feiyu and XIAO, Xianming, 1995, Advances and present state of the application of organic petrology to petroleum exploration: Earth Science Frontiers (Dixue Qianyuan), v. 2, no. 4, p. 189-196 (in Chinese, English summary).

Indexed under FI. (E.R.)

WANG, Huatian, 1995, Metallogenesis and fluid inclusion geochemistry of gold deposits in southwest Zhejiang: Geol. and Geochem., no. 3, p. 63-69 (in Chinese).

WANG, Shengyuan and FAN, Wenling, 1994, Gold solubility in SiO_2-HCl-H_2O system at 200°C: A preliminary assessment of the implications of silicification with regard to gold mineralization: Chinese J. Geochem., v. 13, no. 1, p. 13-23 (in English). Authors at Open Laboratory of Ore Deposit Geochemistry, Inst. Geochemistry, Chinese Acad. Sci., Guiyang 550002, PRC.

Thermodynamic calculations show that $AuH_3SiO_4^0$ would be far more abundant than $AuCl_2^-$ under physicochemical conditions of geological interest, suggesting that silica is much more important than chloride as ligands for Au transport. In systems containing both S and silica, $AuH_3SiO_4^0$ would be increasingly more important than Au $(HS)_2^-$ as the proportion of SiO_2 in the system increases. SiO_2 precipitation is an effective mechanism governing Au deposition, and thus explains the close association of silicification and Au mineralization. (From authors' abstract by E.R.)

WANG, Xuekun, 1995, Geochemical characteristics of the Dushan reworked antimony deposit, Guizhou: Geol. Rev (Dizhi Lunping), v. 41, no. 1, p. 61-73 (in Chinese, English summary).

Indexed under FI. (E.R.)

WANG, Ying, 1995, Water rock interaction in the formation of Qiqiu No. 1 gold deposit, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 697-700. Author at Dept. Engineering Geology, SW Jiaotong Univ., Chengdu Sichuan, PRC.

The Qiqiu No. 1 Au deposit is the largest one in Xinjiang, China. Based on thorough studies of ore-forming conditions, the author concludes that the deposit is of magmatic, hydrothermal origin. Some chemical reactions resulting in the precipitation of Au are demonstrated. The ore-forming T is between 241°C and 260°C, the pH values from 5.48 to 6.79, and the Eh values -2.20 to -2.25 V. During the early stage of mineralization, Au was mainly transported in the forms of $[AuCl_2]^-$ and $[AuCl_4]^-$, contrasted with the transportation forms of $[Au(HS)_2]^-$ and $[AuS_2]^{3-}$ in the late stage. (Authors' abstract)

CO_2 and CH_4 contents are large. Th of quartz FI vary between 170°C and 300°C, most 24°C and 260°C. We estimate the premineralization P of ~880 bar, equivalent to a depth of 3.5 km, the P of the mineralization stage is 350 bar, corresponding to a depth of 1.4 km. (From author's text by E.R.)

WASSERMAN, E., WOOD, B. and DAVIES, A., 1995, Equation of state for aqueous silica species at pressures from 1 bar to 29 kb and temperatures from 25° to 900°C based on simulated values of the dielectric constant: Chem. Geol., v. 121, p. 3-xx.

WEBSTER, J.D., CONGDON, R.D. and LYONS, P.C., 1995, Determining pre-eruptive compositions of late Paleozoic magma from kaolinized volcanic ashes: Analysis of glass inclusions in quartz microphenocrysts from tonsteins: Geochim. Cosmochim. Acta, v.

59, p. 711-720. First author at Dept. Mineral Sciences, American Museum of Natural History, Central Park West at 79th St., New York, NY 10024.

Glass I in quartz microphenocrysts were analyzed for major and minor elements by electron microprobe and H, Li, Be, B, Rb, Sr, Y, Nb, Mo, Sn, Cs, Ce, Th, and U by ion microprobe. The phenocrysts and I occur as fresh relicts in about 11 strongly kaolinized, air-fall volcanic ash units (tonsteins) in the central Appalachian basin; the ashes were erupted during the Pennsylvanian.

Interpretation of I compositions indicates the strongly altered tonsteins were derived from K-enriched, metaluminous to mildly peraluminous magma(s). The tonsteins can be divided into two groups on the basis of trapped M compositions. Pre-eruptive volatile abundances in the source magma(s) were generally high but also highly variable. Cl contents of M ranged from 0.02-0.23 wt %, and F ranged from 0.01-0.7 wt %. Concentrations of H_2O in M ranged from 1.6-6.5 wt %. The high pre-eruptive H_2O contents are consistent with large eruptive volumes indicating the precursor rhyolites were the result of plinian eruptions. Even though pre-eruptive water concentrations exhibit no recognizable trends with any elements studied, magmatic evolution appears to have been a strong function of F and H_2O in M; the thermal stabilities of quartz and feldspar were controlled by F and H_2O activities at P of ~0.5-1 kb. (From authors' abstract by E.R.)

WEN, Chunqi, CAI, Jianming, LIU, Wenzhou, QIN, Gongjion and CHENG, Shifang, 1995, Geochemical characteristics of fluid inclusion in the Jinding lead-zinc deposit, Yunnan, China: Kuangwu Yanshi/J. Mineral. and Petrol., v. 15, no. 4, p. 78-84 (in Chinese).

WENDLER, M., KRÜNER, H. and FRISCHAT, G.H., 1995, Gas bubbles in glassmelts under microgravity. Part 3. A further helium diffusion experiment: Phys. Chem. Glasses, v. 36, p. 109-113.

WHITE, N.C. and HEDENQUIST, J.W., 1995, Epithermal gold deposits: Styles, characteristics and exploration: Soc. Economic Geologists Newsletter, no. 23, p. 1, 9-13.

A detailed review of the differences between the low- and high-sulfidation types of epithermal Au deposits (based in part on FI evidence), and their implications for exploration. (E.R.)

WHITNEY, D.L. and TRACY, R.J., 1995, Garnet as open systems during metamorphism (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-263.

Most metamorphic garnets are chemically zoned during growth. Interior compositions are assumed to be armored from further communication with the rock matrix except by the very slow process of lattice diffusion. Growth zoned garnet interiors are therefore generally not in equilibrium with matrix phases. When garnet fractures during metamorphism, however, interior volumes near microcracks can communicate chemically with the matrix via intergranular F and may develop local zoning by participation in late prograde or retrograde reactions. A sufficient density of fracture pathways can result in substantial dissolution/reprecipitation of garnet and/or production of new phases. Atoll garnets may result from complete replacement of garnet cores. Fracture-assisted modification of garnet is indicated by (1) compositional and textural perturbations that can be related to visible or healed fractures and veins, and (2) reverse zoned plagioclase (and even quartz) I surrounded by zoning haloes in garnet. These observations demonstrate localized post-entrapment net transfer in garnet at elevated T. FI concentrated near fractures and associated with local modification of garnet zoning are evidence for involvement of F in garnet compositional modification. For example, trails of FI in garnet from the Taconic Range, NY and CT, are truncated by an I-free near-rim region of garnet that grew subsequent to fracturing and F infiltration. FI data are consistent with entrapment near P-T conditions estimated for garnet rim growth by thermobarometry. Fracturing of garnet may be facilitated by abundant mineral I, by other pre-existing zones of weakness, and by vein-forming mechanisms in the host rock. Radial fractures around plagioclase and quartz I in some garnets suggest that differential expansion of I and garnet may create large local stresses that contribute to opening of garnet interiors. Modeling suggests that cracking is favored by nearly isothermal decompression, a commonly observed metamorphic P-T path. (Authors' abstract)

WILEN, L.A. and DASH, D.G., 1995, Giant facets at ice grain boundary grooves: Science, v. 270, p. 1184-1186.

Of possible pertinence to the crystallization of ice in supercooled FI. (E.R.)

WILKINSON, J.J., GLEESON, S.A. and COLES, B., 1995, ICP-AES analysis of fluid inclusions I: Recent developments and applications (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 269. Author at Dept. Geology, Imperial College of Science and Medicine, Prince Consort Road, London SW7 2BP, UK.

Recent advances in processing methodology (Coles et al., The Analyst, in press) have improved the detection limit for ICP-AES analysis of decrepitates by up to two orders of magnitude, for laser-ablation analysis by one order of magnitude and for standard solution nebulisation (e.g., leachate) by several hundred percent. This is achieved by the use of Correlated Background Correction (CBC), which uses the high degree of correlation between the relative fluctuations in the spectral background at different wavelengths to effectively predict the background emission under transient analyte peaks. The procedure substantially reduces both systematic and random fluctuations in background emissions and makes viable the analysis of smaller samples or samples containing more dilute FI. It has also highlighted certain analytical problems such as the fact that background suppression, probably due to plasma cooling, is unavoidable during analysis of most samples and can result in the introduction of bias of several percent in the element ratios determined.

These developments are illustrated with a range of applications including analysis of synthetic I standards which provide controls on analytical accuracy and precision; and natural samples where the use of CBC has demonstrated that small-scale (spatial and temporal) variations in hydrothermal F chemistry can be resolved. (From authors' abstract by E.R.)

WILKINSON, J.J., JENKIN, G.R.T., FALLICK, A.E. and FOSTER, R.P., 1995, Oxygen and isotopic evolution of Variscan crustal fluids, South Cornwall, U.K.: Chem. Geol., v. 123, p. 239-254.

Structural analysis of quartz systems and FI criteria were used to distinguish five different F types which flowed through a segment of Palaeozoic crust in SE England during the Variscan Orogeny. Mineralogical constraints in combination with FI thermobarometry enabled the T of vein formation to be estimated, and isotopic compositions of F were determined by analysis of vein material and direct measurement on F extracted from I. Peak, low-grade (pumpellyite-actinolite facies) metamorphic F had a high δD and $\delta^{18}O$ signature (δD = -18 to -10‰, $\delta^{18}O$ = +10.6 to +11.9‰) that evolved to compositions in the range δD = -28 to -13‰, $\delta^{18}O$ = +7.9 to +11.4‰ during later retrogression and uplift. F in the contact aureole of the Cornubian Batholith had δD values intermediate between typical magmatic compositions and the regional metamorphic F (-23 to -43‰), and a similar range of $\delta^{18}O$ values to both magmatic and the regional metamorphic F (between +5.6 and +14.0‰). These compositions are comparable with those of F responsible for Sn-W mineralisation in the province. Post-orogenic F chemical and isotopic compositions were exotic and indicate significant infiltration of externally-derived F during late- to post-orogenic brittle faulting. Low-T, low-salinity F which circulated in ENE-WSW-trending brittle normal faults had low $\delta^{18}O$ values (-0.3 to +7.4‰), suggestive of a significant meteoric component. Low-T, high-salinity F, which flowed through N-S- to NNW-SSE-trending strike-slip faults and fractures and were responsible for Pb-Zn mineralisation, had significantly D- and $\delta^{18}O$-depleted compositions (δD = -80 to -49‰, $\delta^{18}O$ = -0.1 to +4.7‰), typical of basinal brines. These data document the isotopic evolution of F in an external (Rhenohercynian) part of the Variscan Orogen, through the complete cycle of foreland thrust-belt development and low-grade regional metamorphism, S-type granite emplacement and associated hydrothermal systems, post-orogenic collapse and low-T F flow in regional fractures. There is limited overlap in isotopic composition between the different F types, indicating that F flowing through the same host rocks at each stage of orogenesis may be distinguished on the basis of their O and H isotopic compositions. These data provide a framework for future studies involving F of unknown origin in the Variscan and are a reference for comparison with the isotopic evolution of F in other orogenic belts. (Authors' abstract)

WILLIAMS, T.J., CANDELA, P.A. and PICCOLI, P.M., 1995, The partitioning of copper between silicate melts and two-phase aqueous fluids: An experimental investigation at 1 kbar, 800°C and 0.5 kbar, 850°C: Contrib. Mineral. Petrol., v. 121, p. 388-399. Authors at Dept. Geology, Univ. Maryland, College Park, MD 20742.

Experiments were performed in the three phase system high-silica rhyolite M + low-salinity aqueous V + hydrosaline brine, to investigate the partitioning equilibria for Cu in magmatic-hydrothermal systems at 800°C and 1 kb, and 850°C and 0.5 kb. (From authors' abstract by E.R.)

WILSON, N.S.F. and MacLEOD, G., 1995, Gas chromatographic analysis of organic molecules in fluid inclusions within sulphide ore minerals: Atlantic Geoscience Soc., Abstracts, 1995 Colloquium and Annual General Mtg., Antigonish, Nova Scotia, published in Atlantic Geol., v. 31, p. 63. First author at Dept. Earth Sciences, Dalhousie Univ., Halifax, NS, Canada.

This paper outlines a method to analyze FI in ore minerals for organic molecules by the direct crushing of host phases on-line to a G chromatograph. This technique has rarely been performed on sulphide ore minerals, and the sampling therefore considered a range of geological and ore depositional environments. Results show organic phases, most notably low molecular weight hydrocarbon gases, evident in varying proportions. High molecular weight hydrocarbons were also present but at lower levels. A negative correlation is inferred with the increase of Tf and the presence of CH_4. Therefore, organic phases are present in ore minerals and at the time or ore precipitation, although at this stage the effects of organic molecules interacting with inorganic species and minerals, directly or indirectly, is poorly constrained. A more integrated and detailed study is required to constrain these reactions and to clarify the effect of organic molecules in ore mineralisation systems. (Authors' abstract)

WINDH, Jacqueline, 1995, Saddle Reef and related gold mineralization, Hill End gold field, Australia: Evolution of an auriferous vein system during progressive deformation: Econ. Geol., v. 90, p. 1764-1775. Author at Etheridge Henley Williams Geoscience Consultants, PO Box 250, West Deakin, ACT 2600, Australia.

Au mineralization occurred during the middle to latest stages of deformation. Mineralization was via low-salinity, H_2O-CO_2-CH_4 F [literature data]. Au deposition occurred in the vicinity of vein intersections as a result of repeated F P fluctuations that may have allowed mixing of relatively reduced F, which had locally equilibrated with carbonaceous wall rocks, with more oxidized, deeply sourced, auriferous F. (From author's abstract by E.R.)

WINSLOW, D.M., CHAMBERLAIN, C.P. and ZEITLER, P.K., 1995, Metamorphism and melting of the lithosphere due to rapid denudation, Nanga Parbat Massif Himalaya: J. Geology, v. 103, p. 395-409. First author at Dept. Earth and Environmental Sciences, Lehigh Univ., Bethlehem, PA 18015.

Thermobarometry on the nonmigmatized gneisses reveals conditions of 540-740°C at 7.1-13.1 kbar. Thermobarometry in the migmatized rocks reveals final equilibration at 608-675°C at 3.9-6.8 kb. Early FI occur in quartz I within garnet porphyroblasts that grew during decompression. The last FI to be trapped occur in microfractures that locally crosscut several grain boundaries and, hence, record conditions after quartz grain boundary migration ceased. Examination of all the petrologic and FI data conclusively show a very rapid denudation event late in the collisional process. Rapid denudation resulted in the advection of isotherms to shallow crustal levels causing an elevated geotherm ~60°C/km) in the upper crust, metamorphism along shear zones, and partial melting of the crust at depths of ca. 22 km. (From authors' abstract by E.R.)

WOOD, B.J., 1995, The effect of H_2O on the 410-kilometer seismic discontinuity: Science, v. 268, p. 74-76. Author at Dept. Geology, Univ. Bristol, Bristol BS8 1RJ, UK.

The observed width of the discontinuity constrains the maximum H_2O content of upper mantle olivine to ~200 ppm by weight. (From author's abstract by E.R.)

WOOD, B.J., FROST, D. and PAWLEY, A., 1995, Experimental measurements of the properties of H_2O and CO_2 above 10 kb: Bochumer Geol. U. Geotech. Arb., v. 44, p. 264-266.

WOOD, G.D., TOBIN, R.C. and STEPHENSON, J.T., 1995, Stratigraphy, paleoenvironmental and thermal maturity of Cambrian strata, Reelfoot Rift, southeastern Missouri: A case study of integrated palynology, sedimentology and geophysics (abst.): AAPG Abstracts, v. 4, p. 106.

Indexed under FI. (E.R.)

WOOD, K.Y., 1995, Kyanite-bearing pegmatites in the blue ridge of North Carolina (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. A-469.

Unusual kyanite-bearing pegmatites occur in hercynite Opx amphibole schists in the Ashe Metamorphic Suite of the Eastern Blue Ridge of North Carolina. Several textural, mineralogical and chemical features suggest an igneous origin for these pegmatites. These include zonal structure; wide variation in crystal size, orientation, and morphology; clustering of tourmaline crystals around some kyanite blades; elevated manganese in garnets; graphic intergrowths of tourmaline plus quartz; and euhedral mica crystals.

Inner zone quartz contains CO_2-N_2 FI ($XCO_2 = 0.90$) with molar volumes from 40 to 60 cm^3/mol. Extrapolation of isochores to peak metamorphic conditions (defined by coexisting kyanite and sillimanite in associated pelitic schists) suggest minimum formation conditions of 620 MPa and 600°C. Partial melting in the pelitic rocks suggests that the peak T may have been slightly higher. However, the presence of muscovite places an upper limit of ~710°C on peak T. (From authors' abstract by H.E.B.)

WOODRUFF, L.G., FROELICH, A.J., BELKIN, H.E. and GOTTFRIED, David, 1995, Evolution of tholeiitic diabase sheet systems in the eastern United States: Examples from the Culpeper Basin, Virginia-Maryland, and the Gettysburg Basin, Pennsylvania: J. Volcanol. and Geothermal Res., v. 64, p. 143-169.

High-TiO_2 quartz-normative- (HTQ) tholeiite sheets of Early Jurassic age have intruded mainly Late Triassic sedimentary rock-several early basins in the eastern U.S. Field observations, petrographic geochemical analyses and stable isotope data from three HTQ sheet systems in the Culpeper basin of Virginia and Maryland and the Gettysburg basin of Pennsylvania were used to develop a general model of magmatic differentiation and magmatic hydrothermal interaction for HTQ sheets. Differentiated diabase in all three sheets have petrographic and geochemical signatures and FI indicating hydrothermal alteration beginning near magmatic T and continuing to relatively low T. S and O isotope data are consistent with a magmatic origin for the hydrothermal F. The influence of H_2O on the physical properties of the residual L, including density, viscosity and liquidus T, may have facilitated the lateral movement >15 km updip in the sheets. Exsolution of a Cl- and S-rich metal-bearing aqueous F from residual magma resulted in concentration and redistribution of incompatible and aqueous-soluble elements in late-stage differentiated rocks. This proposed hydrothermal mechanism has important economic implications as it exerts a strong control on the final distribution of noble metals in these types of diabase sheets. (From authors' abstract by E.R.)

WORDEN, R.H., SMALLEY, P.C. and OXTOBY, N.H., 1995, Gas scouring by thermochemical sulfate reduction at 140°C (abst): AAPG Bull., v. 79, no. 6, p. 854-863.

Indexed under FI. (E.R.)

WORDEN, R.H., WARREN, E.A., SMALLEY, P.C., PRIMMER, T.J. and OXTOBY, N.H., 1995, Reply to a discussion of 'Evidence for resetting of fluid inclusion temperatures from quartz cements in oilfields' by Osborne and Haszeldine (1993): Marine and Petroleum Geol., v. 12, p. 566-570. First author at Dept. Geology, The Queen's Univ. Belfast, Belfast BT7 1NN, UK.

In their paper, Osborne and Haszeldine (1993) asserted that, because of their propensity to deform and "reset," FI in quartz cement cannot be relied upon as indicators of cement precipitation T. We welcome their paper in that it is always wise to scrutinize the validity of data upon which models are built. However, we feel that all the pieces of evidence for I resetting presented by Osborne and Haszeldine are better explained in other ways. While accepting that in certain cases it may be *possible* for FI in quartz to be reset, our contention is that this is rare under diagenetic conditions. A blanket dismissal of such FI data would thus deny researchers a valuable tool for understanding sandstone diagenesis. (Authors' abstract)

See also Walderhaug (1995), this volume. (E.R.)

WU, Changnian, ZHU, Jinchu, LIU, Changshi and XIONG, Xiaolin, 1995, Study of compositions of melt[ing] fluid inclusions in pegmatites, Altay, Xinjiang: Geochimica, v. 24, no. 4, p. 347-358 (in Chinese, English abstract). Authors at Dept. Earth Sciences, Nanjing Univ., Nanjing 210008, PR China.

Laser Raman microprobe was applied to analyse the composition of different phases of individual M FI in spodumenes and beryls from the pegmatites of Koktokay, Kelumute and Kuwei, Altay, Xinjiang. The solid phases were identified as dxl silicate minerals, and the quantitative composition of F phases were also obtained. The whole composition of M FI was estimated based on both dxls and F phase components. The solubility of F in M was also discussed. The results indicate that the F in M was saturated or oversaturated, and the F phase fractionated from the M phase. The corresponding residual pegmatitic magma system may have entered the magmatic-hydrothermal transitional stage in which crystal, M and F phases coexist. The formation of Altay pegmatite was closely related to the magmatic-hydrothermal transitional stage. (Authors' abstract)

WU, Changnian, ZHU, Jinchu, LIU, Changshi, YANG, Shengzu, NING, Guangjin and ZHU, Bingyu, 1995, The physico-chemical conditions of formation of beryl in the Kuwei pegmatite, Altay, Xinjiang: Acta Mineralogica Sinica, v. 15, no. 3, p. 346-351 (in Chinese, English abstract). First author at Dept. Earth Sciences, Nanjing Univ., Nanjing 210093, PR China.

The physico-chemical conditions of formation of beryl have been explored based on I studies of beryls from the Altay pegmatite, Xinjiang. Two types of I have been found: silicate dxl-bearing FI and G-L FI. The silicate dxl-bearing FI represent a supercritical F phase of magmatic-hydrothermal transitional stage. Based on the studies of the density, salinity, T and P of formation of I, it is suggested that CO_2 density is fairly high, $\rho CO_2 = 0.68\text{-}0.96$ g/cm^3; salinity very low, NaCl wt % = 3.21%-3.77%; T >480°C, P ~1.5-3.77 kb in the system during the formation of beryls. (Authors' abstract)

WU, Chengyu, YUAN, Zhongxin, HUANG, Dianhao and BAI, Ge, 1995, Genesis of REE-bearing fluids related to calc-alkalic and alkalic granitic systems: Implications from isotope and fluid inclusion geochemistry, *in* Pasava, Kríbek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 547-550. Authors at Inst. Mineral Deposits, Chinese Acad. Geological Sciences, Beijing, PRC.

Two types of REE-bearing F are recognized in China, which are related to alkalic and calc-alkalic granitic systems, respectively. FI and isotope geochemistry reveal that the two types of systems originate from the lower crust and the upper crust, respectively. Rare earths are largely derived from source regions which generate the magmas, rather than from surrounding wall rocks at high level. Although situations are changeable from place to place, both magmatic F and meteoric waters are, in most cases, involved in hydrothermal alteration and circulation which result in rare earth mineralization. (Authors' abstract)

Quartz, calcite and fluorite from the Maoniuping deposit had Th 150-300 and 340-410°C. Sal = 3-20% and 28-43 for two types of PI. Dms = halite, barite, apatite(?), $K_2SO_4 + Na_2SO_4$. Quartz from the Longnan deposit had Th 300-360°C; sal. 1-2%. (E.R.)

XIA, Linqi, XIA, Zuchun, ZHANG, Cheng and XU, Xueyi, 1993, On the relationship between mantle metasomatism and partial melting—Evidence from mantle-derived lherzolite xenoliths from Nüshan, China: Chinese J. Geochem., v. 12, no. 4, p. 289-306 (in English). Authors at Xi'an Research Inst. Geology and Mineral Resources, Ministry of Geology and Mineral Resources, Xi'an 710054, PRC.

Studies of the mantle-derived lherzolites from Nüshan show that in addition to CO_2, there were present H_2O and small amounts of CO, CH_4, SO_2, Cl and F in the initial mantle F derived from the asthenospheric mantle plume. The initial F accumulated in some regions of the mantle, resulting in lowering of the mantle solidus (and liquidus) and partial melting of the upper mantle. M formed from low-degree of F-involved partial melting of the upper mantle would be highly enriched in incompatible elements. F and M are all the metasomatic agents for mantle metasomatism, and the interaction between them and the depleted mantle could result in the substantial local enrichment of LREE and incompatible elements in the latter. In case that the concentration of H_2O in the F (and M) is lower, only cryptic metasomatism would occur; in case that the concentration of H_2O is higher, the degree of partial melting would be higher and hydrous metasomatic phases (e.g., amphiboles) would nucleate. Under such circumstances, there would occur modal metasomatism. (Authors' abstract)

XIA, Xinjie and SHU, Jianwen, 1995, Geologic characteristics and origin of the Limei zinc sulfide deposit: Geotectonica et Metallogenia, v. 19, p. 197-204 (in Chinese, English abstract). Author at The 405 Geological Team, Hunan Bureau of Geology and Mineral Resources, Jishou 416007, China.

The economically important Limei Zn-sulfide deposit of the Yutang massive Pb and Zn-sulfide deposit was predicted by the Diwa theory several years ago. The deposit is polygenetic with the Zn content high (>5%) while the Pb content is very low. The main orebodies which occur in a platform margin in algal reef limestone of Qingxudong Formation are structurally controlled by the dome and Diwa structures (NNE- and WNW-trending). During the platform stage, structural pressure solution mineralization occurred owing to the P-melting effect of the ore source bed and during the Diwa mineralization occurred vadose hydrothermal mineralization. Ore-forming metals (Zn, Pb) were derived primarily from the carbonate wall rocks. (Author's abstract)

Th and FI chemistry is given for FI hosted by galena, barite, and calcite. (H.E.B.)

XIA, Yong, WU, Xueyi and YANG, Yuangen, 1995, Fluid inclusion studies of gold deposits in the Gezhen shear zone, Hainan Province, China: Chinese J. Geochemistry, v. 14, p. 371-380 (in English).

See FIR, v. 27, p. 161. (E.R.)

XIANG, Xinkui, 1991, Tectonic evolution of the Taqian-Zhuxi polymetallic metallogenic zone, northeastern Jiangxi Province, China, and the formation of polygenetic compound ore deposits (abst.): Contributions of Chinese Scientists to 2nd Int'l Symp. on Diwa Tectonics and Metallogeny, August 1991, Blagoveshchensk, USSR, p. 80-81. Author at The 916 Geological Team, Jiangxi Bureau of Geology, Jiujiang, Jiangxi, China.

The explosion T [i.e., Td] of quartz associated with metal sulfide in the Taqian mine is 320-360°C. $\delta^{34}S$‰ values of ore bodies in the Zhuxi mine range from 2.0 to 4.3 and 3.4 on average. The T for ore formation is 135°C, but explosion T of another sphalerite is 190°C. Ore deposits formed in the maximum-mobility period of the Diwa stage were partially or wholly buried under the geosynclinal metamorphic rocks because of the gravity sliding-overthrust occurring in the residual-mobility period, thus forming blind or half-blind deposits. (From author's abstract by H.E.B.)

XIAO, Rongge, CHEN, Huiquan, SHUAI, Kaiye and YANG, Zhongfang, 1994, Mineralization of Jinman copper deposit in Mesozoic sedimentary rocks in Lanping, Yunnan Province: Geoscience (Xiandai Dizhi), J. Graduate School, Chinese Univ. Geosciences, v. 8, no. 4, p. 490-496 (in Chinese, English abstract). Authors at China Univ. Geosciences, Beijing 100083, China.

The epihydrothermal Cu deposits occur within red sedimentary rocks of Lanping-Simao Mesozoic-Cenozoic basin, Yunnan province. The assemblage of quartz-ankerite-Cu sulfides, including chalcopyrite, bornite and clino[h?]edrite, is prevalent in veins within sand and shale rocks, whereas cilnoedrite [sic], calcite and barite fill vugs within fundamental carbonates. Ore structure is characterized by brecciated and vein structure. Ore veins are situated in regions of fold associating longitudinal fault breccia zones.

Sr, S and Pb isotopes, REE evidence and FI data from Jinman Cu deposits suggest that ore-forming elements originated from sedimentary rock, Cu-bearing F from basinal brines and S from reduced sulfate and leached sedimentary sulfides. Ore-bearing F with salinities ranging from 5% to 20% NaCl consists of $H_2O\text{-}NaCl\text{-}CO_2$ type brine, which homogenized at T between 150°C and 300°C.

CO_2-bearing FI suggest the P >6 × 10^7 Pa during mineralization. This P corresponds to rock P at depths of 3 km. Minerogenesis of the ore-bearing brine deposits and abrupt metallogenesis are suggested. The ore-bearing brine, being amassed into suitable structural regions like oil and natural gas before metalization, explodes abruptly and deposits metallic minerals during mobilization. Mineralization stages consist of distinct phases, expulsion filling, infiltration filling and structural reforming phases. The hydrothermal movement was included during the first and second phases. (Authors' abstract)

XIE, Yanhan, WANG, Yinglan and ZHHANG, Rupan, 1995, A discovery of REE mineral in fluid inclusions from Beiyun Obo deposit: Chinse Sci. Bull. (Keue Tongbao), v. 40, p. 1870-1872 (in English).

XU, G., YAO, S., ZHANG, C. and WANG, P., 1995, A case study of the Zhilingtou gold-silver deposit, Zhejiang, China: Australasian Inst. Mining and Metallurgy, Publication Series, 9/95 [PACRIM 1995], p.645-649.

Indexed under FI. (E.R.)

XU, Qidong, ZHONG, Zengqiu, QI, Xianmao and SUO, Shutian, 1995, Ore-forming fluids in mesothermal gold deposits of Tongbo-Dabie area: Their properties and precipitation mechanism: Mineral. Deposita, v. 16, p. 59-72 (in Chinese, English abstract). First author at China Univ. Geosciences, Wuhan 430074, China.

FI studies of 10 mesothermal Au deposits (occurrences) in Tongbo-Dabie area show that the ore-forming F are of the NaCl-CO_2-H_2O system with low salinity (6 wt % NaCl) and rich CO_2 (10 mol %). At the depth of 4-10 km, the F dominated by evolutionary water precipitated during the complex three-stage immiscible process which took place due to the sudden change of P from the lithostatic P state to the hydrostatic P state, and Au mineralization occurred at the late stage of this process. The sudden change of the P state resulted from the uplifting of the Tongbo-Dabie orogenic belt at the late stage of Mesozoic collision orogeny when the deformation system of this belt transformed from the compression state to the extension state. (Authors' abstract)

YAMASHIA, H. and OHTANI, E., 1995, High-pressure and high-temperature experiments of group II kimberlite at 7 GPa: Compositions of volatile-rich melts in the upper mantle: Kanagawa Prefecture Museum, Natural Science, v. 24, p. 1-8 (in Chinese).

YANG, Wenbo, SPENCER, R.J. and KROUSE, H.R., 1995, Stable isotope and major element compositions of fluid inclusions in Devonian and Cambrian dolomite cements, western Canada: Geochim. Cosmochim. Acta, v. 59, p. 3159-3172. First author at Dept. Geology and Geophysics, Univ. Calgary, Calgary, Alberta T2N 1N4, Canada.

Homogenization and melting T, major element and H and O isotope data for FI, and C and O isotope data for dolomite from the Manetoe Facies (Devonian) and Cathedral Formation (Cambrian) of western Canada indicate that the dolomite cements formed from alteration of the host limestone by heated mixtures of evaporated seawater or residual evaporite brines and meteoric water.

The measured $\delta^{18}O$ values for FI waters are much more negative (~8‰) than those calculated for waters in isotope equilibrium with dolomite at the moderately high Tf. FI waters appear to have exchanged O isotopes (reequilibrated) with the host dolomite as they cooled. The data may provide low T isotope exchange equilibrium fractionation factors between dolomite and water.

Since no H-bearing compounds other than H_2O were found in these samples using Quadrupole Mass Spectrometry, the I F likely retained their initial H isotope compositions. Therefore, their δD values (-81 to -42‰) are more useful for determining the origin of the dolomitizing F. (Authors' abstract)

YANG, Wenbo, SPENCER, R.J., KROUSE, H.R., LOWENSTEIN, T.K. and CASAS, E., 1995, Stable isotopes of lake and fluid inclusion brines, Dabusun Lake, Qaidam Basin, western China: Hydrology and paleoclimatology in arid environments: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 117, no. 3-4, p. 279-290.

The Qaidam Basin, underlain by salt, is the largest (120,000 km^2) on the Qinghai-Tibet Plateau, western China. Numerous shallow to ephemeral saline lakes and dry saline pans are present on the Qarhan Salt Plain. Dabusun Lake, the largest (~200 km^2), contains high salinity Na-Mg-Cl brines. Whereas it precipitates halite, it is fringed by a potash salt flat. The dominant inflow to Dabusun Lake, the Golmud River, contains dilute $Na^+HCO_3^-$-rich meteoric waters. Dabusun Lake brines fall on an evaporation trend given by $\delta D(0/00) = 3.3\ \delta^{18}O-43$. Both δD and $\delta^{18}O$ values increase with salinity which in turn varies considerably with flooding and evaporation. The isotope compositions of the FI brines from modern halite formed along the lake's edge are intermediate to those of Dabusun Lake brines and those from the salt flat. Shallow sediments beneath Qarhan consist of interbedded salts and mud. A short core section (1.3-1.7 m depth) from the northern edge of Dabusun Lake was found to contain three dissolution surfaces and three mud partings. The $\delta^{18}O$ values for FI in 22 primary halite samples from this section show a record of episodic flooding (lower $\delta^{18}O$ values) followed by evaporation (gradual increase in $\delta^{18}O$ values). P FI in halite crystallized initially at the surface provide a geochemical record of surface brines. Their major element compositions varied through time. More concentrated F indicate more arid conditions in the basin, whereas wetter conditions prevailed during intervals of non-salt deposition when laminated muds accumulated. The isotope compositions together with the activity of H_2O of FI in primary halite were used to determine isotope variations in regional precipitation and hence paleoclimatic changes on the Qinghai-Tibet Plateau during the past 50,000 years. (Authors' abstract)

YAO, Qingjun and DEMICCO, R.V., 1995, Paleoflow patterns of dolomitizing fluids and paleohydrogeology of the southern Canadian Rocky Mountains: Evidence from dolomite geometry and numerical modeling: Geology, v. 23, p. 791-794.

Massive dolomites, hosted in the Cambrian-Ordovician of southern Canadian Rocky Mountains, form strata-bound sheets over broad platforms, except near the margin, where they also form dikes that crosscut sedimentary bedding planes. Field evidence indicates that the two kinds of dolomite bodies were formed by pervasive, formation-parallel flow and fracture-channeled, cross-formational flow, respectively. FI data indicated that the primary dolomitizing F were warm to hot (100 to 200°C) saline brines (13-25 wt %). The timing of dolomitization (Silurian to Late Devonian) coincided with the timing of the early Paleozoic contractional deformation in the west. Finite element modeling showed that the observed dolomite geometry and geochemistry are consistent with miogeocline-scale ground-water flow driven by west-to-east topographic relief. (Authors' abstract)

YAO, Q.J., ONSTOTT, T.C., LA FRENIERE, L., LORENZ, J.C. and BOSTICK, N.H., 1995, Thermal and hydrothermal history of southern Piceance Basin: New fluid inclusion, vitrinite reflectance, and stable isotope evidence (abst.): Geol. Soc. Am., Absts. with Programs, v. 27, no. 6, p. 312.

YAO, Zujin, 1995, Tectonic-hydrologic characteristics of the gold metallogenic belt along the northern margin of North China platform: Mineral Deposits (Kuangchuang Dizhi), v. 14, no. 4, p. 335-345 (in Chinese, English abstract). Authors at Inst. Hydrogeology and Engineering Geology, Zhengding 050803, China.

Lying 100°-130° E longitude and 38°-43° N latitude, the EW-trending Au metallogenic belt along the northern margin of North China platform, a belt 2000 km in length and 100 km in width, consists of >100 hydrothermal Au-Ag deposits. Wall rocks include Archean and Proterozoic metamorphic rocks as well as Mesozoic granite and volcanic rocks. In the past, controversy existed concerning such ore-forming problems as hydrothermal types and metallogenic epochs of these ore deposits, and even of one deposit.

Based on measured data of some 500 I in ores from over 40 deposits, the. author has compiled a deuterium contour map for the study area. The distribution of deuterium might be explained by Mesozoic paleogeography. It can be seen from the diagram that varied ore deposits show an integrity and unity in the ore-forming process of meteoric water.

On the basis of calculated water-rock ratio of each ore-forming system and its position in the $\delta^{18}O$-δD coordinate, the author has found that ore deposits of this Au metallogenic belt might be divided into three metallogenic series, with each series composed of a core and a periphery, suggesting that ore deposits formed by ore F rich in magmatic water are located at the core, and lots of ore deposits formed by ore F deficient in magmatic water make up the periphery around the core. There seems to be regularity in the arrangement of the three metallogenic series: from the inland to the epicontinental area, ore-forming T increase from 190°C through 275°C to 300°C, and metallogenic epochs change correspondingly from old to young, i.e., from $J_1 + J_2$ to J_3 + K. (From authors' abstract by H.E.B.)

YARDLEY, B.W.D. and BANKS, D.A., 1995, The behaviour of chloride and bromide during the metamorphic cycle, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 625-628. Authors at Dept. Earth Sciences, Univ. Leeds, UK.

FI from metamorphic rocks developed from continental and continental margin sequences are commonly of high salinity, and their Cl/Br ratios are broadly similar to those of F from comparable sedimentary formations drilled today, although there may be some relative enrichment in I and depletion in Br. Metamorphic F from oceanic settings appear to be of much lower salinity, reflecting either different burial rates or the lack of evaporites in the sedimentary succession. Thus the salinity of metamorphic F, and hence the potential for F immiscibility at high grades, may be inherited from the sedimentary environment. (Authors' abstract)

YARDLEY, B.W.D., MEERE, P.A., CATHELINEAU, M. and VALLEY, J.W., 1995, Are quartz veins forming under Strasbourg today? A stable isotope study of vein quartz from Soultz-sous-Forêts (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 185.

Drilling in the Upper Rhine Graben near Soultz-sous Forêts, c.50 km north of Strasbourg, France, has been carried out as part of the European Hot Dry Rock Project. Two drill holes, GPK 1 and EPS 1, reached depths >2000 m and encountered flows of warm water (≤150°C) in granite. Drillcore of granite from EPS 1 includes fractured regions with altered rock enclosing veins of quartz, baryte and carbonate. FI suggest that the veins minerals grew under similar thermal conditions to those prevailing today, but show a wider range of F salinities (Meere et al., this meeting).

Small (c. 1 mg) pieces of granite-hosted vein quartz from EPS 1 have been analyzed for their O isotopic composition using on-line laser fluorination at Madison. The results show significant variation within veins (<c.2.5‰), but even larger differences between veins. Original igneous quartz is of rather uniform composition, $\delta^{18}O_{SMOW}$ = c.10‰.

Fourteen analyses of a single vein from 1639 m depth range from 13.5 to 16.1 ‰, with a tendency to a bimodal distribution, while most analyses of four deeper veins correspond to the lighter part of this range, or are even lighter. The deepest vein analysed, from 2052 m, yielded values c. 10.5‰, and the T calculated assuming equilibrium between this quartz and the present F (-2.5‰, Pauwels et al., 1993, Geochim. Cosmochim. Acta, 57, 2737-2749) is c. 190°C, compared to the F quartz geothermometer T of 196.5°C, and measured T of 150°C. Our results suggest veins grew under substantially the present day conditions, but the scatter could be interpreted in terms of either change in T with an essentially constant F, or change in F composition within the present thermal structure. The latter alternative agrees well with the FI evidence, and the lighter, deeper F may reflect more extensive exchange with granite in the present hydrothermal system while the heavier F retain a signature that may reflect connate waters in the overlying sediments. Interestingly, a single analysis of vein quartz from GPK 1 (Fouillac and Genter, 1991, Geotherm. Sci. and Tech., 3, 105-117) is still heavier than any of the values reported here, suggesting a still greater contribution from connate F. (Authors' abstract)

See also Meere et al., this issue. (E.R.)

YECHIELI, Yoseph, RONEN, Daniel and BERKOWITZ, Brian, 1995, Are sedimentary salt layers always impermeable?: Geophys. Res. Lett., v. 22, no. 20, p. 2761-2764. First author at Geol. Surv. Israel, Jerusalem, Israel.

We report here, for the first time, the finding of a 24 to 31 m deep, 1000 y old, water-saturated and highly hydraulically conductive salt layer composed of idiomorphic halite crystals in the coastal area of the Dead Sea. The high hydraulic conductivity of the layer was evidenced by laboratory and field tests and by the rapid fluctuations of the water table, in a well penetrating the layer, following variations in the water level of the Dead Sea. Such layers may lead to intensive and rapid flow of water and non-polar liquids. (Authors' abstract)

YERMOLAYEV, N.P., CHINENOV, V.A., KHOROSHILOV, V.L., GORYACHKIN, N.I. and SIDOROV, V.A., 1994, Mineralizing-fluid characteristics at gold and silver deposits in black shales: Geokhimiya, no. 8-9, p. 1275-1286 (in Russian; translated in Geochem. Int'l, v. 32, no. 4, p. 145-156, 1995). Authors at Lithosphere Inst., Russian Acad. Sci., Moscow, Russia.

The dependence of the chemical composition of the F on the degree of physicochemical openness of the ore-forming system is analyzed. The changes in composition of the F that are detected during mineralization are identical in different regions, in host carbonaceous shales that differ in age and metamorphism, and in different epochs of metallogenic activation and do not depend on the presence or absence of magmatic rocks. (Authors' abstract)

YIN, Jianzhao and SHI, Hongyun, 1995, Mineralogy characteristics of quartz in Zhangquanzhuang gold deposit, northwestern Hebei Province: Geoscience (Xiandai Dizhi), J. Graduate School, China Univ. Geosciences, v. 8, no. 4, p. 459-465 (in Chinese, English abstract).

See FIR, v. 27, p. 166.

YOU, C.F., SPIVACK, A.J., GIESKES, J.M., ROSENBAUER, R. and BISCHOFF, J.L., 1995, Experimental study of boron geochemistry: Implications for fluid processes in subduction zones: Geochim. Cosmochim. Acta, v. 59, p. 2435-2442. First author at Scripps Inst. Oceanography, La Jolla, CA 92093.

Our experimental results demonstrate high mobilization of bulk B in sediments (both exchangeable and lattice bound) at elevated T (200-350°C), in good agreement with previous observations of B in metasediments indicating progressive depletion during metamorphism. (From authors' abstract by E.R.)

YU, Tiejie and LUO, Zongduan, 1995, A combined method for the preparation of samples for stable isotopic analysis and the compositional analysis of gas and liquid phases in fluid inclusions: Acta Mineralogica Sinica, v. 15, no. 3, p. 338-345 (in Chinese, English abstract). Authors at Research Inst. Geology for Mineral Resources, CNNC, Guilin 541004, PR China.

A combined method has been developed for the preparation of samples for stable isotopic analysis and the compositional analysis of G and L phases in FI, i.e., the preparation of samples for stable isotopic analysis with G-chromatography. The $\delta^{13}C$, δD, $\delta^{18}O$ and the composition of G and L phases in FI can be measured on the same sample.

The whole set of equipment is good in performance. The requirements [are satisfactory] for FI measurement. The standard deviation for the preparation of samples and determination results is ≤3‰ for δD; ≤0.3‰ for $\delta^{18}O$; and 0.14‰ for $\delta^{13}C$. The composition of G phase in FI which can be determined includes CO_2, H_2, CO, CH_4, N_2, H_2O, etc. The composition of L phase can be determined by the available methods. The main anions and cations in FI including K^+, Na^+, Ca^{2+}, Mg^{2+}, F^-, Cl^-, SO_4^{2-}, etc. can be determined. (Authors' abstract)

YU, Wenqing and LI, Changshun, 1995, Geological features of the Xiangluwanzi gold deposit and its origin in Jilin Province: Jilin Geology, v. 14, no. 3, p. 44-54 (in Chinese, English abstract). Authors at Ministry of Nuclear Industry, Changchun City 130062, China.

In this paper, the characteristic of deposit origin as well as ore guide are described, mainly including geologic setting, features and ore-control factors, especially a brittle-ductile shear zone as both rock control and ore control, its origin and criteria for ore prospecting in the Yancongqiaozi-Longtou area. (Authors' abstract)

Presents Th and FI chemistry data. (H.E.B.)

YUI, T.-F., 1995, Stable isotope studies of marble/schist in the Tungao area, northeastern Taiwan: Characteristics of the metamor-

Tungao area, northeastern Taiwan: Characteristics of the metamorphic fluid: Geol. Soc. China, v. 38, p. 1-14.

YUSUPOV, R.G., POLYKOVSKIY, V.S. and MUSTAFIN, S.K., 1994, Native metals and nonmetals, carbides and silicides and the gas composition of their fluid inclusions (central and southern Tien Shan): Dokl. Ross. Akad. Nauk, v. 336, no. 4, p. 518-520 (in Russian).

ZACHARIÁS, J., PERTOLD, Z., PUDILOVÁ, M., PERTOLDOVÁ, J., BENDEL, J. and MARCOUX, E.M., 1995, Porphyry-Au mineralization in the Bohemian Massif: Its magmatic and hydrothermal evolution, *in* Pasava, Křibek and Zák, eds., Mineral Deposits: Balkema, Rotterdam, p. 211-214. First author at Fac. Sci., Charles Univ., Prague, Czech Republic.

A new mineralisation of porphyry Au style has been recently described from Bohemian Massif at the Petráckova Hora deposit. Five structural types of quartz (Q) veins have been described, Q_1 being the oldest and most Au-rich. FI studies have been successful only in Q_2, Q_3, Q_5 types and were extremely difficult due to intense deformation of all Q veins.

Most of the FI are two-phase, L-rich (4-23 wt % NaCl eq., Th(L): 230-375°C); minor are the polyphase FI (L, V, NaCl ± KCl ± opaque dms, 46-50 wt % NaCl eq., Th-tot (L): 220-300°C). No V-rich FI has been found; however; the Th-salinity diagram shows trend [i.e., a positive slope] similar to the boiling effect. The existence of two types of solutions, one of them highly saline, could be explained by immiscibility or the presence of different, directly magma-derived solutions. Similar FI (L-rich and polyphase) have been also found in magmatic quartz from the granodiorite. This together with the stable isotope characteristics could reflect the magmatic character of the major part of Au-bearing F. (From authors' text by E.R.)

ZACHARIAS, J., PUDILOVA, M., PERTOLD, Z., PERTOLDOVA, J., BENDL, J. and WILKINSON, J., 1995, Fluid characteristics of Variscan porphyry gold system: An example from Bohemian Massif, Czech Republic (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 270-271. First author at Charles Univ., Albertov 6, 128 43 Prague 2, Czech Republic.

The Petráckova deposit is related to a small (0.16 km^2) granodiorite stock, which intruded into Cambrian metasedimentary and volcanosedimentary rocks. Mineralisation (Au+/-W,Bi,Cu) is related to a stockwork of thin quartz veins and veinlets (0.X-15 cm). Ore assemblages indicate lower fugacities of S, Te, O than typical for hydrothermal and porphyry Au deposits. Hydrothermal alterations are present only in small volumes. K-feldspar alteration and silicification prevail, phyllic and propylitic alterations are absent. O isotope studies of cogenetic minerals from Q veins revealed high T character (550-450°C) and relatively constant F composition (6-7‰ $\delta^{18}O$). Isotopic T for K-alterations (530-610°C) are identical with that of granodiorite (530-640°C), and composition of alteration and magmatic F (5.5-6.5 $\delta^{18}O$)is similar to that of Au-Q-veins. The estimated $\delta^{18}O$ whole rock value for granodiorite (4.6‰) is lower than typical values for igneous rocks.

FI have been studied in three vein types, with no significant differences found. Most of the FI are two-phase L-rich (4-23 wt. % eq. NaCl, TFM: -23.5 to -22°C and Th(L): 230-360°C), minor type represent polyphase I with two to three dms (NaCl and KCl). The estimated KCl/NaCl ratio (1.4) is higher than in most porphyry Cu deposits. Increase in salinities together with decrease in Th indicate possible boiling of F. However, no V-rich FI have been found to confirm this suggestion.

Using the isotopic T of Q vein formation (530-450°C), FI isochores indicate possible TP of 1-2.8 kb. This does not correlate with a supposedly shallow subvolcanic character of intrusion. (From authors' abstract by E.R.)

ZAGORSKIY, V.Ye., PROKOF'YEV, V.Yu. and KUZ'MINA, T.M., 1992, Melt inclusions in spodumene and quartz from rare-metal pegmatites: Dokl. Ross. Akad. Nauk, v. 325, no. 2, p. 354-356 (in Russian; translated in Dokl. Acad. Nauk SSSR, v. 327, no. 8, p. 121-xxx, 1994).

ZEEH, S., 1995, Complex replacement of saddle dolomite by fluorite within zebra dolomites: An example from Radnig, Carinthia, Austria: Mineral. Deposita, v. 30, p. 469-475. Author at Geologisch-Paläontologisches Inst., Im Neuenheimer Feld 234, D-69120 Heidelberg, Germany.

A lateral transition of saddle dolomite into fluorite is observed within zebra dolomites of the Triassic Wetterstein Formation of the Drau Range (Carinthia/Austria). This lithological change is the result of a replacement of saddle dolomite by fluorite. Artificial staining of fluorite crystals by electron bombardment during cathodoluminescence indicates that fluorite crystals have a zonation typical of fluorite as well as of saddle dolomite. A combined dissolution/precipitation model is therefore proposed. FI studies indicate that these processes occurred at T between 124 and 156°C. (Authors' abstract)

ZEEH, S., BECHSTAEDT, T., McKENZIE, J. and RICHTER, D.K., 1995, Diagenetic evolution of the Carnian Wetterstein platforms of the Eastern Alps: Sedimentology, v. 42, p. 199-222.

Indexed under FI. (E.R.)

ZENG, Zhangren and ZHANG, Lianchang, 1995, Analysis of ore-forming physicochemical conditions and ore-forming mechanism of gold deposit in Kanggul Xinjiang: J. Xi'an College of Geology, v. 7, no. 3, p. 1-8 (in Chinese, English abstract). Authors at Xi'an College of Geology, PR China.

The Kanggul Au deposit is an alteration rock-type Au deposit formed in a volcanic rock sequence. The deposit is controlled by the ductile shear zone. By studying the mineral I and calculating the data of thermodynamics it is found that the ore-forming T is 320-150°C, the P is 6.00×10^7 to 1.50×10^7 pa and the ore-forming F is [moderately salty], neutral acidity and reducing. The Au is [carried] in the form of S-H complex in the F. The mechanism of the Au deposit-enrichment is as follows: a mixed function of the rising hydrothermal solution and the meteoric water; the decrease of reducing S and T; the change of pH value in the solution, and so on. The deposit was formed in the phase of ductile-brittle deformation. (Authors' abstract)

ZHANG, Jingrong, LU, Jianjun, WU, Aiping, ZHU, Kaijun and SHENG, Zhonglie, 1995, Ore-fluid systems of fine disseminated gold deposits along the southeastern margin of the Yangtze Plate: Chinese J. Geochem., v. 14, no. 3, p. 193-202 (in English). First author at Dept. Earth Sciences, Nanjing Univ., Nanjing 210093, PRC.

Fine disseminated Au deposits occurring along the SE margin of the Yangtze Plate belong to the epithermal type resulting from different systems of ore-forming F. According to their sources, the ore-forming F can be divided into four systems: (a) meteoric water system; (b) oil-brine system; (c) basin-brine system; and (d) magmatic-formation water system. The four hydrothermal systems are responsible for four types of Au deposits, respectively. The meteoric water system produces hot spring Au deposits. The basin-brines, which are derived from fissure water, structural water and absorbed water sealed up in strata, are responsible for the basin-brine-type deposits. The oil-brine system, having the same source as the basin-brines, is characterized by the involvement of organic matter and is responsible for the oil-brine-type deposits. Inclusion F data show that there are obvious differences in chemical composition and C, O, H and S isotopes for these hydrothermal systems. Different metallogenic provinces, in which one of the four systems is dominant, can be recognized in the region. (Authors' abstract)

ZHANG, J., QUAY, P.D. and WILBUR, D.O., 1995, Carbon isotope fractionation during gas-water exchange and dissolution of CO_2: Geochim. Cosmochim. Acta, v. 59, p. 107-114.

ZHANG, Lianchang, ZENG, Zhangren and HAN, Z.X., 1995, Geochemistry of Kangguer gold deposit, Xinjiang: Contrib. Geology and Mineral Resources Research, v. 9, no. 4, p. 12-21. Authors at Xian College of Geology, Ziam 710054, China.

The Kangguer Au deposit of shear belt type, recently discovered, occurs in the volcanics of eastern Tianhan Mountain. Results of trace elements, REE, O, S, Pb isotope analysis and mineral I reveal that ore-forming materials are supplied from volcanic rock. The ore-forming F is composed of meteoric water. By ductile deformation and metamorphism and intrusion of granitic magma, Au migrated, moved to and enriched in mylonite belt. (Authors' abstract)

ZHANG, Ligang, CHEN, Zhensheng, LIU, Jingxiu and YU, Guixiang, 1995, Hydrogen isotope kinetic fractionation in water-rock exchange systems, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 231-235. Authors at Yichang Inst. Geology and Mineral Resources, CAGS, Hubei, PRC.

δD values of FI in quartz at 13 different types of Mesozoic hydrothermal ore deposits in eastern China change with location. In south China, the ore deposits of the central area such as TC, YS and LSK have δD values of ~-60% [sic, throughout abstract, E.R.]; whereas, that in the western region, the LH Au deposit, has δD values of ~-85%. In northern China, the Jiaojia-style Au deposits and JQD vein-type Au deposit of the eastern region have δD values of ~-85% and the BNM vein-type Au deposit of the western region has δD values of ~-130%. In northeast China, the SPS Au deposit of the western region has δD values of ~-130%. In NE China, the SPS Au deposit of the eastern area has δD values of ~-95%; the TJK Au deposit of the middle region has δD values of ~-110%; and the ER Ag deposit of the western part has δD -150%. Correspondingly, the δD values of altered rocks (or minerals) from ore bodies or from wall rocks of ore veins are equivalent to those from FI (except the TC Cu deposit). This indicates that the deposits appear to be in isotopic disequilibrium. (Authors' abstract)

ZHANG, Ligang, CHEN, Zhensheng, LIU, Jingxiu, YU, Guixiang, WANG, Bingcheng, XU, Jinfang and ZHENG, Wenshen, 1995, Water-rock exchange in the Jiaojia style gold deposit—Hydrogen and oxygen isotopic study of altered rocks: Mineral Deposits, v. 14, no. 3, p. 261-272 (in Chinese, English abstract). First author at Yichang Inst. Geology and Mineral Resources, Yichang 443003, PR China.

Vertically downward from the surface to the depth of 1000 m in the Taishang deposit, a large-sized Jiaojia style Au deposit, $\delta^{18}O$ values of 38 phyllic whole-rock samples decrease from 13.0‰± to 8.0‰±, $\delta^{18}O$ values of eight quartz and sericite pairs from phyllic rocks decrease from 14.0‰ and 11.5‰ to 11.0‰± and 9.0‰±, and δD values of 13 phyllic and sericite samples vary from -70‰ to [-]94‰, averaging (85 ± 7)‰ or so. These data demonstrate that $\Delta_{quartz\text{-}sericite}$ values vary stably between 2‰ and 3‰ δ, suggesting that quartz and sericite have basically attained O isotopic equilibrium. Nevertheless, δD values of phyllic rocks and sericite are almost equal to δD values of FI in vein quartz, implying the existence of H isotope dynamic fractionation between hydrothermal F and sericite, which is probably related to boiling and dehydrogenation.

The $\delta^{18}O$ value of ore-forming F at the principal ore-forming stage is estimated to be 5‰±. Therefore, the calculated effective W/R ratio should be >5.0 when the T decreases from 350°C at depth to 250°C at surface. It is hence concluded that the formation of the Jiaojia style large-sized Au deposit must have experienced two W/R stages. At the first stage, extensive interaction took place between meteoric water and basic rocks in a high-T environment at depth; at the second stage, ore-forming F produced at depth ascended to the fractured shatter zone, resulting in diffusion, W/R exchange and mineralization-deposition. On such a basis, metallogenic model of two stage W/R exchange in a buffered open system has been established. (Authors' abstract)

ZHANG, Ligang, LIU, Jingxiu and YU, Guaxiang, 1995, A study on the two-stepped water-rock interaction of some ore deposits from eastern China: H and O isotope composition and evolution (abst.): Resource Geol., v. 45, no. 4, p. 247-248.

Isotopic data for the O and H are given for FI from the Yingshan. PbZnAg(Cu) deposit in Jiangxi, Jiaojia style Taishang Au deposits, Shandong, and the Tuanjiegou Au deposit, Heilongjiang, PRC. (E.R.)

ZHANG, Mingxian and XU, Jiuhua, 1995, Ore-forming fluid geochemistry and genesis of the Chucha-Luanshigou gold deposit in Henan province of China: Contrib. Geol. and Mineral. Resources Research, v. 10, no. 4, p. 60-70 (in Chinese, English abstract). First author at Southwest Inst. Metallurgical Geology, Chengdu 610051, PR China.

Chucha-Luanshigou Au deposit discovered recently is one of the ore deposits in the Central-North Ore Belt of the famous Xiaoqinling Gold Field. Au-bearing quartz veins are controlled by shear zone. They are distributed in Qingmayu Group of Archean. Epoch of hydrothermal Au mineralization is further divided into four stages. Study on the physical geochemical conditions of FI suggest that the deposit is an intermediate-high T hydrothermal deposit. The stable isotopic data of H, O and C suggest that the F of mineralization has characteristics of magmatic water with the addition of meteoric water. The isotopic composition of S and Pb indicate that the material of mineralization was produced by the anatexis of metapyroclastic rocks of Taihua Group, even though its reactivation, migration and enrichment is related with granitic activity of Yanshanian. The cluster analysis of alteration wall-rock minor elements suggests that Au is closely related to Pb, Ag, Cu and indicates that Au and Pb are of the same source. (Authors' abstract)

ZHANG, Yaxiong, 1995, Fluid inclusion study on gold deposits in Shuichang area, Zhejiang: Tectonies and Metallogeny (Geotectonica et Metallogenia Quarterly), v. 19, p. 274-280 (in Chinese).

ZHANG, Youxue, STOLPER, E.M. and IHINGER, P.D., 1995, Kinetics of the reaction $H_2O + O = 2OH$ in rhyolitic and albitic glasses: Preliminary results: Am. Mineral., v. 80, p. 593-612.

ZHANG, Yunpu, SUN, Zhifu and ZHENG, Xiaoli, 1994, Main genetic types gold deposits in Zhao-Ye region, Shandong Province and the metallogenic model of Jiaojia gold deposit (abst.): Abstracts of 9th Symp. Int'l Assoc. On Genesis of Ore Deposits, Beijing, China, Aug. 12-18, 1994, p. 781-783. First author at Bureau of Geology and Mineral Resources, Shandong 265400, China.

The study on the composition of FI in quartz and δD, $\delta^{18}O$ data [deposit unspecified] shows that hydrothermal F is mainly meteoric water and partly from dehydration in diagenetic process of granites. (From authors' abstract by E.R.)

ZHANG, Zhaochong and MAO, Jingwen, 1995, Geology and geochemistry of the Dongping gold telluride deposit, Heibei Province, North China: Int'l Geol. Rev., v. 37, p. 1094-1108. First author at Inst. Geology, Chinese Acad. Geological Sciences, Beijing 100037, PRC.

The Dongping Au telluride deposit, located on the northern margin of the China-Korea platform, is one of the largest Au deposits in China. The deposit is spatially and temporally associated with the Shuiquangou complex (comprising calc-alkaline, weakly alkaline, and alkaline rocks) and genetically related to the weakly alkaline rocks.

The Dongping deposit is a system of quartz-filled fractures and K-feldspar-altered rocks. The ore veins consist mainly of quartz, K-feldspar with minor pyrite, tellurides, Au, sphalerite, chalcopyrite, galena, specularite, calcite, sericite, and barite. Mineralization in the deposit can be divided into five stages, with Au mineralization occurring in two major stages—in stage II as native Au in specularite-quartz veins, and in stage III as native Au and Au tellurides associated with base-metal sulfides and disseminated pyrite in altered K-feldspar rocks. The proportion of Au that is native is >90%. Pyrite is the most common sulfide mineral and can be recognized as three generations. All pyrites of the three generations have a cubic shape, which may suggest a low fS_2-forming environment. (Authors' abstract)

Th, salinity and H- and O-isotope compositions of FI are used to interpret the petrogenesis of the deposit. (H.E.B.)

ZHANG, Zhijian, XIA, Weihua, ZHANG, Wenhuai and FENG, Zhiwen, 1995, Organic inclusions of Xitieshan lead-zinc deposit and their significance: Earth Sci. (Digiu Kexue), J. China Univ. Geosciences, v. 20, no. 2, p. 225-230 (in Chinese, English abstract). Authors at Dept. Mineral Resources, China Univ. Geosciences, Wuhan 430074, China.

The discovery and preliminary study of organic I in the main metallogenic stage shows that Xiutieshan deposit is not a massive sulfide type, or other deposit with syngenetic characteristics, but a type of thermal deposit which has relations with epigenetic, exotic organic matter for the wall rocks. The study provides a new thought and a new approach to re-recognize and reevaluate the role of organic matter playing in the process of metallogenesis. (Authors' abstract)

ZHANG, Zhijian and ZHANG, Wenhuai, 1995, Progress in the study of organic inclusions: Geological Science and Tech. Information (Dizhi Keji Qingbao), v. 14, no. 3, p. 39-43 (in Chinese, English summary).

Indexed under FI. (E.R.)

ZHEN, Yunqing, DU, Jisheng, LIU, Liling and WANG, Yanghu, 1995, Physicochemical condition of mineralizing fluids in copper ore deposit, the Zhongtiao rift zone: J. Guilin Inst. Technology (Guilin Gong Xueyuan Xuebao), v. 15, no. 2, p. 113-123 (in Chinese, English abstract).

The compositions of I in Cu ores from main deposits of the Zhongtiao rift zone consist of G-rich I and G-L I, as well as I of NaCl dms. Ore-forming T range mainly from 140°C to 300°C and increase from 400°C to 620°C during the later stage of ore formation. The chemical compositions and the chemical successions of the major ore deposits are similar. They are generally rich in Cl^-, Na^+, Ca^{2+}, H_2O and CO_2. The mineralizing F are mainly of high salinity (32-40 wt % NaCl eq.). The mineralizing F density is 1.0-1.18 g/cm^3. The ore-forming physical conditions of ore deposits are different. Their precipitation environments have some differences. Ore deposits are of the submarine low-mesothermal Cu type. (Authors' abstract)

ZHENG, Chuanjiu, 1995, The geological features and its origin of the Huanggoushan gold deposit, Jilin province: Jilin Geol. (Jilin Dizhi), v. 14, no. 3, p. 1-16 (in Chinese, English abstract). Author at Jilin Inst. Geological Sciences, Changchun City 130012, China.

It is quite obvious that the Huanggoushan Au deposit is controlled by structures, and the ore bodies are complicated veins, mostly formed in the open spaces of marble, showing the metallogenic characteristics of multiple stages with multiple hydrothermal brecciation. The ore-forming F is mainly meteorological water, having epithermal, low salinity near intermediate mineralizing setting and belonging to epithermal hydrothermal deposit. [FI data, H.E.B.] (Author's abstract)

ZHENG, Yaxin, 1995, Some zoning patterns and ore deposits in modern and geothermal systems around the edges of Qinghai-Xizang (Tibet) plateau of China, *in* Kharaka and Chudaev, eds., Water-Rock Interaction: Balkema, Rotterdam, p. 661-663. Author at CISNAR, Chinese Acad. Sci., Beijing, PRC.

Some ore-forming elements Hg, As, Sb, Li, Rb, Cs, W, Sn, Be, B are distributed in the inner zone of Tengchong's geothermal anomaly area, located at the SE edge of Qinghai-Xizang (Tibet) plateau. The outer zone of Tengchong's geothermal anomaly area is characterized by country rock alteration, where Pb, Zn, Mn, Ni, Co and Ba are anomalously high. Some precious metals, for example, Ag, are also found in the inner zone area. The inborn state of microscopic Au grains in some Carlin-type deposits, located at the eastern edge of Qinghai-Xizang (Tibet) plateau, reveals these ore bodies in close relationship with fossil geothermal systems and formed in hydrothermal stages. (Author's abstract)

The Dongbeizhai (Carlin-type) Au deposit is one of the largest Au deposits in SW China. The T of the hydrothermal F was in the range of 120°C-220°C, and the mineralization depth was <2 km. The hydrothermal minerals in Dongbeizhai Au deposits have $\delta^{34}S$ values of -5.8 to 6.3‰ (sulphide), $\delta^{18}O$ values of 15.1 to 27.2‰ (quartz and calcite), and $\delta^{13}C$ values of -4.7 to 2.7‰ (calcite). Hydrothermal F had $\delta^{18}O$ values 12.8 to 16.7‰ (based on the isotope fractionation equation of calcite-water) δD values -66.6 to -75.5‰ (FI). The initial ratio $^{87}Sr/^{80}Sr$ in the hydrothermal calcite is similar to that in the host carbonate rock. Pb isotopic compositions show that the ore Pb has a genetic relation with the carbonate rock. (From authors' text by E.R.)

ZHENG, Yongfei, FU, Bin and GONG, Bing, 1995, The thermal history of the Huangmeijian intrusion in Anhui and its relation to mineralization: Isotopic evidence: Acta Geol. Sinica (Dizhi Xuebao), v. 69, no. 4, p. 337-348 (in Chinese, English abstract). Authors at Dept. Earth Sciences, Univ. Science and Technology of China, Hefei, Anhui, China.

Whole-rock Rb-Sr, zircon U-Pb and hornblende, biotite and K-feldspar K-Ar ages were used to reconstruct the cooling history of the Huangmeijian intrusion in the Anqing-Lujiang quartz-syenite belt in Anhui. A hydrothermal U deposit was found in the contact zone of the Huangmeijian intrusion. Pitchblende U-Pb isochron dating yields a mineralization age of 114 Ma, which is close to the time of closure of the K-Ar system of biotite. FI microthermometry suggests a mineralization T of 230 to 240°C, which is in agreement with the T of the Ar closure in the biotite to orthoclase K-Ar system. This suggests a close relation between the slow cooling of the intrusion and the hydrothermal U mineralization process. (From authors' abstract by H.E.B.)

ZHOU, Dean, 1995, Isotope geochemistry of southern Asia Zone wollastonite mudstone-type Au deposit in Western Qinling: Geol. and Prospecting, v. 31, no. 4, p. 36-42 (in Chinese).

ZHOU, Dejin, MOLAN, E., XU, Ping, HAN, Song, HUANG, Zhongxiang, JIA, Xiuqin and DONG, Jinquan, 1995, The REE characteristics of fluid-melt inclusions in Lei-Qiong mantle xenoliths: Acta Petrologica Sinica, v. 11, no. 4, p. 434-440 (in Chinese, English abstract). First author at Inst. Geology, Chinese Acad. Sci., Beijing 100029, PR China.

In this research, instrumental neutron activation analysis (INAA) is used to analyze 12 pure mineral samples selected from mantle xenoliths in Lei-Qiong area (Leizhou Peninsula and Hainan Island). The spectrum gathering time of the analysing in INAA is 15,000 seconds which is five to 10 times [that] for analysing granite. Leizhou and Hainan F-MI-free minerals have different REE contents, which confirmed the heterogeneity in Leizhou and Hainan mantle sources. The REE contents differences between same minerals with and without F-MI selected from same mantle xenolith sample suggested that the F-MI are rich in REE, especially LREE. And the differences among the abundance of I and REE contents of same minerals selected from different mantle xenoliths and of different minerals selected from same mantle xenolith indicates the existence of heterogeneity in mantle F. (Authors' abstract)

ZHOU, Fengying, ZHU, Jinchu and WANG, Rucheng, 1995, A study on fluid-melt inclusions in topaz greisen from the Laiziling granite—Discussion on the genesis of topaz greisen: Acta Mineralogica Sinica, v. 15, no. 3, p. 259-264 (in Chinese, English abstract). Authors at Dept. Earth Sciences, Nanjing Univ., Nanjing 210093, PR China.

It is found that topaz greisen in the Laiziling granite in Hunan Province possesses characteristics of both magmatism and metasomatism. Its genesis has long been a controversial issue. Inclusion studies of minerals from the topaz greisen (especially F-MI) indicates that the topaz greisen crystallized during the magmatic-hydrothermal transitional stage of magma evolution. The co-occurrence of magmatism and metasomatism resulted from water/rock reaction between hydrothermal solutions and crystallized minerals during the process of crystallization of low T rock-forming M. (Authors' abstract)

ZHOU, Taihe, 1994, The Black Ridge gold deposit, *in* I.W. Withnall, ed., 1995 Field Conf.: Clermont-Anakie Region, Central Queensland: Geol. Soc. Australia, p. 82-87. Author at Nat'l Key Centre in Economic Geology, James Cook Univ., Australia.

The new geological, mineralogical, and geochemical data for the deposit are inconsistent with the placer model and favour a hydrothermal F mixing model. Mineralogical and FI studies indicate that the F T were ~100 to 250°C during the alteration and mineralisation. C and O stable isotopic data of siderite alteration suggest there were two different F sources, and a F mixing process along the unconformity may have caused the Au mineralisation. Hydrothermal alteration and mineralisation may have been generated by either igneous activity or tectonic movement-related metamorphism after Permian sedimentation. In either case, the potential for post-Permian hydrothermal Au mineralisation may be significant in central Queensland and eastern Australia generally. (From authors' abstract by H.E.B.)

ZHOU, Taihe, 1995, Copper skarn deposits in eastern China: Australasian Inst. Mining and Metallurgy, Publication Series, 9/95 [PACRIM 1995], p. 675-679.

Indexed under FI. (E.R.)

ZHOU, Xiugao, XIE, Shucheng and HU, Guojun, 1995, The biometallogenesis of sedimentary and stratabound gold deposits: Press of China Univ. Geosciences, Wuhan, PRC, 77 p. (in Chinese, English contents and abstracts, p. 75-76).

Many treatises have talked about physical and chemical metallogenesis of sedimentary and stratabound Au deposits, but few about biometallogenesis. With the improvement in methods and technology and the renewal of ideology, much attention has been paid to biometallogenesis in recent years. The book mainly discusses the biometallogenesis of Au deposits, with a summary of previous research and the authors' recent achievements. These researches indicate that organisms and their products including organic matter and organic F play an important role in metallogenesis of many Au deposits. "Organism-organic matter-fluid" metallogenic system occurs in many basin-orogenic belts. (Authors' abstract)

The Table of Contents indicates that the following ore deposits and/or types are discussed: stratabound Au deposits; Witwatersrand Au deposit; Carlin-type Au deposits; Dongbeizhai Au, Songpan, Sichuan Province. (E.R.)

ZHOU, Yongzhang, LU, Huanzhang, GUHA, Jayanta and CHOWN, E.H., 1995, Fluid inclusions and hydrothermal fluids of Hetai gold deposit, western Guangdong, China: Acta Mineralogica Sinica, v. 15, no. 4, p. 411-417 (in Chinese, English abstract). First author at Guangzhou Inst. Geochemistry, Chinese Acad. Sci., Guangzhou 510640, PR China.

There are three compositional types of FI in the Hetai Au field: low-salinity (~1.5-6 eq. wt % NaCl) H_2O-CO_2 type, moderate salinity (~6-14 eq. wt % NaCl) aqueous type, and CO_2-dominated type. Their Th range from 130°C to 310°C, and the confined P from 50 MPa to 170 MPa. The primary mineralizing F is a H_2O-NaCl-CO_2-dominated system with low salinity, principally derived from a mixed source of metamorphic and meteoric water. The CO_2 effervescence and unmixing took place during the evolution of this F. The statistical distribution of Th indicates that there were two times [of] large-scale unmixing of the primary hydrothermal F into a moderately saline aqueous phase and a non-saline CO_2-dominated phase. (Authors' abstract)

ZHU, Shaohua and DONG, Yongguan, 1995, Study on the ore-forming mechanism of gold deposits in Altai, Xinjiang: Volcanology and Mineral Resources, v. 16, no. 1, p. 19-34 (in Chinese, English abstract). Authors at IGMR, Nanjing 210016, PRC.

The active continent margin which formed after Jungger plate undergoing to the Siberian plate was called Ertix tectonic-magmatic metallogenic province and divided into five metallogenic zones. The ore-forming T was from 160°C to 320°C, P from 7.34 to 70.30 MPa, The salinities of ore-forming solutions are ~5-10 eq. wt % NaCl, densities are 0.720-0.970 g/cm^3, fO_2 is 10^{-25} to 10^{-59}, fS_2 is $10^{-17.5}$ to $10^{-6.0}$, reducing parameters are 0.17-17.02. As a result the Au deposits in the Altai area were formed in middle to lower T, small depth, lower P, lower salinity and basicity reduction environments.

The Au in the wall rocks is active. Its variability coefficient is high, the abilities of activity, movement and [en]richment are strong, the poor-rich belts of Au existed frequently. It is suggested that the metallogenic elements came mainly from phyllite, and there are lot of Ca^{++} in the ore-forming F after studying the characteristics of Au-bearing pyrites in different types of rocks in the Duolanasayi Au deposit. The features of H, O isotope in I of quartz suggest that the ore-forming L are derived from various sources, but mostly from atmospheric water in main metallogenic stage.

The Au in rocks was activated by strong oxidizing agent such as C, S to move as the types of $Au[HCO_3]$, $Na[Au(SO_4)_2]$, $Na[Au(S_2O_3)]$ and mineralized by replacing some rocks selectively. (Authors' abstract)

ZIDAROVA, B.P. and PIPEROV, N.B., 1995, Temperature and molecular composition of the mineral-forming fluids in Slavianka fluorite deposit: Rev. Bulgarian Geol. Soc., v. 55, P-T. 3, p. 9-xx.

ZIEMANN, M. and THOMAS, R., 1995, Thermobarometric and micro-Raman investigations on fluid and melt inclusions in sillimanite from Reinbolt Hill/East-Antarctica (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 274. First author at Univ. Potsdam, Inst. Geosciences, Germany.

Sillimanite of gemstone quality was studied from a pegmatite of the Reinbolt Hill locality in the east-Antarctic granulite province. The samples contain primary elongate silicate MI with gaseous parts and syngenetic nearly isometric FI. High density CO_2 and N_2 with various contents were detected in the gaseous phases with the Raman-spectroscopy. From these and micro-thermometric investigations, the conditions of the sillimanite crystallization from the melt were estimated: solidus: 719°C, 6.1 kb and liquidus: 747°C, 6.3 kb.

The investigations show that during growth of this sillimanite and I formation the F composition changed considerably. Because of the absence of SI the results are quite definite. In case of several I generations this could cause false interpretations.

Possible reasons for formation of these gaseous I with different density values (from 0.98 ≤1.06 g/cm^3) and N_2-contents (from 20 to 40 mol %) were discussed. (Author's abstract)

ZIMMER, Carl, 1995, The ocean within, *in* M.L. McKinney and R.L. Tolliver, eds., Current Issues in Geology: Selected Readings, 1995 edition: West Publishing Co., St. Paul, Minnesota, p. 22-24.

Indexed under FI. (E.R.)

ZIMMERMANN, H., 1995a, Fluid inclusion analysis of halite from the solar saltwork of Inagua, Bahamas (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 275. Author at Inst. Geologie und Dynamik der Lithosphäre, Univ. Göttingen, Goldschmidtstr, 3D-37077, Göttingen, Germany.

Microextraction and chemical analysis of single FI (> 0.2 mm) in evaporites can give us information on the history of seawater composition, and on secondary processes occurring in salt deposits due to brines. The interpretation of FI data observed in fossil evaporites seems to be limited. Therefore, we studied the recent process of trapping brine in halite from solar saltworks. Inagua is a good place to look at evaporation and trapping processes under natural but controlled conditions, since we find halite crystals of the size of 2 to 6 cm containing comparatively large FI. The chemical compositions of the evaporating brine, the halite precipitating from this brine and the F trapped in halite during precipitation are analysed. Major components (Na, K, Mg, Ca, Cl, SO_4) and minor components (Li, F, Br) of brine, halite and inclusion are determined by Ion Chromatography (IC); Rb, Sr, Cs, I, and B in the evaporating brine (reservoirs, crystallizers) by ICP-MS. The element distribution between the different L and solid phases is studied. (Author's abstract)

ZIMMERMANN, H., 1995b, Fluid inclusion studies of Messinian evaporites from Sicily—Preliminary results (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 276. Author at Inst. Geologie und Dynamik der Lithosphäre, Univ. Göttingen, Goldschmidtstr, 3D-37077, Göttingen, Germany.

The Sicilian salt deposits are of Miocene age and can be divided into unit A, B, C, and D, with unit B containing ≤10 kainite horizons. The Br distribution of halite and kainite shows possibly primary patterns. FI (>0.2 mm) in vertical and lateral profiles of halite are extracted and analysed (Na, K, Mg, Ca, Li; Cl, SO_4, F, Br) by Ion Chromatography (IC) in order to reconstruct brine compositions during the process of precipitation. (Author's abstract)

ZIMMERMANN, J.L., GIULIANI, G. and CHEILLETZ, A., 1995, Quadrupolar mass spectrometric study of fluids in gems: An application to Colombian emeralds (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 277-278. First author at CRPG, CNRS, BP 20, 54501 Vandoeuvre-lès-Nancy Cedex, France.

F were extracted by heating under vacuum and analysed by means of a BALZERS QMG 420 quadrupolar mass spectrometer. Continuous heating analyses permit the release of each F. The corresponding curves give the liberation rates according to T. Bending points and maximum of curves correspond to T of gases desorption, I decrepitation and channel opening. In a second series of analyses, G are extracted by incremental heating. At each step, T stays constant until F P levels off to an asymptotical value. F are separated into several fractions, using cold traps, oxidation and reduction processes. P in the line, of known volume, is measured with a capacitance manometer before the G analysis through the quadrupolar mass spectrometer. Quantities and compositions of F released at each step are so determined.

Continuous liberation curves (from ambient T to 1200°C) of each G show three domains corresponding to F locations in beryls. Adsorbed G are liberated from 100°C to 200°C, the T of maximum rate for I decrepitation are between 450°C and 500°C, and the ones for the release of F in channels are between 880°C and 1000°C. These results confirm those on beryls from different origins and ages.

For step heating analyses, the T steps were selected from the results of previous continuous heating analyses: 400°C, 550°C, 720°C, 900°C, 1000°C and 1150°C. Composition of the whole F phase is: H_2O (80 to 92%), N_2 (3 to 10%), CO_2 (2.5 to 5%), H_2 (<5%), CO (<1.5%), CH_4 (<0.5%), organic compounds (dissociation mass) and inert gases: He, Ar, Ne. The first two steps correspond to F in I, ~1 to 7%, depending on samples. The largest part located in channels is released at 720°C and especially at 900°C steps.

These results confirm and define the data obtained by microthermometry and by Raman Spectrometry on FI.

Water released from the structural channels represents the original water of formation which may be characterized by its D/H ratio. Preliminary studies on H, C, O isotopes show evidence [of] the basinal waters signature of the mineralizing F associated to carbonates, quartz and emeralds. (From authors' abstract by E.R.)

ZIMMERMAN, J.L. and MORETTO, Robert, 1994, On the liberation of water and gases from halite crystals: Determination of their positions [sites?] and their origins (abst.): 15th Reunion Sci. de la Terre, p. 119 (in French). First author at Centre de Recherche Petrographiques et Geochimiques CNRS, 15 rue N.D. des Pauvres, BP 20, 54500 Vandoeuvre-les-Nancy Cedex, France.

Qualitative and quantitative studies of F in clear halite crystals with several macroscopic I (1 mm), and in milky halite crystals rich in small I (<30 µm) were undertaken by thermogravimetric and coupled manometry-mass spectrometry analyses.

Water is the most abundant F in the two halite varieties, but there is five times more in the milky halites (0.2 to 0.5 g %). The concentrations of CO_2 gas and hydrogen are much lower: CO_2/H_2O <0.01 and H_2/H_2O ≤0.005. The organic compositions, most notably CH_4, are equally present in both types of halite (≤0.05% of H_2O); but they are twice as abundant in the milky halites. Equal amounts of nitrogen were recorded, and in certain samples, H_2S and SO_2.

Histograms of gas liberation versus their diffusion characteristics were determined in the two types of salt, by incremental heating from 80°C to 460°C. Nitrogen is liberated <240°C; it is adsorbed and probably of atmospheric origin. Approximately 90% of H_2O is extracted between 275°C and 420°C until decrepitation of the I. Also, CO_2 release occurs primarily in this T region; however, <420°C, carbonate dissociation is an equal product. Hydrogen, the concentration of which corresponds to <0.5% that of H_2O, is liberated continually from 200°C to 460°C, with a single activation energy of 30 kcal/mol; <60% is extracted <360°C. The bulk of the hydrogen is liberated by cracking of the organic matter present in the halite crystals; a small fraction, however, occurs in the crystal lattice. (Authors' abstract; translation courtesy of Dr. A.P. Gize)

ZINCHUK I.M., BAGATAJEV, R.M., VISHTALIUK, S.D. and SVOREN', J.M. , 1995, The volatiles in mineral-forming fluids of Mykytivka Sb-Hg deposit (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 279-280. Authors at Inst. Geology and Geochemistry of Combustible Minerals, Nat'l Acad. Sci., L'viv, Ukraine.

Mykytivka Sb-Hg deposit contains cinnabar, antimonite, arsenopyrite, quartz and dickite. Preore Fe-Mg carbonates with bournonite, sphalerite, Pb-Sb sulfosalts and postore quarts-dickite veinlets are less common.

The ores was formed from CO_2-saturated heterogeneous water solutions at 200-150°C (preore stage), 160-110°C (main stage) and from undersaturated by CO_2 homogeneous solutions at 110-80°C (postore stage).

The G were analyzed by mass spectrometry, after crushing in vacuum without heating. Analytical results are given as volume ratios, put in standard conditions. I in quartz, cinnabar, antimonite and silicificated ore-enclosing sandstones were analyzed.

The analytical results display, that among volatile components CO_2 prevails over N and CH_4 is minor. In some quartz samples ethane was found (≤1.7%).

The sulphides—both cinnabar and antimonite—show very uniform composition of gases with prevailing CO_2 (86.5-99.3%) and minor N_2 (0-6.9%) and CH_4 (0.7-7.9%) contents.

The quartzes was divided into two groups. Synore quartzes show maximum contents of CO_2 (avg. 92.5%) similarly to sulphides. Preore quartzes differ from synore ones by increased N_2 contents (avg. 16.9%) and decreased CH_4 (<2.5%).

The metasomatites (silicificated sandstones) have volatiles similar to those in preore quartzes: (60.0-85.6%) and relatively high N_2 (8.0-37.0%). The CH_4 concentration is 0-9.8%.

The data obtained show that the composition of gases does not correspond with composition of volatiles of katagenetic F [from sediments] because of very low concentration of CH_4 and does not correspond with oil[-field] waters for the same reason. The conception of migration of ore-forming F from deep-seated sources is in better agreement with data obtained. (From authors' abstract by E.R.)

ZINCHUK, I.M., KALYUZHNY, V.A., PLATONOVA, E.L. and MUROMTSEVA, A.O., 1995, The parameters of migration of hydrocarbons in Lviv-Volyn coal basin of Ukraine (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 281-282. Authors at Inst. Geology and Geochemistry of Combustible Minerals, Nat'l Acad. Sci., Lviv, Ukraine.

The Devonian and Carboniferous formations of Lviv-Volyn coal basin contain numerous small oil and gas shows, oil and gas seeps at the surface and in boreholes. Macroscopic fractures in limestones and argillites contain numerous calcite and quartz-calcite veins with barite, celestite and anhydrite. These same veins often contain tar and oil filled openings or accumulations of hard bitumen.

Both quartz and calcite contain numerous P and S coexisting I of water solution and organic F. This fact is an evidence for heterogeneous two-phase state of mineral-forming system; in some samples we found evidences for three-phase heterogeneous state of system, in which water phase coexisted with two L organic phases.

The concentration of water solutions in inclusions does not exceed 10-12 wt %. Microthermometric analyses of oil and water I indicate, that the vein minerals was precipitated at 110-200°C.

The organic I may be divided based on optical characteristics and behaviour during freezing into several types:

Type I. The most abundant type contains colourless light oil or condensate with blue fluorescence under UV illumination. Often contain droplets of dark brown (bituminous?) substance. May be subdivided into two subtypes:

I-a. Two-phase inclusions L1+G (L1 = 80-85%) display almost full crystallization of L during freezing. Th L = 70-128°C, and I-b. One-phase inclusions L1 (G) which heterogenize at low T by condensing of L or by appearing of F bubble due to a density of F. The L phase displays partial crystallization; Th = -20 - +180°C.

Type II. One-phase inclusions with white-blue fluorescence, which heterogenize at low T by condensing of L or by appearing of G bubble due to a density of F without appearing of crystals. Th = (-60-30)°C. The F of these I consist of mixture of light hydrocarbons.

II-b. Essentially CH_4 inclusions without fluorescence. During freezing display crystallization of minute crystal of CO_2, which during heating dissolves in L at (-90-75)°C. Homogenization appears at (-80-65)°C. This type of inclusion is rare.

Type III. Colourless one or two-phase at room T inclusions with blue or rarely light yellow fluorescence, which display the coexistence of two L.

III-a. The more abundant type of inclusions, which consist of two liquids L1+L2. During freezing the small G bubble appears. The volume ratios of liquids L1 and L2 are very changeable during freezing. After deep cooling the crystallization of one of L appears. The gradual melting takes place at (-120-122)°C. The partial homogenization L1+L2+G - L1+L2 appears at (-53-39)°C, and full homogenization from -26 to +53°C in different inclusions.

III-b. The rare type of inclusions, which are filled at room T by the dense F, which after cooling is divided to two liquids L1+L2 (L1 = 5%) and then G bubble appears. The main peculiarity of inclusions behaviour is the existence of L1 in restricted T interval from -64 to +4°C. Out of this interval L1 is fully dissolved in L2. After cooling lower than -106°C the minute crystal appears in L2.

Type IV. This type of inclusions is relatively rare. The two- or three-phase L3+G; L3+L1+G inclusions contain 10-80 % of dark red-brown or yellow-brown liquid L3 with red-brown fluorescence. In polarized light this substance has a marked birefringence.

Two trends of evolution of composition of hydrocarbon systems in I were determined. For veinlets formed on progressive stage of catagenetic processes the evolution from oil-like mixtures to more light essentially CH_4 fluids is typical.

The reverse trend was determined for veins formed on regressive stage of basin history, including veins in zones of deep faults. The hydrocarbon phase of F changed its composition in time; migrating F lost light components, especially CH_4 being transformed to oil-like mixture. This process was accompanied by destruction of part of components and forming of bitumen-like L and solid anthraxolite-type substances at shallow levels.

For some boreholes the T of F exceeded minimum values, determined by I (70-100°C);it decreased during vertical migration by 15-20° per 100 m with regional geothermal gradient 2° per 100 m. Such discrepancy probably is caused by fast F inflow along deep faults from more heated levels. (From authors' abstract by E.R.)

ZINCHUK, I.M. and VISHTALIUK, S.D., 1995, The gases of inclusions in sandstones minerals of Donets basin (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 283-285. Authors at Inst. Geology and Geochemistry of Combustible Minerals, Nat'l Acad. Sci., Lviv, Ukraine.

We made separate analyses of gases, released from whole rock and from clastic grains of rock. The sand fractions, free from cement minerals, were obtained by means of chemical, mechanical and U-sound disintegration of rocks. G were released from I by crushing of specimens in vacuum without heating and analyzed by mass spectrometry. Analytical results are adduced as volume ratios, put in standard conditions. The analyses display wide dispersion of compositions of G, even within one stratum. There is no correlation among G composition for whole rock and its detrital fraction.

Besides sandstones the G of I in minerals from veinlets in Carboniferous rocks were analyzed. Inclusions have very uniform composition, averaging 3% CA_2 [sic] + 94% CH_4 + 3% N_2. Only coarse-grained smoky calcite from septarian veinlets in siderite concretion has high CO_2 -17.8%, that is close to sandstones of enclosing series. (From authors' abstract by E.R.)

ZOLOMAREB, A.A. and KRASNOVA, I.N., 1995, [Thermobarogeochemistry]: St. Petersburg, Russia, 25 p. (in Russian)

A student textbook for a FI course, using material from various references. (E.R.)

ZWART, E.W., 1995a, Fluid inclusion analyses as tool for qualitative F flow interpretation (abst): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra nova, vol. 7, suppl. no. 1, p. 197.

Analyses of FI in late diagenetic minerals of the Zechstein 2 deposits in NW Germany suggest a rather uniform flow and development of F when well samples along a carbonate platform-top to basin transect are studied.

Calcite that replaces dolomite, fluorite, fracture-filling calcite and anhydrite reveal two and three phase aqueous I of which some generations have an obvious primary origin. Single phase gaseous (CH_4-CO_2) I are predominantly found as secondary trails but also as mixtures with aqueous F in fluorite. Detailed compositional analyses of the aqueous phase show a F system that closely approximates that of $CaCl_2$-NaCl-H_2O.

In this area we see a F development that can be traced from the moment after the calcitization of most of the rocks begins with a pure aqueous F with minor fluctuations in NaCl and $CaCl_2$ content. This stage is followed by occlusion of remaining pores by fluorite in which traces of hydrocarbons are abundant. The final anhydrite and calcite cements show mostly uniform aqueous I with only minor secondary hydrocarbon contents. The examined wells that came from a restricted area on the paleoplatform show closely related compositions. The well drilled ±30 km further east revealed besides $CaCl_2$-NaCl-H_2O and CH_4-CO_2 also H_2S, KCl and LiCl. A possible explanation for this difference is that tectonic barriers in the substrate (i.e., faults) separated different F flows. (From authors' abstract by E.R.)

ZWART, E.W., 1995b, Fluid inclusions in carbonate rocks and calcite cements: PhD thesis, Vrije Univ. Amsterdam, 155 p.

Includes a review of FI techniques and interpretation, and studies of late diagenetic carbonates of the Permian, Zechstein, Germany, fresh water FI in subaerially exposed calcite, and FI thermal constraints on apatite and zircon fission track annealing in Oslo Graben, Norway. The SEM technique involved freezing a sample at LN_2, fracturing it while mounted on solid CO_2, warming to room T, drying for 24 hrs, and then C coating.

See also next item. (E.R.)

ZWART, E.W. and TOURET, J.L.R., 1995, Melting behaviour and composition of aqueous fluid inclusions in fluorite and calcite: Applications within the system H_2O-$CaCl_2$-NaCl: Eur. J. Mineral., v. 6, p. 773-786. Authors at Inst. Earth Sciences, Vrije Univ., De Boelelaan 1085, 1081 HV, Amsterdam, The Netherlands.

In samples from Ca2 Zechstein formations in NW Germany, aqueous L-V as well as L-V-solid (LVS) I in calcite and fluorite contain high salt concentrations, particularly belonging to the system H_2O-$CaCl_2$-NaCl. Emphasis is laid on the recognition of phase transitions and compositions by sequential heating and freezing.

LV I clearly show a Te ~-52°C, although the actual forming and melting of antarcticite could not be observed. Melting of ice (-27.8° to -24.4°C) and hydrohalite (HH, -15.8°C to +15.4°C) reveal the composition (16-19 wt % NaCl, 7-11 wt % $CaCl_2$) when plotted on the relevant ternary phase diagram. Melting of hydrohalite >0.1°C is metastable.

LVS I belong to two categories, Type (I), with the dissolution T of halite lower than the Th (Ts < Th), shows the normal equilibrium melting (-31°C to -26.3°C -melting of ice, -7.4°C to -6.6°C - melting of HH) and contain 21-23 wt % NaCl and 11-15 wt % $CaCl_2$. Type (II), with Ts > Th, shows non-equilibrium melting in the presence of a halite cube; the presence of LiCl and KCl depress the eutectic point; the NaCl content can be estimated at 21 wt %.

CO_2-CH_4 clathrates form around the V phase and melt at -16.4°C to -15°C for LV I and at -31°C to -28.2°C for LVS I. Their nature is confirmed by Raman analyses, which also reveal traces of H_2S. (Authors' abstract)

See also previous item. (E.R.)

ZWENG, P.L. and CLARK, A.H., 1995, Hypogene evolution of the Toqupala porphyry copper-molybdenum deposit, Moquegua, southeastern Peru, *in* F.W. Pierce and J.G. Bolm, eds., Porphyry Copper Deposits of the American Cordillera: Arizona Geol. Soc. Digest, v. 20, p. 566-612. First author at Redwood City, CA.

The deposit is centered on a dacitic/latitic intrusive complex and associated alteration and mineralization features related to four (early, tourmaline, main, and late) hydrothermal events.

Hydrothermal F of the first three stages were of moderate T (335-480°C) and high salinity (extreme in the tourmaline stage) and were boiling. A change from lithostatic to near-hydrostatic P conditions occurred near the end of the early stage, and all subsequent hydrothermal stages formed at epithermal-type P of 300 bars or less. Late stage F were significantly cooler (220-370°C) and lower in salinity and did not boil; they may record encroachment of oxygenated meteoric waters into a decaying juvenile hydrothermal system.

The four hydrothermal stages correspond closely to the early, transitional, and late stages documented by Gustafson and Hunt (1975) at El Salvador, Chile, indicating that both deposits followed broadly similar evolutionary trends. Differences between these deposits reflect the degree of development of each hydrothermal event. (From authors' abstract by E.R.)

INDICES

The user should keep in mind the following features of these indices. The indexing procedures and entries are continuously evolving and hence are *not* uniform from one volume of *Fluid Inclusion Research* to the next, and even within a given volume, consistency cannot be claimed. The number of indexing entries has been reduced this year, and *in many entries, only the more significant items are listed.* One major change has been made. Both *Analysis data* and *Daughter minerals* entries have been split up into two categories: *aqueous* and *silicate melt.* But there is always some possibility for ambiguity, and some items might involve both types of inclusions.

Indexed items are cited by first author's last name only. This may cause occasional ambiguity (e.g., with prolific authors or with different authors having same last name), but this inconvenience is believed to be less than that present in using the previous procedure, where a whole page had to be scanned for *every* citation that was looked up. Feedback from users on indexing procedures and/or indexing entries (and omissions) is *welcomed.*

Subject Index

See general notes above. I have tried to make this a user-oriented index rather than a documentalist's type index. Only data in the title and abstract are indexed, and then only if they appear to be of more than incidental mention. Thus most ore deposit studies could also be listed under "Rock-water interaction" but are not. Misleading or erroneous translations may have resulted in occasional incorrect or omitted entries. Some entries are included under a given appropriate subject heading even though the index word does not occur in the abstract. The aim has been to err on the side of completeness and convenience to the user. Thus, I have attempted to index some related or possibly pertinent items, and even ones involving negative data or evidence, under each category. The deposit-type terms such as porphyry copper and Mississippi Valley are used loosely. The deposit type is indexed only where it is evident without research. Analyses for specific elements are indexed only when they are particularly unusual or significant; thus, semiquantitative spectrographic analyses and statements of analyses as "Na-Ca-Cl fluids" are generally ignored. The mineral host for the inclusions studied is indexed except for quartz and calcite, and for decrepitation studies. Entries that would include too many citations to be useful are listed without citations. Some entries with broad and diffuse applicability have only a few of the most pertinent citation references. Names in parentheses refer to individual articles in a volume entered alphabetically here under the editor's name.

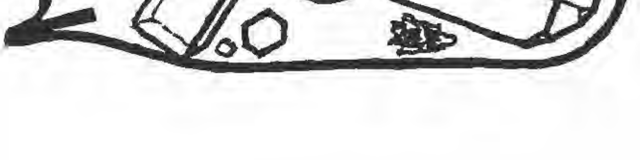
Locality Index

Notes: See head of Subject Index. Individual deposit place names are indexed only when significant data are presented. Inexact place names (e.g., "Soviet Far East") are not entered, nor are individual mines in districts known by a district name, although some may be so entered, in error. Cyrillic (and Chinese) place names are listed as they were given in the original transliteration; various transliteration procedures yield different spellings: Began and Began'skii, Blyava and Blyavinsk, Kochkar and Kochkarskoje, Volhynia and Volyn, Kirin and Jilin. For place names starting with an adjective (e.g., North Pennines), see main entry also. Names starting with M., Mt., Monte, and Mount are alphabetized exactly as spelled.

Pantelleria, Italy—D'Alessandro, Kovalenko
Parzán F-Pb-Zn, Spain—Fanlo
Pedra Preta W, Para Brazil—Rios
Pedreira Remina pegmatite, Brazil—Iwata
Petráckova Hora porph. Au, Bohemia—Zachariás
Pezinko Au, Slovakia—Andras
Pian Di Celle volcano, San Venanzo, Italy—Sharygin
Picos de Europa Zn-Pb, Spain—Mangas
Pilot Sn-W-polymetallic, Thailand—Linnen
Pine Grove porph. Mo, UT—Lowenstern, Shinohara
Planyanzi Au, PRC—Li
Polaris MVT Pb-Zn—Christensen, Kesler
Pontide Island Au-Ag, Turkey—Tüysüz
Ponza Island, Italy—DeVivo
Porgera Au, Papua New Guinea—Cameron, Richards
Port Coldwell Pb-Zn-Ag, Ontario—McCuaig
Prasolovskoye Au-Ag-Te-Se, Kurils CIS—So
Punta del Cobre Cu-Fe, Chile—Marscik
Pajingo Au-Ag, Queensland—Bobis
Qaidam Basin NaCl, PRC—Spencer, Yang
Qinling mobile belt, PRC—Cong
Qiqiu Nol Au, Xinjiang, PRC—Wang
Quellaveco porph Cu, Peru—Kihien
Questa Mo, NM—Cline
Rabaul volcano, PNG—Roggensack
Radnig CaF_2, Austria—Zeeh
Red Mountain, AZ—Student
Redwing Au, Mutare belt, Zimbabwe—Chenjerai, Schmidt Mumm
Renison granite, Tasmania—Bajwah
Renison Sn, Tasmania—Kitto
Ribeira pegmatite, Portugal—Doumbia
Rithanth, Kumaun Lesser Himalaya polymetallic—Rawat
Rodalquilar Au-alunite, Spain—Arribas
Rosia Poieni porphyry, Romania—Hallbauer
Round Mountain, NV—Henry
Rushan Au, Jiadong, PRC—LI
Ryabinovaya porph. Cu-Au, CIS—Myznikov, Naumov
SE Missouri, MVT—Kesler
Sabie-Pilgrim's Rest Au, SA—Boer
Salado fm, NM—Jones
Salobo polymetallic, Para, Brazil — Réquia
Salsigne Au, France—Benchekroun
Sambo Pb-Zn-Ba, S. Korea—Kim
San Bartolome polymetallic, Ecuador—Mulshaw
San Cristobal Au, Chile—Egbert
San Rafael Sn-Cu, Peru—Kontak
San Rafael W-Sn, Spain—Garcia
Santo Tomas II (Philex) porph. Cu-Au, Philippines—Tarkian
Santorini volcano, Greece—Vaggelli
Sardana Pb-Zn, Yakutia, CIS—Pavlov
Scott Au-Ag, Pajingo, Queensland—Bobis
Shaxi porph. Cu-Au, E. China—Ren
Shuangwang Au, PRC—Nie
Shuichang area Au, Zhejiang, PRC—Zhang
Sierra del Guadarrama W-Sn, Spain—Noronha
Silesian-Cracow Pb-Zn, Poland—Kozlowski
Sinceni West peg. Sn, Swaziland—Trumbull
Sítio Exu pegmatite, Brazil—Beurlen
Skaergaard, Greenland—Hanghøj, Rose-Hansen
Skellefte district, Sweden—Broman
Skouries porph. Cu, Greece—Frei
Slavianka CaF_2, Bularia—Zidarova
Sleeper Au-Ag, NV—Saunders
Slovak Ore Mountains—Grecula
Snow Lake massive sulfide, Manitoba—Menard
Somoncura Massif, Argentina—Bjerg
Songpan Au, Sichuan, PRC—Zhou
Sorkuduk skarn Cu-Mo, Xinjiang, PRC—Renyi
Soultz geothermal, Rhine graben—Royer, Stussi, Yardley
South Pennine MVT, UK—Ewbank
South-west England Pb-Zn—Cox
St. Austell, Cornwall, UK—Irwin
St. Austell granite, SW England—Cox
Stepok Pb-Zn, CIS—Shumlyanskiy
Stillwater complex, MT—Meurer
Strel'tsovskii U, CIS—Kotov
Stříbro Pb-Zn, Czech Republic—Dobes
Stripa granite, Sweden—Irwin
Sudbury, Ont.—Farrow
Sukhaybarat East Au, Saudi Arabia—Albino
Sulfur Springs geothermal, Valles caldera, NM—Sasada
Sullivan Pb-Zn-Ag massive sulfides Kimberley, BC—De Paoli, Leitch, Taylor
Sunshine mine, Coeur d'Alene district, ID—Eaton
Svartsengi geothermal, Iceland—Franzson
SE Missouri MVT—Kesler
Taqian-Zhuxi polymetallic, Jiangxi, PRC—Xiang
Tarnagula Au, Victoria, Australia—Molloy
Taxco epithermal Ag, Guerro, Mexico—Simmons
Tayoltita Ag-Au, Durango, Mexico—Conrad, Simmons
Telkibánya Tokaj Mtns epithermal, Hungary—Molnár
Temora Au-Ag, NSW—Allibone
Tennant Creek Au-Cu, Australia—Khin
Timberville Zn, TN—Appold
Tirek Au, Algeria—Semiani
Tokaj Mtns. Au, Hungary—Molnár
Tolukuma Au-Ag, PNG—Langmead, Semple
Tomiño Au, Spain—Hébert
Tongbo-Dabie area Au, PRC—Xu
Toquepala porph Cu-Mo, Peru—Zweng
Tri-state MVT—Kesler
Trimpoiele, Romania—Hallbauer
Troodos ophiolite—Batanova, Bettison, Kelley
Tummalapalle U, India—Dhana
Tunisia Pb-Zn diapir OD—Charef
Tux-Lanersbach magnesite-W, Austria—Raith
Taishang Jiaojia-style Au, PRC—Zhang
Uderiná Au, Slovakia—Mato
Uluguru granulite, Tamania—Herms
Um Ara, Egypt—Abdalla
Upper Chegem caldera complex, CIS—Babanskiy
Upper Mississippi Valley Zn-Pb—Rowan, Spirakis
Uwamuki koroko, Japan—Maglambayan
Val d'Or, Abatiba belt, Canada—Robert
Val Graveglia Mn, Italy—Marescotti
Vale do Ribeira-PR fluorite, Brazil—Ronchi
Valle de Tena, CaF_2, Pyrenees—Subiás
Valles caldera, NM—Stix
Velence Mtns. pegs, Hungary—Molnár
Ventotene Island, Italy—DeVivo
Verkhneye Sn, Karadub ore field, CIS—Reyf
Vesuvius—Belkin, Fulignati, Marianelli
Viburnum Trend MVT—Kesler
Viceroy Au, Zimbabwe—Schmidt Mumm
Vidly Cu-Mo porph. Czech Rep.—Aichler
Viet Nam Au—Do, Dzung
Villamanin Au-Cu-Ni-Co, Spain—Paniagua
Vinliden Au, Sweden—Broman
Volta Grande CaF_2, Paraná, Brazil—Ronchi
Vulcano Island, Italy—Voltaggio
Vyhne-Klokoe Fe skarn, Slovakia—Kodera
Wage-sennin Fe, Iwate Pref., Japan—Murata
Waihi Au-Ag, New Zealand—Brathwaite
Wakamarina Au-W, New Zealand—Skinner
Waldenstein Fe, Austria—Prochaska
Walton Ba-Pb-Zn-Cu-Ag, Nova Scotia—Kontak
Wattle Gully Au, Victoria, Australia—Cox
Wendeng Au, Shandong PRC—Lai
Werra halite, Poland—Kovalevich
Wiluna Au, Australia—Hagemann
Witwatersrand, Au, SA—Boer, Coetzee, Drennan, Eugster, Frimmel, Robb, Zhou
Wufeng epithermal Au, Jilin, PRC—Rui
Wulashan Au, PRC—Nie
Wuxu polymetallic, PRC—Qin
Wynad Au, India—Santosh
Xiangluwanzi Au, Jilin, PRC—Yu
Xiaoqinling Au, PRC—Qin
Xiaoxinancha porph. Cu-Au, Jilin, PRC—Li, Rui
Xiayinfang Au, Pinquan, Hebei, PRC—Ruan
Xiazhuang U orefield, South Carolina, PRC—Liu, Sun
Xorkuduk skarn Cu(Mo), Xingiang, PRC—Chen
Yanbian area porph. Cu-Au, Jilin, PRC—Rui
Yerington porph. Cu, NV—Dilles, Gustafson
Yingshan Pb-Zn-Ag, Jiangxi, PRC—Hua, Zhang
Zabargad Island, Red Sea—Brueckner, Sciuto
Zhao-Ye region Au, Shandong, PRC—Zhang
Zhangquanzhuang Au, Hebei, PRC—Yin
Zhilingtou Au-Ag, Zhejiang, PRC—Xu
Zhongtia Cu, PRC—Zhen
Zidarovo Cu-polymetallic, Bulgaria—Tarkian
Zinkgruvan massive sulfide, Sweden—Chomiak

Index of Non-first Authors

First authors are found alphabetically in Abstracts and Citations. Note: Please see caveats about the spelling of author's names on p. 1.



ERRATA

Volume	Page	Item* or ¶	Line**	Change
24	272	col. 3		Under Segalstad, change page references to 150 and 217
26	218	left	-	Add Sushchevskaya to "Boreholes..."
27	11	3L	1	Delete lower case "i"
	63	4R	1	Change name to "STEIN, H.J."
	82	2R	-1	Add table: Mean of Pine Grove glass I (wt %) SiO_2 71.0 TiO_2# 140 ppm Al_2O_3 12.72 FeO^{tot} 0.66 MgO# 60 ppm MnO 0.144 CaO 0.285 Na_2O 4.04 K_2O 4.09 H_2O 7.12 Cl 580 ppm F 3340 ppm S <60 ppm Mo# 3 ppm Li# 176 ppm B# 52 ppm Sr# 0.2 ppm Rb# 473 ppm Total 100.5
	97	2R	-2	Change "CI" to "Cl"
	98	4L	3	Delete "[sic]"
	105	4R	2	Change to "Geol. Soc. [UK] Spec..."
	110	2L	8	Add "[sic]" after "19^{-9} g"
	126	4L	3	Add (in Japanese)
	136	5L	1	Change to "SHIMIZU, Noby"
	154	1R, ¶3	1	Change to "at 700°C and 3 and..."
	183	left	-	Under "Boreholes..." add: Nielsen, Shimizu, Simonov, and Vollbrecht

* Includes partial items.

** Minus lines refer to lines up from end of item.