FLUID INCLUSION RESEARCH

Edwin Roedder
Editor

Harvey E. Belkin
Associate Editor

Volume 29
1996

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VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

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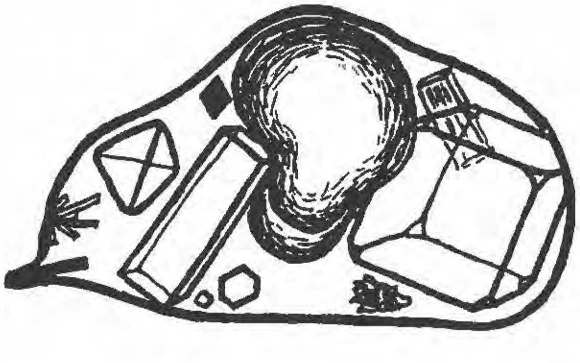

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PREFACE

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, and from the Chinese and Russian literature, 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 1501 abstracts, citations or annotated citations, of which 21% are from non-English publications and 22% are from the 30th International Geological Congress. A total of 29 theses, (BS, MS, or Ph.D.) are included. 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 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%, 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 Joyce M. Angleberger for the excellent typography and editorial help.

June 8, 1998

Edwin Roedder, Editor

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INDICES

CONTRIBUTORS, VOLUME 29

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. Unfortunately, with the FIR finances as they are, we cannot be as generous with complimentary copies as we used to be, so we can only send a few such copies to the major contributors this year.

Alexandrov, A., Kiev, Ukraine
Berdnikov, N., Khabarovsk, Russia
Bin Liu, Shanghai, People's Republic of China
Boiron, M.-C., Nancy, France
Bortnikov, N.S., Moscow, Russia
Brown, D.A., Canberra, Australia
Burke, E.A.J., Amsterdam, The Netherlands
Diamond, L., Bern, Switzerland
Dobes, P., Prague, Czech Republic
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Hurai, V., Bratislava, Slovakia
Kigai, I., Moscow, Russia
Kyle, J.R., Austin, Texas
Landis, G., Denver, Colorado
Lattanzi, P., Cagliari, Italy
Lu, H.-Z., Chicoutimi, Quebec, Canada
Molnar, F., Ottawa, Canada
Rose-Hansen, J., Copenhagen, Denmark
Sasada, M., Tsukuba, Japan
Sasaki, M., Tsukuba, Japan
Sawaki, T., Tsukuba, Japan
Sharygin, V.V., Novosibirsk, Russia
Simmons, S., Auckland, New Zealand
Sobolev, A.V., Moscow, Russia
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Touret, J.L.R., Amsterdam, The Netherlands
Wilkins, R.W.T., North Ryde, Australia
Xu, Jiuhua, Beijing, People's Republic of China
Zhou Chao, Xian, People's Republic of China

SUBSCRIPTION INFORMATION

Volume 29 (1996); Volume 28 (1995, photocopy); Volume 27 (1994), Volume 26 (1993), Volume 25 (1992), Volume 24 (1991; Volume 23 (1990, photocopy)–$40 and Volume 22 (1989, photocopy)–$20; Volume 21 (1988)–$15; back issues of Volumes 1-20 (if in stock) or photocopies of back issues–$6/volume; *all postpaid if payment received in advance.* Standing subscription orders receive 20% discount (e.g., Volume 28–$32). All subscription correspondence and checks (made out to "TREASURER OF VIRGINIA TECH" in U.S. dollars and drawn on a U.S. bank) should be sent to:

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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 either 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 30 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
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Cambridge, MA 02183, USA

June 8, 1998

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,* 1995, v. 28; 1996, v. 29; 1997, v. 30.

The Society for Luminescent Microscopy and Spectroscopy continues to issue Newsletters (the latest is Volume 10, no. 1, Spring, 1998) 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: Jinny Sisson, email (jinnys@rice.edu). A 10th Anniversary meeting is tentatively scheduled for August 17-19, 1998.

"Fluids of the Earth's Interior," a special issue of Earth Science Frontiers, Volume 3, no. 3/4, 1996, was published in PRC. Articles (in English) deal with fluid inclusion studies.

16th Réunion des Sci. de la Terre, Orleans, France, was held April 10-12, 1996.

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.

IV Spanish Geological Congress was held July 1-5, 1996; 12 items on fluid inclusions, all in Spanish with English abstracts, were published in Geogaceta.

The 30th International Geological Congress was held Aug. 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 Volume 2 from a fluid inclusion session. Of the 7,974 abstracts published, 330 will be found in this issue of FIR, with the following caveats: extensive editing was necessary on these abstracts, not only for shortening, but due to language problems. In addition, note the following complications:

The first APIFIS (Asian & Pacific International Fluid Inclusion Society) and IAGOD (COFFI, Commission on Ore-Forming Fluids in Inclusions) workshop was held in connection with the 30th IGC, Beijing, 1996. Several groups of abstracts on both FI and high pressure studies were distributed at the meeting, some of which were identical to abstracts in the 3-volume IGC abstract set (see above), a few were modified versions, and many were not given at the IGC. Also, 38 abstracts dealing with FI were printed in the 61-page APIFIS 1996 Special Issue Newsletter. Most of these were not presented as verbal papers at either the workshop or the IGC, but are given in this volume.

IAVCEI European Union Geosciences, Strassburg, March, 1997.

The Betekhin Symposium was held April 8-10, 1997, in Moscow, CIS

ECROFI XIV was held July 1-4, 1997, in Nancy, France.

4th SGA Biennial Meeting, Turku, Finland, was held Aug. 11-13, 1997.

The Chinese Society on Petrology, Mineralogy and Geochemistry held a conference on fluid inclusions in Wuhan, Hebei Province, China, October 6-8, 1997, with about 40 participants.

New journal announcement. Prof. V. A. Kormushin, Chairman of The Scientific Society, "Termobarogeochemist" in the Republic of Kazakhstan, announces that it will publish Fluid Inclusions and Ore Formation in English and in Russian, the first issue to come out in 1998. Manuscripts in English are invited; submit to Editorial Board, 75-4 Pushkin St., Almaty, 480100 Republic of Kazakhstan. Phone (3272) 61-00-75; fax (3272) 69-61-16. Journal annual subscripion, four issues per year, is $136.

IAGC - Water-Rock Interaction-9, Taupo, New Zealand, was held March 30 to April 4, 1998.

7th International Kimberlite Conference, Rondebosch, S. Africa, was held April 13-17, 1998.

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

VII Exper. Min., Pet., and Geochem. Meeting (EMPG-VII), Orleans, France, May 14-16, 1998.

GAC/MAC, Quebec, Canada, May 18-20, 1998.

Geochem. Crustal Fluids, Crete, Greece, May 22-27, 1998.

AGU/MSA/GS Spring Meeting, Boston, MA, May 26-29, 1998.

PACROFI VII, Las Vegas, NV, June 1-4, 1998 (68 abstracts).

IAVCEI International Volcanological Congress '98, Rondebosch, S. Africa, July 11-17, 1998. Contact email ivc98@geology.uct.ac.za

17th General Meeting of IMA, Toronto, Canada, August 9-14, 1998. Contact: A.J. Naldrett. Telephone (416) 978-3030. Email ima98@quartz-geology.utoronto.ca. Special Session on Fluid and Melt Inclusions.

8th Annual V.M. Goldschmidt Conference, Toulouse, France, Aug. 30 to Sept. 3, 1998. Email goldconf@lucid.ups-tlse.fr. Special Session on Hydrothermal Reactions.

European Union Socrates - Intensive Program, Modern Trends in fluid-phase petrology, Sept. 12-18, 1998, Univ. Siena; contact M.-L. Frezzotti, email (frezzotti@dst.unisi.it)

International Symposium "Mineral Forming Fluids and Ore Genesis, in conjunction with II Symposium APIFIS (Asian and Pacific International Fluid Inclusion Society, Sept. 15-18, 1998, Tashkent, Uzbekistan. Email symp@rubin.gov.uz Note: the APIFIS Symposium was originally scheduled for Oct. 4-8.

GSA Annual, Toronto, Canada, Oct. 26-29, 1998.

AFU Fall, San Francisco, Dec. 6-10, 1998.

GSA Annual, Boulder, CO, Oct. 25-28, 1999, including a two-day SEG short course on Techniques in Hydrothermal Ore Deposits.

5th Biennial SGA Meeting, London, UK, 1999

11th IAGOD Quadrennial Symposium Symposium S. Africa 2002.

ABBREVIATIONS

The Cyrillic sequence, , is converted to abcdef. Other than the normal scientific and reference abbreviations, we use mainly the following:

aq	aqueous	Mt	metric tonnes
CL	cathodoluminescence	P	pressure; primary
dm	daughter mineral†	PS	pseudosecondary
dp	daughter phase†	S	secondary
dxl	daughter crystal	sal	salinity
eq.	equivalent	t	tonne
F	fluid; degree of fill§	T	temperature (°C)
FI	fluid inclusion	Td	temperature of decrepitation*
FIP	fluid inclusion panes	Te	temperature of eutectic melting*
FIR	<u>Fluid Inclusion Research</u>	Th	temperature of homogenization*
G	gas	Tm	temperature of melting*
H	homogenization	Tn	temperature of nucleation*
I	inclusion	Tt	temperature of trapping*
M	melt	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 meanTn ice (on cooling). A few use "Tc" 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	Ky	thousand years
HC	hydrocarbon	Ma	million (10^6)years
F	degree of fill	My	million (10^6) years
ppb	parts per billion (10^9)	mybp	million years before present
ppm	parts per million (10^6)	Ga	billion (10^9) years
µg/g	parts per million (10^6)	XCO2	mole fraction CO_2
‰	parts per thousand	K	temperature Kelvin
ppt	parts per thousand	mg	milligram (10^{-3} g)
per mil	parts per thousand	µg	microgram (10^{-6} g)
per mille	parts per thousand	ng	nanogram (10^{-9} g)
%	parts per hundred	J	joule
percent	parts per hundred	KJ	kilojoule
Ka	thousand years		

The original author's usage has also been followed on *pressure*. Most use bars (≈ atm ≈ 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 = 109 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 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 undetectable 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.

ANALYTICAL METHOD ACRONYMS

The rapid new developments in analytical methods and instrumentation in recent years has brought on a plethoria of acronyms, many of which are meaningful only to the specialist. As these terms may differ from one laboratory to another, and are frequently used without definition, particularly in abstracts, I list here those found in the present volume, along with a few of their cousins from other recent volumes. I would appreciate any corrections or additions.

AAS	Atomic absorption spectrometry
AES-LM	Atomic emission spectroscopy-Laser microprobe
AFTA	Apatite fission track analysis
BSE	Backscattered electrons
CEA	Capillary electrophoresis analysis
CFS	Cold crush fast scan
CIA	Capillary ion analysis
CL	Cathodoluminescence
CLSM	Confocal laser scanning microscopy
CRYO-SEM-EDS	Cryogenic-Scanning electron microscope-Energy dispersive spectrometry
CRYO-XRF	Cryogenic - X-ray fluorescence
CSLM	Confocal scanning laser microscopy
DAC	Diamond anvil cell
D-ICP	Decrepitation-Inductively coupled plasma
EM	Electron microprobe
EMP	Electron microprobe
EPMA	Electron probe microanalysis
EPR	Electron paramagnetic resonance
ESEM	Environmental scanning electron microscopy
ESR	Electron spin resonance
EXAFS	X-ray absorption spectroscopy
FES	??
FES-ICP-AES	??-Inductively coupled plasma-Atomic emission spectroscopy
FTIR	Fourier transform-infrared (spectroscopy)
GC	Gas chromatography
GC-IC	Gas chromatography-Ion chromatography
GC-MS	Gas chromatography-Mass spectrometry
GF-AA	Graphite furnace-Atomic absorption
GOR	??
1H-MAS-NMR	1H-Magic-angle-spinning-Nuclear magnetic resonance (spectrometry)
HDAC	Hydrothermal diamond anvil cell
HR-LA/ICP-MS	??-Laser ablation/Inductively coupled plasma-Mass spectrometry
HRTEM	High resolution transmission electron microscopy
IC	Ion chromatography
ICP	Inductively coupled plasma (if unspecified, normally with decrepitation)
ICP-AES	Inductively coupled plasma-Atomic emission spectrometry
IMS	Infrared microscopy
INNA	Instrumental neutron activation analysis
IR-MS	Isotope ratio-Mass spectrometry
IRM-MS	Isotope ratio monitoring mass spectrometry
L-ICP	Laser-Inductively coupled plasma
L-ICP-MS	Laser-Inductively coupled plasma-Mass spectrometry
LA-ICP-MS	Laser ablation-Inductively coupled plasma-Mass spectrometry
LAM-ICP-MS	Laser ablation microprobe-Inductively coupled plasma-Mass spectrometry
LAMP-ICP-MS	Laser ablation microprobe-Inductively coupled plasma-Mass spectrometry
LA-EOS	Laser ablation-Optical emission spectrometry (French usage)
LA-ICP-MS	Laser activated-Inductively coupled plasma-Mass spectrometry
LA-OES	Laser ablation-Optical emission spectroscopy
LASIRMAS	Laser ablation stable isotope ratio microanalysis system
LMNGMS	Laser microprobe noble gas mass spectrometry
LMPY-GC-MS	Laser ??-Gas chromatography-Mass spectrometry
LMR	Laser Raman spectrometry (?)
LR	Laser Raman
LRG	??
LR-GC/IC	??-Gas chromatography-Ion chromatography

LRM	Laser Raman microspectrometry
LRS	Laser Raman spectroscopy
MAS-NMR	Magic angle spinning-Nuclear magnetic resonance
MC-ICP-MS	Multiple collector-Inductively coupled plasma-Mass spectrometry
MECA	Micro extraction chemical analysis
MLA-OES	Micro laser ablation-Optical emission spectrometry
MT	Microthermometric
MTE	??
NIR	Near infrared
PIGME	Proton induced gamma emission (or Particle induced...)
PIXE	Proton induced X-ray emission (or Particle induced...)
QMS	Quadrupole mass spectrometry
RMP	Raman microprobe
RMS	Raman microsampling spectroscopy
RP-HPLC-ED	Reverse phase-high performance liquid chromatography-Electrochemical detection
RS	Raman spectrometry
RNNA	Radionuclide neutron activation analysis
SAED	??
SE	Secondary electron (imaging)
SEM	Scanning electron microscopy
SEM-CL	Scanning electron microscopy-Cathodoluminescence
SEM-EDS	Scanning electron microscopy-Energy dispersive spectrometry
SEM-WDS	Scanning electron microscopy-Wavelength dispersive spectroscopy
SHRIMP	Super high resolution ion microprobe
SIGMA	Selected inclusion gas micro-analyzer
SIMS	Secondary ion mass spectrometry (ion microprobe)
SPM	Scanning proton microprobe
SXRF	Synchrotron X-ray fluorescence
SYXRF	Synchrotron X-ray fluorescence
TBG	Thermobarogeochemical
TDCS	Thermo decrepitation-Cryogenic separation
TD-MS	Thermal decrepitation-Mass spectrometry
TEM	Transmission electron microscopy
TOF-SIMS	??-Secondary ion mass spectrometry
UV-LA-ICP-MS	Ultra violet-Laser (i.e., Eximer) ablation-Inductively coupled plasma-Mass spectrometry
UVR	Ultraviolet Raman (spectroscopy)
XAFS	X-ray absorption fine structure
XCT	X-ray computerized tomography
XRF	X-ray fluorescence

ABSTRACTS AND CITATIONS, 1996

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 (and e-mail address, if available) 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 Portugese 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.

ABDALLA, H.M., ISHIHARA, S., MATSUEDA, H. and ABDEL MONEM, A.A., 1996, On the albite-enriched granitoids at Um Ara area, Southeastern Desert, Egypt. 1. Geochemical, ore potentiality and fluid inclusion studies: J of Geochem. Exploration, v. 57, p. 127-138. First author at Nuclear Materials Authority, Cairo, Egypt.

A radioactive and metasomatically albite-enriched microgranite stock was emplaced at the northern contact of Um Ara monzogranite pluton. Rock/F interaction within the apogranite is well displayed as petrographical and geochemical zonal patterns in response to K- and Na-metasomatism.

Microthermometric study of FI in quartz of the amazonitized and albitized microgranites indicates that high to moderate T, saline F interacted with the solidified microgranite cupola in the early metasomatic processes. I of the K-enriched zone homogenize in the range of 285-425°C, with sal of 7-22.1 wt.% NaCl eq. However, I in the later fracture and joint-filling quartz veins and fluorite veinlets homogenize in the range of 190-310°C, with sal of 2-5.1 wt.% NaCl eq. It is suggested that the presence of K^+, Na^+ and F^- in the ore F was essential to stabilize complexes of the rare metal elements during extraction and transportation. In contrast, contemporaneous decrease of T and sal, loss of CO_2 and increasing pH due to decreasing P are considered the essential factors for localization of disseminated mineralization of Zr, Y, Nb, Zn and Th and the fracture-filling with U in the apical parts of the Um Ara apogranite stock. (From authors' abstract by E.R.)

ABDULAGATOV, I.M. and DVORYANCHIKOV, V.I., 1995, The thermodynamic properties of geothermal fluids (abst.): Abstracts, Geokhimiya, 1995, no. 5, p. 612-620 (in Russian, translated in Geoch. Int'l., v. 33, no. 1, p. 103-112, 1996). Authors at Geothermal Problems Inst., Dagestan Scientific Center, Russian Acad. of Sci., Makhachkala.

ADABI, M.H., RAO PRASADA, C. and KITTO, P.A., 1996, The source of hydrothermal fluids responsible for carbonate alteration, Renison, Tasmania, Australia: Abstracts, Geol. Soc. of Australia, v. 41, p. 7. First author at Univ. of Tasmania, Dept. of Geol., Hobart, Tasmania, Australia.

Indexed under FI (E.R.)

ADAMS, M.C., 1996, Chemistry of fluids from Ascension £ 1, a deep geothermal well on Ascension Island, South Atlantic Ocean: Geothermics, v. 25, no. 4-5, p. 561-579.

Indexed under FI (E.R.)

AESCHBACH-HERTIG, W., KIPFER, R., HOFFER, M., IMBODEN, D.M., WIELER, R., and SIGNER, P., 1996, Quantification of gas fluxes from the subcontinental mantle: The example of Laacher See, a maar lake in Germany (abst.): Abstracts, Geoch. Cosmo. Acta, v. 60., no. 1, p. 31 First author at Environmental Physics, Swiss Federal Inst. for Environmental Sci. and Technol., CH-8600 Dübendorf, Switzerland.

Vertical and horizontal distributions of helium and neon isotopes were measured in the water of Laacher See. Neon is in appropriate atmospheric equilibrium throughout the lake, but the concentrations of both helium isotopes increase with depth and indicates the presence of mantle-derived helium. Release of bubbles of nearly CO_2 (> 99%) observable in shallow waters at the eastern shore, as well as detected by divers in about 30 m depth, was identified as an important source of the helium excess in the lake. If carefully sampled by divers to avoid air contamination, the bubbles exhibit mantle influenced isotopic signatures not only for helium, but also for neon and argon. Based on the elemental ratios of carbon, neon and argon to ^3He, the fluxes of volatiles from the mantle into Laacher See are determined as 7.4×10^7 atoms for $^{-2}s^{-2}$ for ^3He, 13×10^7 atoms for $m^{-2}s^{-1}$ for ^{20}Ne, 26×10^7 atoms $m^{-2}s^{-1}$ for ^{36}Ar, and 6.4×10^{17} molecules $m^{-2}s^{-1}$ for CO_2. (From authors' abstract by E.R.)

AHLBERG, A., and **GOLDSTEIN, R.H.,** 1996, Fluid inclusions in quartz overgrowths: evidence of Mid-Jurassic volcanic hot brine flushing at shallow burial depth in the Lower Jurassic Höör Sandstone, southern Sweden (abst.): Short Papers and Abstracts for the Jubilee Meeting–"Current Problems, Ideas, and Results in Geology"–Stockholm 16-18 October 1996 at the celebration of the 125th anniversary of the Geological Society of Sweden; edited by Björn Sundquist; GFF, V. 118, Jubilee Issue, 1996, p. A104. First author at Dept. of Geol., Lund Univ., Solvegatan 13, SE-223 62 Lund, Sweden.

The Rhaetian-Hettangian Höör Sandstone, resting directly on Proterozoic gneiss in the Swedish part of the Fennoscandian Border Zone, is extensively quartz indurated. CL microscopy reveals that cementation precluded any severe sediment compaction and that silica mainly was derived from extraformational sources. Alteration of smectites and devitrification of volcanic glass is super-imposed Toarcian-Aalenian volcanic tuffites are regarded as plausible sources of dissolved silica. Vitrinite reflectance and FI data imply a positive correlation between thermal influences, initial permeability and the degree of quartz cementation. Hence the distribution of cement was controlled by the initial permeability and the paths of hot F flow within the strata.

Primary FI in quartz overgrowths reveal entrapment of aq solutions of NaCl (10.5 wt.%), a CaCl-rich brine (18.8 wt.% eq. NaCl) and a complex composite brine (22.3 wt.% eq. NaCl). Th vary widely, between 90 and 200°C. However, single cement-zones yielded petrographically consistent groups of Th values implying repeated pore F entrapment at T ranging from 100 to 195°C (Fig. 17:1).

Middle Jurassic volcanic necks penetrated the Höör Sandstone at shallow burial depth prior to major sediment compaction, and associated heat flows caused flushing of hot brines through permeable strata within the Höör Sandstone. Extensive silica precipitation was triggered as solubilities rapidly decreased during moments of instant cooling and FI were trapped by rapid imperfect early cement growth, near the maximum T experienced by the rock (T peak).

The heat flow and brine migrations of the Höör Sandstone strongly contrast moderate T fresh water and burial diagenesis of adjacent equivalent strata within Fennoscandian Border Zone and the Danish Basin. (Authors' abstract)

FI #	Th (°C)	Tm$_{ice}$ (°C)	Te (°C)
1	155.8	–	–
2	156.7	-6.8	–
3	159.3	-6.2	-22
4	–	–	–
5	134.1	-20.1	–
6	128.5	-20.1	-54
7	147.0	-20.5	–
8	153.8	-7	–
9	164.5	-7.1	-21
10	165.3	-7	–
11	142.9	–	–
12	136.7	–	–
13	161.5	–	–
14	109	–	–
15	160.3	–	–
16	144	–	–
17	142.9	–	–

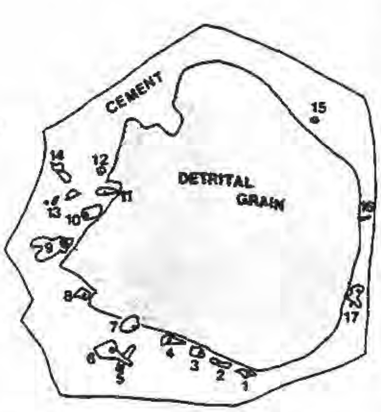


Fig. 17.1. Fluid inclusion data from the quartz overgrowths on a single grain.

AHMAD, S. and **NAYAK, V.K.,** 1996, Fluid inclusion characteristics, genetic and metallogenic analysis of fluorspar field, Chandidongri, district Rajnandgaon, Madhya Pradesh, India (abst.): 30th Int'l. Geog. Cong., Abstracts, v. 1, p. 389. Authors at Dept. of Applied Geol., Indian School of Mines, Dhanbad, India.

In the F-Cu-Pb-Zn mineralization at Chandidongri (21°05'N : 80°38'E), India, fluorite is associated with the minor sulphides–chalcopyrite, galena, sphalerite, and pyrite in silicified fault-breccia and quartz reef within a granitoid complex along a 20 km long N-S shear zone. Minute specks of fluorite have also been documented in granite, pegmatite veins and basic rocks. Fluorite is the dominant mineral with some yttrofluorite and traces of cerofluorite and borofluorite. Fluorite of various colours and grain size occurs as disseminations, small lenticles, stringers, veins and veinlets and is exploited from two main productive quarries with an average grade of 18% CaF_2.

The microthermometric examination of fluorite, quartz associated with it, and quartz of granite revealed four types of FI: (a) Aq Bi-phase (b) Mono-phase (c) Poly-phase (d) Aq Carbonic phase. Th in P I in fluorite, quartz associated with it and quartz of granite ranges between 175 - 225°C, 159 - 180°C, and 132 - 203°C respectively, thereby indicating low to moderate T. The density varies between 0.80 - 1.10 in fluorite; 0.96 - 0.99 in quartz associated with fluorite and 0.957 - 1.115 gm/cm^3 in quartz of granite. Sal in fluorite and quartz associated with it ranges between 3.0 - 13.0 and 9.1 - 12.99 wt.% NaCl eq. Significance of major, minor and trace elements in 7 fluorite samples are interpreted and discussed. The deposit of fluorspar is recognized as a vein, fracture-filling, structurally controlled, low T epithermal deposit type. (From authors' abstract by E.R.)

AI, Youngfu, ZENG, Yishang, and **ZHU, Yongfeng,** 1996, Liquid immiscibility in felsic magma and its ore-forming potentiality (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 624. Authors at Dept. of Geol., Peking Univ., Beijing 100871, China P.R.

The experimental results show that granite-KBF_4-Na_2MoO_4-WO_3 system is a homogenous M at high T; with decrease in T, however, the M decomposes into three immiscible M: silicate M, ore-forming M, and M with volatiles. (From authors' abstract by E.R.)

AÏSSA, M. and **VOLFINGER, M.,** 1996, Microchemical characterization of fluids and minerals of Sn-W skarn of El Hammam (Central Morocco) (abst.): 16th Earth Science Meeting, (Abstracts), published by Soc. Géol. Fr., Paris, p. 86 [151?] (in French). First author at Faculty of Sci. of Meknès, Morrocco.

Microthermometry studies of F of this district reveal that the Sn skarns are associated with F rich in chlorides (late-magmatic origin?) and that the W skarns are associated with CH_4-rich G, probably of metamorphic origin. In other places boron skarns are developed, sometimes replacing the previous skarns, connected with diluted aq F. To geochemically distinguish the sources of boron (granitic or rhyolitic) and the metals, the contents of minor and trace elements are determined in these F and in the associated minerals: hedenbergite and scheelite in the tungsten episode, diopside, andradite and malayite in the tin episode. Analyses have been carried out on separated minerals with optical ICP, neutron activation, electron and nuclear microprobes. The nuclear microprobe allows for non-destructive analysis of F enclosed in minerals, if the contribution from the F itself can be distinguished from the noise of the matrix. In this way, Cu, Zn, As and Pb have been detected in the Sn-episode F in diopside (on top of Fe and Mn present in the matrix). Also, boron has been found in minerals and/or F associated with the Sn episode. Whole-rock analyses show that the W-bearing pyroxenite is richer in Cr, Zn, Sc, Rb, Sr, Zr, U and Th than the Sn-bearing garnetite. (Authors' abstract, translated by E.A.J. Burke)

AKAMATSU, Kazuo, MATSUEDA, Hiroharu, NAKAMURA, Noboru, and **YUI, Shunzo,** 1996, Hydrothermal alteration and gold mineralization at Otaru-Akaiwa, southwestern Hokkaido, Japan (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 657. Authors at Dept. Earth & Planetary Sci., Hokkaido Univ., Japan.

Extensive hydrothermal alterations are well developed. The alteration can be divided into three zones. Based on the FI and sulfur isotope studies, the estimated formation T of these alteration zones are about 190 - 240°C. Stable isotopic studies for oxygen and sulfur of altered rocks and minerals show clear water-rock interaction process in the hydrothermal alteration of this area.

Considering these facts mentioned above, propylitization might have followed just after the Miocene volcanic activities of andesite and dacite in this area, and is superimposed by acid and neutral hydrothermal alterations. The eastern part of alteration zones could have been formed by the strong acid sulfate hydrothermal fluids originated in magmatic F or circulating sea water, while the western part by neutral and relatively higher saline hydrothermal water. Gold precipitation might be caused by the decomposition of gold bisulfide complex according to oxidation of sulfur species in mixing of F with meteoric water at the shallow level of the eastern part, while cooling and/or dilution of hydrothermal F at the western part. (From authors' abstract by E.R.)

AKBAROV, H.A. and **POLYKOVSKY, V.S.,** 1996, The methods of thermobarogeochemistry: The possibilities and the experience of their use in the time of geology-prospecting or exploration work in Uzbekistan (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 11-13. Authors at Mining-Geological Center, Tashkent State Tech. Univ.

A review. (E.R.)

AL-FILALI, I.Y. and **DROOP, G.T.R.,** 1996a, Aqueous flu-ids in arc-related high-T, low-P regional metamorphism in the SW Nabitah Mobile Belt, Saudi Arabia (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 583. Authors at Dept. of Earth Sci., Univ. of Manchester, U.K.

The close match between the peak T implied by calcite-dolomite thermometry and those recorded by univariant devolitilisation equilibria suggests that the calcareous rocks were F-bearing during late-prograde and peak metamorphic stages. These F were essentially binary H_2O - CO_2 mixtures with low NaCl and HF concentrations. Most were H_2O - rich, with XCO_2 between 0.02 and 0.2, but values of variance assemblages indicates local control of F composition. High modal abundances of the solid products of decarbonation reactions (e.g. ca. 10-50% wollastonite) in many of the rocks that record low-XCO_2 equilibrium F implies infiltration of significant quantities of externally-derived aq F, but not enough to exhaust the buffering capacity of the rocks. Calculated minimum time-integrated F:rock ratios of five calc-silicate rocks range from 0.7 ± 0.22 to 1.39 ± 0.46 (1 [Ó]); those of seven marbles range from ca. 0 to 8 ± 2.5. The variation occurs on a metre-scale, implying focussing of F flow. Infiltrating F were probably derived both from the prograde dehydration of adjacent meta-basalts and -tuffs and from crystallization of voluminous granitoid intrusions of the 'Nabitah Plutonic Suite'.

The occurrence of retrograde hydration textures in rocks otherwise lacking hydrous minerals testifies to infiltration of aq F during retrograde metamorphism. (From authors' abstract by E.R.)

AL-FILALI, I.Y. and DROOP, G.T.R., 1996b, Interaction of aqueous fluids with calcareous metasediments during high-T, low-P regional metamorphism in the Qadda area, southern Arabian Shield: J. Metamorphic Geol., v. 14 (1996) p. 613-634. First author at Dept. of Earth Sci., Univ. of Manchester, Oxford Rd., Manchester M13 9PL, UK.

Calcsilicate rocks and aluminous dolomitic marbles within the supracrustal sequence have been studied in detail to refine estimates of peak metamorphic *P-T* conditions and assess the role of F during prograde and retrograde metamorphism.

F-independent thermobarometers yield peak *P-T* conditions of *c.* 650-660°C, 4 kbar, both higher than previous estimates, giving a revised average thermal gradient of *c.* 45°C km^{-1}.

The close match between the peak T implied by calcite-dolomite thermometry and those recorded by univariant devolatilization equilibria suggests that the calcareous rocks were F-bearing during late-prograde and peak metamorphic stages. These F were essentially binary H_2O-CO_2 mixtures with low NaCl and HF concentrations. Most were H_2O-rich, with X_{CO_2} between 0.02 and 0.2, but values of *c.* 0.6 are recorded by two samples. (From authors' abstract by E.R.)

ALDERTON, D.H.M. and **BEVINS, R.E.,** 1996, P-T conditions in the South Wales Coalfield: evidence from coexisting hydrocarbon and aqueous fluid inclusions: J. of the Geol. Soc. of London, v. 153, pt. 2, p. 265-275. First author at Dept. of Geol., Royal Holloway (Univ. of London), Egham, Surrey TW20 OEX, UK

Siderite nodules in the Carboniferous Coal Measures of South Wales contain cavities which are often infilled with quartz, carbonates, sulphides, and hydrocarbons. The quartz contains a mixture of hydrocarbon and aq FI. The aq FI consist of a dilute brine (3 wt.% NaCl eq.) and have Th in the range of 97-212°C (mean 143°C). The hydrocarbon FI are dominated by methane with a small component of higher order hydrocarbons; their Th are in the range of 35-78°C (mean 54°C). It is assumed that the two F were trapped simultaneously during growth of the quartz and thus a P-T estimate of entrapment can be obtained by graphical intersection of the hydrocarbon isochores and the aq F bubble point (homogenization) T assuming hydrocarbon saturation. This method gives T between 130 and 160°C, and P between 40 and 55 MPa. The timing of mineralization is uncertain, but it is suggested that it took place during burial and low grade metamorphism of the subsiding sedimentary basin (i.e. in the Upper Carboniferous). The hydrothermal F were probably derived from evolved meteoric or connate waters expelled during subsidence and sediment compaction. (Authors' abstract)

ALDERTON, D.H.M. and **COUTINHO, M.G.N.,** 1996, The geology of shear-zone hosted gold deposits in northeast Brazil (abst.): 30th Int'l. Geol. Cong. Abstracts, v. 2, p. 752. First author at CPRM, Brazil Geol. Survey, Rio de Janeiro, Brazil.

Mesothermal gold-bearing quartz veins are widespread in the Borborena Province, N.E. Brazil, and well exposed in two mines: São Francisco and Cachoeira de Minas mine.

A Pb isotope study of the host rocks has yielded a Pb-Pb isochron age of about 1.0 Ga, regarded as the time of regional high-grade metamorphism at amphibolite facies. Retrogressive metamorphism in the sub greenschist facies (350°C) is common. Calc-alkaline magmatism reflects a genetic link between the magmatism and the gold mineralization.

Ore-mineral studies have placed constraints on the gold metallogenesis and these, combined with the structural information, suggest three stages of mineralization. In the first stage, F enriched in CO_2 and S provided conditions for the precipitation of metals, and gold occurs as submicron particles at the surface of pyrite and chalcopyrite. In the second stage, there is a greater input of additional elements (e.g. Bi, Te, Mo, F and B). The last stage is characterised by an enrichment in Pb, Te and Au. Quartz and tourmaline are common as gangue minerals.

The geochemistry and the mineralogy of the wallrock alteration suggests that the rocks were all subjected to the same metasomatic processes and also that the hydrothermal F composition was not controlled by the chemistry of the host rocks. The relationships between deformation, gold mineralization, and wallrock alteration indicate that the wallrock alteration took place before the gold mineralization.

The hydrothermal F from which the gold-bearing quartz veins crystallised was originally homogeneous and CO_2-rich, but the subsequent immiscibility process caused separation of CO_2-rich and CO_2-poor or H_2O-CO_2 phases. The unmixing of F was related to episodic hydraulic fracturing, which provided P fluctuations during the quartz veins growth. P-T conditions during mineralization indicate that gold precipitated at 270-350°C and 1.0-3.4 kb. Stable isotope analysis of FI in gold-bearing quartz veins indicate that the carbon ($\delta^{13}C$) has a magmatic, possible mantle, derivation (–7.60 to 2.11‰). There is a large scatter in the $\delta^{18}O$ quartz values (7.0 to 14.5‰) or $\delta^{18}O$ values of the F (–1.0 to 9.0‰), suggesting mixing of F from different sources including that of meteoric water. (From authors' abstract by E.R.)

ALEXANDROV, A., GORDIENKO, V., DEREVSKAYA, E., ZEMSKOV, G., IVANOV, A., PANOV, B., SHUMLYANSKIY, V. and **EPOV, O.,** 1996, Deep structure, evolution of fluid systems and endogenic gold-bearing potentiality, southeastern part of Ukrainian Donets Basin (abst.): Pub. of Izd. IFI Urk. Nanchn. Assoc., [Inst. of Fundamental Sci., Sci. Assoc. of Ukraine], Kiev, 74 pp (in Russian with extended Engl. abst.).

The emphasis of this study is an attempt to elaborate criteria suitable to guide Au deposits exploration in regions where magmatism rarely occurs at present surface. Geophysical and remote sensing data have been used. Particularly, two magmatic minima suggest latent intrusive bodies. Geologically, observed external attributes of these intrusions are so-called "Thermal domes," i.e. local plots of altered, up to anchimetamorphic grade enclosing rocks, which cannot be attributed solely to burial metamorphism as indicated by the structural setting. Besides that, associated extensive areas of hydrothermally/metasomatically altered Carboniferous sediments and numerous occurrences of mineralization show evidence that two large hydrothermal convective systems existed within the region. Characteristics of these systems are given on the basis of FI microthermometry (in vein minerals) as well as study of P and ore-bearing solution compositions. Isotope ratios determined for oxygen, hydrogen, sulfur in minerals and oxygen, hydrogen in I infer the nature of mineralization is related indirectly to magmatic activity. (Author's abstract, courtesy A. Aleksandrov).

ALTENBERGER, Uwe, 1996, Fluid enhanced element redistribution, mass transport and volume changes in eclogite and amphibolite facies shear zones of different geological settings, Chem Erde, v. 56, p. 1-24. Author at Institut für Geowissenschaften, Universität Potsdam, Germany.

24 shear zones of eclogite and amphibolite facies conditions in metabasic host rocks of the Norwegian Caldedonides, the Ivrea Zone and the Central European Variscan belt are analyzed for their metasomatic alterations. The mass balance reveals that Ba, K, La, Ce, and F are enriched in all amphibolite facies zones and Cr and Zr are depleted in most zones. The mobilization of the so-called immobile elements (e.g. Zr) is probably caused by the presence of significant amounts of F in the aq F and transport of LRE elements by CO_3^{2-}, F^- and Cl^- complexes. (From author's abstract by E.R.)

ANDERSEN, Tom and **BURKE E.A.J.,** 1996, Methane inclusions in shocked quartz from the Gardnos impact breccia, south Norway: European J. of Mineral., v. 8, no. 5, p. 927-936. First author at Mineralogical-Geological Museum, Oslo, Norway.

A meteorite impact structure of Late-Proterozoic age has recently been recognized at Gardnos in the Hallingdal area, South Norway. The structure is situated in pre-1100 Ma gneisses and metasediments, and consists of a zone of autochtonous breccia, a suevite (impact M) breccia and a series of unbrecciated crater fill sediments. In the late Silurian, the impact structure was overrun by Caledonian nappes, leading to low-grade metamorphic recrystallization ($T_{max} \leq 400°C$, $P_{max} \geq 2.5$ kbar). Shocked quartzite from the autochtonous breccia is impregnated by fine-grained carbonaceous material, giving it a nearly black colour in hand specimens. Micro-Raman spectroscopy shows this material to be poorly crystalline. Planar fractures, typical of shocked quartz, are outlined by graphite I and by trails of S FI. The FI comprise methane I, with minor CO_2 and no visible water ($X_{CH_4} \geq 96$ mol%) and water I with moderate sal. The methane I show H1, H2 and S2 types of microthermometric behaviour; H1 I show a peak of Th to the L at -84 to -112°C. At $T \leq 400°C$, this corresponds to isochore P of 1 to 2.5 kbar, which is compatible with a Caledonian cooling and uplift path, but not with the extreme P at the moment of the impact, nor the low P ($P \leq 0.2$ kbar) encountered in the shallow parts of the impact structure during the final stges of post-impact cooling. Methane was formed *in-situ* by reaction between solid carbonaceous material and aq metamorphic F, and was trapped as the partly open planar fractures healed. The methane-rich FI in shocked quartz from the Gardnos impact structure are thus only indirectly related to the meteorite impact and not at all to hydrocarbons of a deep (mantle) origin. (From authors' abstract by E.R.)

ANDERSON, A.J., 1996, A new oil immersion vessel for optical spindle stage examination of fluid and solid inclusions (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 1. Author at Dept. of Geol., St. Francis Xavier Univ., P.O. Box 5000, Antigonish, Nova Scotia, Canada, B2G 2W5.

A new oil immersion vessel has been developed for petrographic analysis of FI with a spindle stage. With this vessel, immersion L is retained during rotation of the spindle with an oil-seal-shaft. The shaft projects through a wall in the vessel and is used to rotate a circular, disc-shaped magnet about a horizontal axis. A mineral grain or polished wafer may be attached to the end of a metal stub which is held within the vessel by the circular magnet. A FI can be positioned along the horizontal axis of rotation by movement of the stub across the surface of the magnet with a centering screw. Positioning along the vertical axis of rotation is achieved by translating the immersion vessel in a direction parallel to the horizontal rotation axis.

This modified oil immersion vessel has several advantages relative to the prototype described by Anderson and Bodnar (American Mineralogist, 1993). These are: (1) it is much easier to change and position samples, (2) it can be used with a wider range of refractive index oils, (3) it is simpler and more durable, (4) it is less expensive because a goniometer head is not needed for sample positioning, and (5) the number of rotations about the horizontal axis is unlimited. (From author's abstract by E.R.)

ANDERSON, A.J., MAYANOVIC, R.A. and **BAJT, S.,** 1996, A micro-XAFS study of aqueous chlorozinc complexing up to 430°C in fluid inclusions from a pegmatite in the Saxonian granulite massif, Germany (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A3. First author at Dept. of Geol., St. Francis Xavier Univ., Antigonish, N.S., B2G 2W5.

The x-ray microprobe (X26A) at the Nat'l. Synchrotron Light Source (NSLS) was used to collect Zn K-edge x-ray absorption fine structure (XAFS) spectra from saline (ca. 35 wt.% NaCl eq.) FI in pegmatitic quartz between 30 and 430°C. The granitic pegmatites intrude granulite facies rocks of the Saxonian Granulite Massif and are spatially related to sulfide-bearing quartz veins near the town of Harmannsdorf, Germany (R. Thomas pers. comm.). Individual FI within polished quartz wafers were analyzed as the T of the I was controlled with a programmable heating stage which was attached to the X-Y-Z-0 mobile stage of the beam line. XAFS spectra collected in ~50°C intervals up to 430°C indicate that the tetrahedral chlorozinc complex $ZnCl_4^{2-}$ is the dominant species in the FI over the entire T range. In contrast, previous solubility experiments predict that $ZnCl_2^0$ is the dominant aq zinc species at T >300°C in solutions in the 0.5 to 5.0 m total chloride range. Factors contributing to the high-T stability of $ZnCl_4^{2-}$ in the studied FI are currently under investigation.

We conclude that micro-XAFS may be used to obtain direct structural information on some metal complexes in granite/pegmatite-derived F at elevated T. These data are pertinent to our understanding of metal transport and deposition in granite-related hydrothermal systems. (Authors' abstract)

ANDERSON, D.I., 1996, High $^3He/^4He$ basalts and the helium-heat flow paradox: more manifestations of the lead-paradox which is actually the uranium paradox; no plumes needed (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F768, November 12, 1996. Author at Seismological Laboratory, 252-21, California Inst. of Tech., Pasadena, CA 91125; 818-395-6901; e-mail (dla@seismo.gps.caltech.edu)

High $^3He/^4He$ (R) basalts and xenoliths play a central role in noble G models of mantle evolution and plume speculations. High R is invariably attributed to "excess ^3He" and a "primordial undegassed lower mantle." However, basalts from the "depleted degassed" (MORB) reservoir have "excess ^3He," compared to high R ("plume") basalts, in terms of $^3He/^{36}Ar$, $^3He/^{130}Xe$, $^3He/^{20}Ne$, and He/Sr ratios, and overlap "undegassed" basalts in $^3He/CO_2$. On the other hand MORB have excess $^4He/CO_2$ and [^3He] compared to ocean island basalts (OIB). Furthermore, MORB is enriched in $^4He/^{21}Ne$, $^4He/^{40}Ar$ and $^4He/^{136}Xe$ compared to OIB and theoretical production ratios. Since He dissolves in M more readily than the other noble G the separation of MORB and OIB radiogenic ratios at the production ratio indicates that "hotspot" G were in equilibrium with a M, probably MORB. It is only in the $^3He/^4He$ and $^3He/^{238}U$ ratios that MORB is, sometimes, "depleted" in ^3He. Thus, MORB contains an excess of ^4He relative to high R basalts, rather than OIB having "excess ^3He."

MORB degasses, starting at 60 km depth, near ridges. Noble G get flushed out of the M with CO_2 and become trapped in F-filled I in refractory (low U) lithosphere. The high $^3He/^4He$ is frozen in since M (U, Th) and G (CO_2, He) have separated. The MORB reservoir continues to evolve ^4He, reaching R of ~8 atmospheric (Ra) today. The F-filled I retain an R of about 50 Ra, a value appropriate for old lithosphere. The MORB source has U abundance of 20 to 30 ppb causing a large decrease in R compared to values that MORB and its degassed volatiles had when the lithosphere formed. Mid-plate volcanism releases the G in these "delayed release time capsules" giving a transient high R pulse to volcanoes utilizing new lithospheric cracks or conduits. The required high U in the MORB source also explains the Pb-paradox (high ^{206}Pb). The trapping of He in the lithosphere explains the He-heat flow paradox. High $^3He/^4He$ basalts and xenoliths reflect low ^4He and are from old refractory lithosphere, not undegassed primordial lower mantle. (Authors' abstract)

ANOVITZ, L.M., BLENCOE, J.G., JOYCE, D.B. and **HORITA, J.,** 1996, Activity/composition relations of H_2O - N_2 and H_2O - CO_2 fluids at 500°C, 500 bars (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A-159. First author at M.S. 6110, Building. 4500-S, Oak Ridge Nat'l. Laboratory, Oak Ridge, TN 37831-6100.

Accurate, precise activity/composition (a/X) relations for mixed-species supercritical F are critical to a wide range of geological and industrial applications. We have completed experiments on the a/X relations of H_2O - N_2 and H_2O - CO_2 F at 500°C, 500 bars, and obtained more accurate and precise data than any currently available, especially for water-poor compositions.

The experiments were performed in a hydrogen-service internally heated G apparatus. $Ag_{25}Pd_{75}$ capsules were loaded with (1) water, (2) Cu, N or silver oxalate as a source for the second F component, and (3) either a Ni / NiO or CO / CoO fO_2 buffer. Vacuum line techniques permit extremely accurate and precise sample analysis. Each capsule is punctured in the vacuum system, and water and the diluent component separated cryogenically. Water is reduced to hydrogen using a U-furnace, and the mass of each component is measured using a standard volume connected to a Toepler pump. We can measure 0.1 mg of H_2O with better than 1% AP accuracy.

H_2O - N2 and H_2O - CO_2 samples were reacted at 500°C, 500 bars and $0.062 \le a(H_2O) \le 0.792$. The resulting a/X data were treated using two-variable linear programming to fit two parameter Margules equations. This yielded: for H_2O / N_2, $W(H_2O) = 2846.1$ J/mol•K and $W(N_2) = 3455.4$ J/mol•K; and for H_2O / CO_2, $W(H_2O) = 3229.8$ J/mol•K and $W(CO_2) = 6386.4$ J/mol•K. As uncertainties are not orthogonal, standard uncertainties cannot be given. Results for H_2O - N_2 F differ significantly from the limited data curent available (Basaev et al., 1974; Shmulovich et al., 1982). In addition, our data suggest that H_2O - CO_2 mixing is strongly non-ideal at 500°C, 500 bars, unlike results predicted from MRK equations (Kerrick and Jacobs, 1981, Holloway, 1977). These results clearly indicate that significant revisions to a/X models for both H_2O - N and H_2O - CO_2 F are needed. (From authors' abstract by E.R.)

ARANCIBIA, O.N. and **CLARK, A.H.,** 1996, Early magnetite-amphibole-plagioclase alteration-mineralization in the Island Copper porphyry copper-gold-molybdenum deposit, British Columbia: Econ. Geol., v. 91, p. 402-438. First author at 1919 Simard Drive, Gloucester, Ontario, Canada K1C 3B9.

The initial hydrothermal event in the evolution of the ca. 377 Mt, 0.41% Cu, Island Copper porphyry Cu-Au-Mo deposit, northern Vancouver Island, was the formation of an extensive alteration-mineralization facies dominated by magnetite, calcic amphibole, and intermediate to sodic plagioclase. Early-stage quasipervasive magnetite-rich alteration and associated magnetite-rich veinlets in this Middle Jurrasic, island arc-hosted, hydrothermal system developed in both an axial dacitic porphyry dike and contiguous basaltic flows and pyroclastic strata.

Mass-exchange calculations demonstrate that early alterations involved intense iron metasomatism of both felsic and mafic country rocks, and lesser and more variable N enrichment, with both Ti and Al behaving as mobile constituents. Paragenetically early FI in the quartz phenocrysts of the dike are tentatively correlated with the magnetite-rich alteration-mineralization and imply that this event was initiated above 650°C and at P of at least 1 kbar and was generated by $FeCl_2$-rich brines, at first single phase and moderately saline (average 15 wt.% NaCl eq.), but latterly boiling at Ca. 560 to 645°C and ≤ ca. 0.55 kbars. The main-stage potassic alteration zone has the configuration of an annulus, ca. 100 to 150m in width, which was entirely superimposed on the more extensive early alteration-mineralization zone at ca. 430 to 575°C and below 451 kbars. Gold, although correlated overall with Cu and potassic alteration, was probably extensively introduced in the early stage.

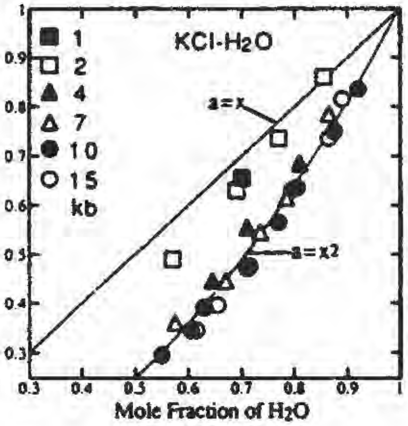
It is inferred that the scarcity of sulfides in the early alteration assemblages reflects the highly oxidized nature of the initial F, in which SO^{2-} exceeded both H_2S and SO_4^{2-}. The deposition of abundant magnetite and the widespread and intense Fe metasomatism which define the early-stage record the high solubility of Fe as $FeCl_2^\circ$ in high-T brines in equilibrium with magnetite-bearing quartzofeldspathic rocks, as well as retrograde solubility of magnetite between ca. 550 and 750°C. (From authors' abstract by E.R.)

ARANOVICH, L.Y. and **NEWTON, R.C.,** 1996a, H_2O activity in concentrated KCl-H_2O solutions at 1-15 kbar and 550-900°C (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A159. First author at Dept. of the Geophysical Sci., Univ. of Chicago, 5734 S. Ellis Ave., Chicago, IL 60637.

H_2O activity in solutions of up to 50 mole% KCl was measured by reversal of the composition of the V phase coexisting with periclase (MgO) and brucite, $Mg(OH)_2$. The H_2O activity is measurably lower than NaCl-H_2O solutions, and, at P above 7 kbar, is nearly equal to the square of the H_2O mole fraction (figure). Six points on the sylvite saturation surface were determined accurately from termination of the brucite-periclase equilibrium curves, which yield six diverse values of a_{KCl}.

Formulas [are given that] reproduce both the H_2O and KCl activities to ±.01 over the entire experimental range.

The very low a_{H_2O} in concentrated KCl solutions at high pressures is undoubtedly the consequence of ionic dissociation of KCl. The behavior is similar to NaCl solutions and reinforces the concept that alkali chloride brines may be feasible as metasomatic F of suitably low a_{H_2O} for a variety of deep-crust and upper mantle processes. (From authors' abstract by E.R.)



ARANOVICH, L.Y. and **NEWTON, R.C.,** 1996b, H_2O activity in concentrated NaCl solutions at high pressures and temperatures measured by the brucite-periclase equilibrium: Contrib. Mineral. Petrol., v. 125, p. 200-212. Authors at Dept. of Geophys. Sci., Univ. of Chicago, IL, 60637.

H_2O activities in concentrated NaCl solutions were measured in the ranges 600-900°C and 2-15 kbar and at NaCl concentrations up to halite saturation by depression of the brucite ($Mg(OH)_2$)-periclase (MgO) dehydration equilibrium. Isobaric halite saturation points terminating the univariant brucite-periclase curves were determined at each experimental P. The five T-composition points in the system NaCl-H_2O are in close agreement with the halite saturation curves (liquidus curves) given by existing data from differential thermal analysis to 6 kbar. At 2 kbar, solutions closely approach an ideal G mixture, whereas at 10 kbar and above the solutions closely approximate an ideal fused salt mixture, where the activities of the H_2O and NaCl correspond to an ideal activity formulation. The thermodynamic behavior of concentrated NaCl solutions at high T and P is thus much simpler than portrayed by extended Debye-Hückel theory. The low H_2O activity at high P in concentrated supercritical NaCl solutions (or hydrosaline M) indicates that such solutions should be feasible as chemically active F capable of coexisting with solid rocks and silicate L (and a CO_2-rich V) in many processes of deep crustal and upper mantle metamorphism and metasomatism. (From authors' abstract by E.R.)

ARCOS, David, SOLER, Albert and **DELGADO, Jordi,** 1996, Fluid evolution in the Cu-Au deposit related to the Carlés granodiorite (Asturias): Eur. J. Mineral., v. 8, p. 975-985. Authors at Dept. de Cristallografia, Mineralogia I Dipòsits Minerals, Univ. de Barcelona, c./Martí I Franques s/n. 08028 Barcelona, Spain.

The Carlés copper-gold deposit, located in the Cantabrian Zone (the outermost zone of the Hercynian Iberian Massif), is associated with a small intrusive body of granodioritic composition of late Hercynian age (283 ± 6 Ma). Four different types of alteration characterize the deposit: a skarn developed in marbles; an amphibole-arsenopyrite replacement of the marbles and of the earlier metasomatic skarn; a K-feldspar alteration mainly developed in the granodiorite; and a greisen-type alteration also developed in the granodiorite. The exoskarn and an endoskarn alteration were the first alterations formed in a high-T episode (702-500°C), while the other three types of alteration and a veining stage hosted in the exoskarn, were formed along with the ore minerals in a lower T stage (500-300°C). Ore mineralogy in the veins of the skarn and K-feldspar alteration consists of copper sulfides and significant amounts of gold; in the greisen and amphibole-arsenopyrite alterations the dominant sulfides are arsenopyrite, löllingite, and pyrite, and gold has been not detected.

FI in garnets from the exoskarn and in quartz from veins of the skarn and the K-feldspar alteration, are highly saline (up to 48 wt.% NaCl eq.), with small quantities of CO_2. FI in quartz from greisen and amphibole-aresenopyrite alterations show low sal (<6 wt.% NaCl eq.), significant amounts of CO_2 ($X_{CO_2} = 0.15\text{-}0.03$), and small amounts of CH_4, N_2, and H_2S were also detected by micro-Raman analysis. The similarity of $\delta^{18}O$ values in quartz from all alteration types, and the FI relationships suggest that an unmixing process took place during the low-T episode, related to a fracturing event. The distributions of ore minerals and FI types suggest that gold and copper were fractionated preferentially into the high-sal F. A decrease in T probably caused the precipitation of gold and copper sulfides in the skarn and K-feldspar alteration. (Authors' abstract)

AREHART, G.B., 1996, Characteristics and origin of sediment-hosted disseminated gold deposits: a review. Ore Geol. Reviews, v. 11, p. 383-403. Author at Wairakei Research Center, Private Bag 2000, Taupo, NZ.

Sediment-hosted disseminated gold (SHDG) deposits compromise a major portion of the gold production and reserves in the U.S. Because of their fine-grained nature and the lack of macroscopic features such as veins, it has proven quite difficult to extract geochemical data that are clearly related to their genesis. However, FI data indicate P corresponding to depths of 2-4 km under lithostatic conditions. T are constrained by FI and phase equilibria to near 225°C. Stable isotope data from alteration minerals and FI indicate that the ore F were dominated by meteoric waters, some of which had clearly exchanged oxygen with wallrocks during their passage through the crust. Although the data vary, most ore F probably had δD values near –150‰ and $\delta^{18}O$ values ranging from –10 to +5. Sulfur isotope values reported from SHDG deposits span a wide range, from –30 to 20‰ (sulfides) and 0 to > 45‰ (sulfates). Ore-related sulfides (pyrite, realgar) fall at the upper end of the range reported for sulfides. The alteration and mineral assemblage indicate the ore F were probably near neutral and gold was likely carried as a bisulfide complex. The decompositional mechanism(s) probably included mixing, cooling, and oxidation. These mechanisms are consistent with the observed alteration features, i.e. quartz precipitation, calcite dissolution and sericite-kaolinite coexistence. It also explains the presence of both siliceous ores containing native Au and sulfide ores containing Au in pyrite. The extreme variations in the sulfur isotopes as seen at Post and FI data from Carlin may be indicative of some phase separation ("boiling"), but such relations have not been documented in other deposits and the importance of phase separation to gold deposition appears minimal. (From author's abstract by E.R.)

AREHART, G.B., CHRISTENSON, B.W., LINDSAY, J.M., and SANO, Y., 1996, Paleofluids at the Golden Cross epithermal mine, New Zealand (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A93. First author at Inst. of Geological and Nuclear Sci., Private Bag 2000, Taupo, New Zealand.

Analyses of FI and isotope ratios in hydrothermal minerals (quartz and calcite) provide a significant insight into the possible sources of F at Golden Cross.

Modal Th for the samples studied range from 145 to 230°C, but the majority of the data fall between 185 and 205°C. The majority of freezing point depression T fall between –0.1 and –0.9°C, corresponding to between 0.2 and 1.5 wt.% NaCl eq. A significant portion of the freezing point depression can be accounted for by dissolved CO_2, therefore, the actual sal are much less than the calculated wt.% NaCl eq. sal.

Stable isotope measurements of oxygen and carbon were made on calcite and both ore-stage and late-stage quartz C isotope values of calcite range between –2.0 and –9.9 (PDB) and O isotope values range between 3.4 and 15.4 (VSMOW). Oxygen isotope values of quartz fall between 7.3 and 11.2 (VSMOW).

Calculated F oxygen isotopic compositions for most samples fall in a limited range of –3 to –6. Most of this variation is attributable to mixing of a deeper evolved meteoric-hydrothermal F with a shallower less-evolved meteoric F. However, a significant number of samples fall outside this range (at higher values). Extrapolation of the mixing trend to higher T (ca. 300°C) yields a F composition near 0 permil. Boiling and subsequent mixing of this deep F with a shallower meteoric F could yield nearly all of the oxygen isotopic compositions observed. F carbon isotope values, noble G isotope ratios and hydrogen isotope ratios of FI are consistent with a magmatic component. (Authors' abstract)

AREHART, G.B., CHRISTENSON, B.W., LINDSAY, J.M., SIMPSON, C.R.J., SIMPSON, M.P., SIMMONS, S.F. and MAUK, J.L., 1996, Paleohydrology of the Golden Cross vein system: Proceedings 18th NZ Geothermal Workshop, 1996, S.F. Simmons et al, eds., Geothermal Inst., The Univ. of Auckland, p. 163-168. First author at Wairakei Research Centre, IGNS, Taupo, NZ.

FI and stable isotopic analyses of carbonates and quartz establish that there are three F represented in the [epithermal] Empire Vein structure at Golden Cross [Coromandel Range]. The first F is a more near-surface meteoric F which has undergone little or no isotopic exchange with the surrounding rocks. The second F comprises a deep geothermal F of probable meteoric origin but which has exchanged oxygen isotopes with the rock through which it has passed at elevated T. The third F is of magmatic origin. In most cases, the latter two F have been significantly diluted by mixing with the first F. (Authors' abstract)

ARIF, M., FALLICK, A.E. and MOON, C.J., 1996, The genesis of emeralds and their host rocks from Swat, northwestern Pakistan: A stable-isotope investigation. Mineral. Deposita, v. 31, p. 255-268. First author at Dept. of Geol., Univ. of Peshawar, Peshawar, N.W.F.P., Pakistan.

Emerald deposits in Swat, northwestern Pakistan, occurring in talc-magnesite and quartz-magnesite assemblages, have been investigated through stable isotope studies. The oxygen isotopic composition ($\delta^{18}O$ SMOW) of emerald shows a strong enrichment in ^{18}O and is remarkably uniform at +15.6 ± 0.4‰ (1σ, n = 7). Each of the two components of water in emerald (channel and I) has a different range of hydrogen isotopic composition: the channel waters being distinctly isotopically heavier. (δD = –51 to –32‰ SMOW) than the other I waters (δD = –96 to

–70‰ SMOW). Similarly the oxygen isotope compositions of tourmaline and fuchsite are relatively constant ($\delta^{18}O$ = +13 to –14‰ SMOW). It is proposed that the Swat magnesites formed due to the carbonation of previously serpentinized ultramafic rocks by a CO_2-bearing F of metamorphic origin. (From authors' abstract by E.R.)

ARKAI, Peter, MERRIMAN, R.J., ROBERTS, Brinley, PEACOR, D.R. and **TOTH, Maria,** 1996, Crystallinity, crystallite size and lattice strain of illite-muscovite and chlorite; comparison of XRD and TEM data for diagenetic to epizonal pelites: European J. of Mineral., v. 8, no. 5, p. 1119-1137. First author at Hungarian Acad. of Sci., Laboratory for Geochem. Research, Budapest, Hungary.

Indexed under FI (E.R.)

ARMBUSTER, Th., KOHLER, Th., MEISEL, Th., NAGLER, Th. F., GOTZINGER, M.A. and **STALDER, H.A.,** 1996, The zeolite, fluorite, quartz assemblages of the fissures at Gibelsbach, Fiesch (Valais, Switzerland): crystal chemistry, REE patterns, and genetic speculations. Schweiz. Mineral. Petrogr. Mitt., v. 76, p. 131-146. First author at Laboratorium für Chemische und Mineralogische Kristallographie, Universität Bern, Freiester.3, CH-3012 Bern, Switzerland.

The mineral assemblage quartz, green octahedral fluorite, heulandite, stellerite, epistilbite, laumontite, chabazite, and scolecite occurs in steeply dipping narrow fissures within a M-type granite host rock at Gibelsbach near Fiesch, Valais (Switzerland), located in the southern part of the Aar massif. Laumontite represents the zeolite formed at the highest T while chabazite formed at the lowest T, probably below 100°C. Primary FI in massive fluorite from Gibelsbach revealed Th of ca. 160°C and are filled with water both low in salt and CO_2. Thus, the I formed above 200°C assuming a P of ca. 1 kbar based on the geothermal gradient. (From authors' abstract by E.R.)

ARMSTRONG, D.C. and **WILLAN, R.C.R.,** 1996, Orthomagmatic quartz and post-magmtic carbonate veins in a reported porphyry copper deposit, Andean Intrusive Suite, Livingston Island, South Shetland Islands. Mineral. Deposita., v. 31, p. 290-306. First author at British Antarctic Survey, Natural Environment Research Council, High Cross, Madingly Rd., Cambridge CB3 OET, UK.

A previously reported porphyry Cu + Mo deposit in an Eocene pluton within the South Shetland Island magmatic arc has been re-interpreted as three distinct hydrothermal assemblages. The oldest assemblage (1) exsolved under confinement from the deep (≅6 km?) cooling magma whereas assemblages (2) and (3) formed during tectonic ± magmatic episodes at depths of < 1.5 km in the late Cenozoic. The three assemblages occur over the 5 × 11 km mapped Barnard Point tonalite pluton.

Assemblage (1) comprises shallowly dipping sheets of aplite, biotite + tourmaline pegmatite, massive 'grey' quartz, and quartz + tourmaline + bornite + chalcopyrite + molybdenite veins. Magnetite + tourmaline + chalcopyrite breccias have associated biotite, K-feldspar and muscovite alteration. FI indicate formation from hot (≅600°C), saline (40 eq. % NaCl + $CaCl_2$) aq-carbonic F that exsolved from the partly consolidated magma. The P control on solution chemistry and nature of fracturing was the depth of the pluton emplacement.

Assemblage (2) consists of steep, vuggy veins and country-rock breccias, with thick propylitic alteration selvages, cemented by microcrystalline quartz, complex intergrowths of FeMg carbonate, bladed barite and trace amounts of bornite and chalcopyrite. These rocks, previously described as breccia (*sensu* 'pebble') dykes in the porphyry complex, are reinterpreted as an influx of moderately hot (175-330°C), weak to modestly saline (2-21 eq. % NaCl), aq-carbonic F that underwent isobaric boiling at 0.8 to 1.3 km depth. Assemblage (3) consists of thin hematitic fault infillings formed during a second episode of brittle faulting. (From authors' abstract by E.R.)

ASKEROVA, Janna, 1996, Fluid regime of metamorphism of Lower-Paleozoic series and fluid inclusion in quartz veins of Sarmich gold deposit (S. Nuratau, Western Uzbekistan) (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 4-5. Author at Inst. of Geol. and Geophys., The Acad. of Sci. of Uzbekistan, 49 Khodzhibaev Str., Tashkent, 700041, Uzbekistan

The Sarmich gold-quartz deposit (Karatau ore-field) is hosted by biotite-chlorite schists. F compositions, determined by equilibria calculations and estimated from FI data are comparable.

P-T conditions for the gold quartz veins (1 kbar, 250-280° C) have been obtained by FI thermometry. Given the calculated Gibbs free energy it becomes obvious that the transportation of F was insignificant [sic]. The commercial gold ores in the deposit have a post-metamorphic, overlapped character. (From author's abstract by E.R.)

AYORA, Carlos, 1996, Fluid Inclusions: European J. of Mineral., v. 8, no. 5, p. 881-1222, preface to series of papers from ECROFI XII meeting (E.R.)

AZAROUAL, M., PASCAL, M.-L. and **ROUX, J.,** 1996, Corundum solubility and aluminum speciation in KOH aqueous solutions at 400°C to 2.0 kbar: Geoch. et Cosmo. Acta, v. 60, no. 23, p. 4601-4614.

Corundum solubility has been measured in KOH aq solutions under supercritical conditions (400°C, from 0.5 to 2.0 kbar). The investigated concentration range was 0.001 < m_{KOH} < 0.1 mol/kg H_2O (From authors' abstract by E.R.)

BABANSKIY, A.D., ASHIKHMINA, N.A., KOVALENKO, V.I., LYATIFOVA, Y.N. and **KONONKOVA, N.N.,** 1995, Inclusions in minerals and the initial magma for the Upper Chegem Calders Complex, North Caucasus: Dokl. Ross. Akad. Nauk, v. 344, no. 2, p. 226-228 (in Russian, translated in Trans. (Dokl.) Russian Acad. Sci., Earth Sci. Sect., v. 345A, no. 9, p. 446-450, 1996). Authors at Inst. for Ore-Deposit Geol., Petrography, Mineral., and Geoch., Russian Acad. of Sci., Moscow.

Abst. in FIR, v. 28 28, p. 8 (E.R.)

BACHILLER, N., QUILEZ, E., CASQUET, C. and **GALINDO, C.,** 1996, Metasomatic albitites and quartz veins in the leucogranites from Burguillos del Cerro (Spain). A model for hydrothermal evolution based on FI: IV Spanish Geological Congress, Universidad de Alcalá, 1-5 July, 1996, published by Geogaceta, v. 20, no. 7 (in Spanish; Engl. abst.): p. 1504-1506. First author at Dpto. de Petrologia y Geoquimica, Facultad de Geologia, UCM, 28040 Madrid.

Slightly peraluminous to metaluminous leucogranites are common as dyke swarms in the Burguillos del Cerro Plutonic Complex. They show superimposed hydrothermal alterations consisting of quartz-rich albitites and Au-bearing quartz veins. Several types of FI have been distinguished in the alteration. They belong to the system H_2O-NaCl-KCl-$MgCl_2$-$CaCl_2$ and range from high sal to low sal types. In any type, a trend of decreasing sal concomitant to a decrease of minimum P and T trapping conditions is found. An evolutive model is proposed consisting in the repetitive mixing of hot saline waters, initially of probably magmatic derivation, with a cold low sal meteoric F, in several discrete episodes of hydrofracturing, under declining regional T conditions. Albitites and quartz veins seem to be temporally and genetically related. (Authors' abstract)

BAKER, Darcy, 1996a, Fluid inclusions and microstructure of flexural-slip bedding-concordant veins within the Ovens Anticline, Lunenberg, Nova Scotia (abst.): pub. in Atlantic Geology, v. 32, p. 282. Author at Dept. of Earth Sci., Dalhousie Univ., Halifax, Nova Scotia B3J 3J5, Canada.

FI and microstructures of flexural-slip bedding-concordant quartz veins (FSBCVs) from the Ovens Anticline of the Meguma Group, were assessed and provide data on conditions and mechanisms of flexural-slip folding . These veins formed along flexural-slip movement horizons and are interpreted to have formed at the same time as flexural-slip folding.

Geobarometric results from planar FI assemblages indicate that fluid P fluctuated and supralithostatic fluid Ps were present. P results, when combined with an independent T of trapping (Tt), range from 0.5 to 5.0 kbars. The fluid was mixed H_2O-NaCl-CO_2-CH_4 type.

FSBCV's contain abundant wall rock inclusion layers (WRIL) that originally were continuous but now are separated by layers of quartz. They host preferrentially oriented FI planes (FIPs), and are composed of elongate quartz crystals which have a preferred crystallographic orientation with respect to elongation direction and possibly with respect to regional folding. FIP orientation appears to be crystallographically influenced. These data suggest that the FIPs measured may not be healed microfractures and their orientation is therefore not influenced by fold-related stress conditions. (Author's abstract.)

See also adjacent item (E.R.)

BAKER, Darcy, 1996b, Fluid inclusions and microstructure of flexural-slip bedding-concordant veins within the Ovens Anticline, Lunenburg, Nova Scotia. Thesis, Dalhousie Univ., Halifax, NS, Canada, 76 pp.

See also adjacent item (E.R.)

BAKER, Timothy, 1996, The Eloise Cu-Au deposit, Cloncurry District, Australia: An example of a deep seated, distal, magmatic hydrothermal vein deposit (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A474. Author at Nat'l. Key Centre for Economic Geol., Dept. of Earth Sci., James Cook Univ., Queensland, Australia.

The Eloise deposit (3.1 Mt @ 5.5% Cu, 1.4 g/t Au and 16 g/t Ag) is hosted by Proterozoic rocks in the Eastern Fold Belt of the Mount Isa Inlier, Australia. The main metasomatism comprised three stages. Pervasive albite alteration (Stage I) was overprinted by Stage II hornblende-biotite-quartz veins and alteration. Stage III mineralization was a retrograde event (200-450°C) and replaced and brecciated the earlier mafic silicates.

Primary FI in pre-mineralization veins had high Th (450-600°C) and very high sal (~30-80 wt.% total salts). FI in Stage III quartz in mineralized veins displayed a wide range of Th (~100-500°C) and had a lower sal (30-50 wt.% total salts). The ultrasaline, high T F are similar to F associated with magmatic hydrothermal systems and a tight sulphur isotope signature (0.0-2.3‰) is consistent with a magmatic sulphur source. The strong ductile-brittle structural control and channelized F flow suggests a deep seated setting (> 3 km?) and differs from the multidirectional vein stockworks that characterize high level porphyry Cu-Au systems. The latter are also characterized by more oxidised conditions (magnetite-pyrite stable) whereas the ore F at Eloise were reduced (pyrrhotite stable). (From author's abstract by E.R.)

BAKKER, R.J., 1996, Adaptation of Bowers & Helgeson (1983) equation of state to isochore calculation in the H_2O-CO_2-CH_4-N_2-NaCl fluid system (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 4-5. Author at CREGU, BP 23, 54501 Vandœuvre-lès-Nancy, France; e-mail (ronald.bakker@urz.uni-heidelberg.de)

The modified Redlich-Kwong EOS according to Bowers & Helgeson (1983) is chosen for extension to complex G mixtures. Originally, Bowers & Helgeson (1983) developed an EOS to predict the region of immiscibility, and not to predict the position of isochores at conditions that exceeds this miscibility gap. However, they offer a relative simple method to calculate isochores in salt-bearing systems that contain H_2O and CO_2. As mentioned before, only the *a* and *b* values for H_2O were regarded as functions of sal, and those for CO_2 remained unaffected. Using a similar approach for other G species, this EOS can be easily extended to CH_4-N_2 bearing F system, assuming that their *a* and *b* values are not affected by the presence of salts. These values are defined by critical properties of the individual G species (Redlich & Kwong, 1949), and they are assumed to be temperature independent. In addition, other G species like CO, H_2, H_2S can also be included.

The G CH_4 and N_2 are introduced in the EOS as proposed by Bowers & Helgeson (1983) according to the above-mentioned mixing rules. These modifications do not affect the accuracy of the original model, and they should be regarded as a first approach to calculate isochores in complex F mixtures containing NaCl and several G species (H_2O-CO_2-CH_4-N_2). (From author's abstract by E.R.)

BAKKER, R.J., DUBESSY, J. and **CATHELINEAU, M.,** 1996, Improvements in clathrate modelling: I. The H_2O - CO_2 system with various salts: Geoch. et Cosmo. Acta, v. 60, no. 10, p. 1657-1681. Authors at CREGU, B.P. 23, F-54501, Vandoeuvre-lès-Nancy Cedex, France.

The formation of clathrates in FI during microthermometric measurements is typical for most natural F systems which include a mixture of H_2O G, and electrolytes. A general model is proposed which gives a complete description of the CO_2 clathrate stability field between 253-293 K and 0-200 MPa, and which can be applied to NaCl, KCl, and $CaCl_2$ bearing systems. The basic concept of the model is the equality of the chemical potential of H_2O in coexisting phases, after classical clathrate modelling. None of the original clathrate models had used a complete set of the most accurate values for the many parameters involved. The lack of well-defined standard conditions and of a thorough error analysis resulted in inaccurate estimation of clathrate stability conditions. According to our modifications which include the use of the most accurate parameters available, the semi-empirical model for the binary H_2O - CO_2 system is improved by the estimation of numerically optimised Kihara parameters $\sigma = 365.9$ pm and $\varepsilon/k = 174.44$ K at low P, and $\sigma = 363.92$ pm and $\varepsilon/k = 174.46$ K at high P. Including the error indications of individual parameters involved in clathrate modelling, range of 365.05 -

366.52 pm and 171.3 - 177.8 K allows a 2% accuracy in the modelled CO_2 clathrate formation P at selected T below Q_2 conditions. a combination of the osmotic coefficient for binary salt - H_2O systems and Henry's constant for G - H_2O systems is sufficiently accurate to estimate the activity of H_2O in aq solutions and the stability conditions of clathrate in electrolyte-bearing systems. The available data on salt-bearing systems is inconsistent, but our improved clathrate stability model is able to reproduce average values. The proposed modifications in clathrate modelling can be used to perform more accurate estimations of bulk density and composition of individual FI from clathrate Tm. Our model is included in several computer programs which can be applied to FI studies. (Authors' abstract)

See also adjacent item (E.R.)

BALTIBAEV, S.K., 1996, Relations between morphological types of migmatites and composition of fluid inclusions (Ladoga metamorphic complex, Baltic shield) (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 611. Author at Inst. of Precambrian Geology and Geochronology, Russian Acad. of Sci., St.-Petersburg, Russia.

Metamorphic transformations in the zonal Ladoga metamorphic complex (Baltic shield) are connected closely with multistage migmatization. The inclusions of CO_2 were found in the quartz from early migmatites. Their density varies in the range of 0.737-0.921 g/cm^3. P-T conditions of migmatitic veins obtained by investigation of FI are 5-5.6 kb and 800-850°C. The low water content in the early migmatite accompanied by high CO_2 content supports the idea of formation of the early migmatite morphotype under the dry granulitic conditions.

Two or three generations of H_2O and CO_2 FI occur in leucosomes. The presence of CH_4 and N_2 is common. The density of CO_2 varies from 1.02 to 0.43 g.cm^3. P-T conditions of this metamorphic event were estimated by using contacts between minerals in melanosomes. P-T estimations (4.5-5.5 kb and 660-780°C) prove that the peak of tonalitic migmatization started under conditions amphibolite facies metamorphism accompanied by the intensive biotitization and amphibolization of the rocks. The appearance of the II morphological types of migmatites are connected with high F (mainly water) contents in the rocks. (From author's abstract by E.R.)

BARAKAT, M.A.K., EL-BADRY, O., and **IBRAHIM, N.**, 1996, Significance of inclusions hosted by quartz for provinance study of Nukhul Reservoir Rocks, North Gulf of Suez, Egypt (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 481. First author at at Exploration Dept., Petroleum Research Inst., Cairo, Egypt.

Early Miocene reservoir rocks represented in the present study by Nukhul Formation are considered as new target for hydrocarbon discoveries at recent time. Among a detailed sedimentological study done on rock samples from Nukhul FM, the study of I trapped by quartz grains show interesting results related to the geological history and the provinance of this formation and its rock components.

The materials of this study are subsurface cores from three wells: NDR-3, DR0-17 and F-80 in the northern part of the Gulf of Suez.

The identified I are classified into solid I and F-gaseous I. Rutile needles, pyrite cubes, zircon, tourmaline and apatite crystals are the most common solid I. While the F-gaseous I include only L or G-bubble either as separate uniphase inclusions or together as biphase ones. They are usually composed of light hydrocarbons and/or saline water.

According to this study it can be concluded that the occurrence of the solid I of the above mentioned variety indicates the derivation of quartz grains from a granitic source rock as it is well known from literature. Also, the existence of F-gaseous I, especially the biphase type is an indication of hydrothermal formation of hosting quartz grains. Some alteration of the solid I especially rutile and apatite is attributed to secondary diagenetic and dynamic phases of disturbances. This phase of dynamic effect is manifested by the occurrence of fractures filled with S I. Some of these cracks represent one series and others are composed of two series. (Authors' abstract.)

BARANOVA, N.N., VOLYNSKIY, A.B., KOZERENKO, S.V., KOVALENKER, V.A., KOLOTOV, V.P. and **KOLPAKOVA, N.N.**, 1996, Fluid-inclusion data on the contents and forms of Au, Te, Sb, and As in mineral-forming solutions at gold-sulfide-telluride epithermal deposits: translated from Geokhimiya, 1995, no. 12, p. 1786-1799 (in Russian, translated in Geochem. Internat'l., v. 33, no. 12, p. 76-89.) Authors at Vernadskiy Inst. of Geochem. and Analytical Chem., Russian Acad. of Sci., Moscow.

Neutron-activation and atomic-absorption analysis of FI in quartz from major mineral assemblages in the mineralized stages of three gold-sulfide-telluride epithermal deposits has given the concentrations of gold, arsenic, antimony, and tellurium, which lie in the ranges 10^{-6} to $10^{-4.5}$, $10^{-2.5}$ to $10^{-1.2}$, $10^{-2.2}$ to $10^{-0.5}$, and 10^{-6} to 10^{-4}, respectively. The predominant forms of gold, arsenic, antimony, and tellurium in the solutions that produced the mineralization in the ore stages were the complex ions $Au(HS)^-{}_2$, H_3AsO_3, $HSb_2S^-{}_4$, and HTe^-. The gold concentrations are related to the arsenic and antimony ones in the I, which show that gold may be transported as sulfur-bearing complexes containing arsenic and/or antimony in a sulfidization process, while the negative correlation between the gold and tellurium concentrations may be due to the ore-concentrating role of tellurium in the formation of gold-tellurium mineralization.

BARASHKOV, Yu.P. and **TALNIKOVA, S.B.**, 1996, Sulfide inclusions in diamonds and kimberlite minerals: similarities and differences exemplified by the Udachnaya kimberlite pipe, Yakutia (in Russian; Engl. abst.): Scientific Journal–Geologiya i Geofizika, v 37, No.6, p. 45-55.

Under discussion are results of a comparative study of compositions of initial sulfide substance in diamonds and kimberlite minerals. Calculated from Me/S, the compositions of initial sulfides in diamonds, olivines, and garnets are subdivided into: (1) monosulfide solid solution (Mss) on the basis of pyrrhotite (Me/S < 1); (2) intermediate Mss with 1 < Me/S < 1.125; (3) pentlandite-based Mss (1.125 < Me/S < 1.175), and (4) intermediate Mss with 1.175 < Me/S < 1.5. The first group Mss from diamonds contains less iron and more nickel than the second group sulfides from olivines and garnets. Among the second group sulfides, garnet I are distinguished by increased Ni and decreased Fe contents. The fourth group intermediate Mss from diamonds has as little as 0.40 wt% Cu impurity, while the same group sulfides from olivines and garnets contain 24.7 and 17.6 wt% Cu, respectively. It is established that Fe and Ni in Mss and possible compositions of sulfides are inversely correlated and points of their compositions form a single trend extending from field Mss+V at 1100°C to center of this field at 1000°C. The sulfides, situated on the diamond porphyry, are characterized by higher Ni contents as compared with I of these minerals from the central domain of the same crystal. The trend of changed Ni contents in initial sulfides suggests a decrease in crystallization T. (Authors' abstract.)

BARCLAY, J., CARROLL, M.R., HOUGHTON, B.F. and **WILSON, C.J.N.**, 1996, Pre-eruptive volatile content and degassing history of an evolving peralkaline volcano: J. of Volcanol. and Geothermal Research, v. 74, p. 75-87. First author at Dept. Geol., Univ. Bristol, Queen's Rd., Bristol, BS8 IRJ, UK.

The volatile contents of MI trapped within phenocrysts of quartz and feldspar in peralkaline rhyolites from Mayor Island, New Zealand, have been studied using Fourier transform infrared spectroscopy and ion microprobe analyses. The glass I analyzed span the ~130 ka subaerial eruptive history of the island and come from volcanic deposits representing a wide range of eruptive styles (explosive vs. effusive, magmatic vs. phreatomagmatic, low vs. high discharge rates). The water content of all I analysed is uniformly high at ~ 4.4 wt.% H_2O, whereas CO_2 contents are below the limits of detection (~50 ppm). Chlorine in MI ranges from 2070 to 5200 ppm, while coexisting matrix glasses have generally lower Cl concentrations of 1700-4200 ppm: the apparent bulk distribution coefficient describing Cl partitioning between M and V phase ([Cl]fluid/[Cl]melt) during degassing is 5-15. Fluorine appears to be less affected by eruptive degassing than is Cl and MI and matrix glass F concentrations show significant overlap (1400-2520 ppm F in I, 1550-2890 ppm F in matrix glass). The observed invariance of MI water content with sample age contrasts with ion microprobe data on incompatible trace elements (e.g., Zr, Nb), which suggest ~35% fractionation between the oldest and youngest samples. This, along with the Cl partitioning behavior, suggests that at least the upper erupting portion of the Mayor Island magma chamber was water-saturated throughout the volcano's 130 ka eruptive history. Furthermore, the large range of eruptive styles observed on Mayor Island are not due to differences in water concentration of the erupting magma but instead must reflect differences in rates of magma ascent and supply (which control the efficiency of nonexplosive degassing). (Authors' abstract)

BARGAR, K.E., KEITH, T.E.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, no. 5/6, p. 639-659.

Heating and freezing data were obtained for FI in hydrothermal quartz, calcite, and anhydrite from several depths in three scientific observation holes drilled along the lower East Rift Zone of Kilauea volcano, Hawaii. Compositions of the I F range from dilute meteoric water to highly modified sea water concentrated by boiling. Comparison of measured drill-hole temperatures with F-I homogenization-temperature (T_h) data indicates that only about 15% of the FI could have formed under the present thermal conditions. The majority of FI studied must have formed during one or more times in the past when T fluctuated in response to the emplacement of nearby dikes and their subsequent cooling. The F-I data indicate that past T in SOH-4 well were as much as 64°C hotter than present T between 1000 and 1500 m in depth and they were a maximum of 68° cooler than present T below 1500 m depth. Similarly, the data show that past T near the bottoms of SOH-1 and SOH-2 wells were up to 45 and 59°C, respectively, cooler than the present thermal conditions; however, the remainder of F-I T_h values for these two drill holes suggests that the T of the trapped waters were nearly the same as the present T at these slightly shallower depths. Several hydrothermal minerals (erionite, mordenite, truscottite, smectite, chlorite-smectite, chalcedony, anhydrite, and hematite), occurring in the drill holes at higher T than they are found in geothermal drill holes of Iceland or other geothermal areas, provide additional evidence for a recent heating trend. (Authors' abstract)

See also Bargar et al., USGS Open File Report 96-0010, 75pp., 1996. (E.R.)

BARGAR, K.E., KEITH T.E.C., TRUSDELL, F.A., EVANS, S.R. and **SYKES, M.L.**, 1996, Hydrothermal alteration mineralogy of SOH drill holes, Kilauea East Rift Zone geothermal area, Hawaii: Open-file report OF 96-0010, U.S. Geol. Survey, 1996. First author at U.S. Geol. Survey, Menlo Park, CA, US.

Indexed under FI, see previous item (E.R.)

BARKER, C.E., LEWAN, M.D., BONE, Yvonne and **MARSHALLSEA, S.J.**, 1996, Thermochronological and petroleum generation studies next to dikes in the Upper Jurassic-Lower Cretaceous Strzelecki Group, onshore Gippsland Basin, Australia (abst.): American Assoc. of Petrol. Geologists annual meeting abstracts, v. 5, p. 10. First author at U.S. Geol. Survey, Denver, CO, US.

FI apatite fission track analysis (AFTA), mean random vitrinite reflectance (Rv-r) data, and heat flow modeling studies of nine basalt dikes ranging from 0.06 m to 40 m thick in the Strzelecki Group were used to constrain the conditions of contact metamorphism of coaly sedimentary organic matter (SOM) to investigate it as an extended-duration natural analog to hydrous pyrolysis experiments. Thermal history reconstruction suggests that at the time of dike intrusion, the host rock was at a paleotemperature of 100 to 120°C. Reequilibrated FI in the host rocks next to thin dikes (< 3.4 m thick) suggest Tmax systematically increases toward the dike margin to ~550°C. These Tmax data are in fair agreement with those predicted by a conductive heat flow model and measured Rv-r. AFTA indicates the time of uplift and cooling as mid to Late Cretaceous and that paleotemperatures were too high for heating duration information to be recorded by annealing of tracks in apatite near the dikes. The estimated Tmax next to some larger dikes (20-40 m thick) as indicated by an extended zone of elevated Rv-r did not fit the pattern seen next to the thin dikes. Heat flow modeling along with whole rock elemental and isotopic data suggest that the extended zone of increased Rv-r is caused by convection of heated F. This is in contrast to the apparent advection effects found adjacent to thin dikes. Laboratory hydrous pyrolysis compares well with contact metamorphism next to thin dikes with respect to the composition of the free hydrocarbons except in samples very close to the dike. Close to the dike, FI evidence indicates a water V super-critical phase in the rock making the organic geochemistry results diverge from those found in hydrous pyrolysis experiments which maintains a L water phase. (Authors' abstract)

BARKER, Colin, SULLIVAN, G.E. and **UNDERSOOD, W.D.**, 1996, Gases in fluid inclusions in veins cutting the Bald Eagle and adjacent formations, Central Pennsylvania, USA (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 6-8. First author at Geosci. Dept., Univ. of Tulsa, Tulsa, OK 74104; e-mail (geos_cgb@centum.utulsa.edu)

Mass spectrometric analysis of individual FI, together with microthermometry, were used to study compositional changes in the F that moved through an Ordovician clastic sequence in central Pennsylvania.

G in individual FI are released by heating a ~10 mg mineral sample in a vacuum system that forms the inlet to a pair of high speed, computer-controlled, UTI 100C quadrupole mass spectrometers. As T rises, phase relationships in the I change in such a way that the P rises rapidly and ruptures the inclusions, releasing the G for analysis. For the geometry of our vacuum system the burst of G lasts about 25-30 msec. The mass spectrometers scan continuously and take 18 msec per mass spectrum. The analog signals are digitized (16-bit) at 200 kHz, and the data transferred to CD-WORM for subsequent off-line processing. During processing the FI burst is recognized by the abrupt increase in mass spectrometer response, and the immediately preceding spectra are subtracted to remove background. Data can be displayed as individual mass spectra or, for groups of inclusions, as ternary diagrams. The system has been described by Barker and Underwood (1992).

Analysis of G in individual FI in quartz and calcites that filled fractures shortly after fracturing show a systematic compositional trend of decreasing methane from the Reedsville shale up through the Bald Eagle sandstone and into the Juniata sandstone. FI compositions in quartz from the Reedsville shale range from methane-rich with minor water, to water-rich with minor methane. There are no higher hydrocarbons or hydrogen sulfide. In contrast, the two-phase I in the Juniata are exclusively water-rich. Quartz and calcite from the intermediate Bald Eagle have water-rich I with minor methane. Little methane appears to have reached the Juniata sandstone even though fractures with green, reduced halos are observed. The accumulated data support the concept that lithostatically-pressured, methane-rich fracturing F from the organic-rich Reedsville shale fractured and reduced the overlying Bald Eagle sandstone before P returned to hydrostatic as the fractures intersected the meteoric groundwater system. FI in the Juniata tend to be less saline and poorer in methane than the F in the underlying Bald Eagle and Reedsville. (From authors' abstract by E.R.)

BARKER, D.S., 1996, Consequences of recycled carbon in carbonatites: The Canadian Mineralogist v. 34, p. 373-387. Author at Dept. Geol. Sci., C1100, Univ. Texas at Austin, Austin, TX 78712.

Formerly, carbonatites were thought to be results of the mantle's purging itself of "juvenile" carbon. However, evidence has been accumulating that carbon from the crust is recycled deep into the mantle by subduction. This non-juvenile carbon may nourish carbonatic magmas. The process by which carbon in the mantle may eventually be incorporated into carbonatite in the crust is probably a circuitous one, involving transport in a variety of phases before accumulation in diverse sources of carbonatic magma. With time, these sources have become more varied and more radiogenic. During its migration, carbonate L acts as an efficient sequestering agent in the mantle, gathering a distinctive retinue of trace elements, especially Sr, Nb, Ba, the light-rare earth elements, Pb, Th and U. Elements that are strongly depleted in carbonatites are Si, Al, Mg, Cr, and Ni. Partition coefficients for carbonate L/minerals yield calculated enrichments that do not agree with those observed unless there are repeated episodes of interaction between carbonate L and progressively enriched mantle. Carbonate-rich L can only survive its upward passage if the rock through which it flows has already lost most of its capacity to react with carbonate L. Such "path clearing" requires the aborted ascent of precursor batches of carbonatic magma. Ultramafic xenoliths from many localities have trace-element and isotopic enrichment and depletion patterns attributed to metasomatic reactions of lithospheric mantle with carbonate-rich L. These carbonate-metasomized xenoliths indicate repeated invasion of the lithosphere by carbon-bearing L of F. This in turn implies that the rarity of carbonatic magma in the upper crust is caused by barriers to its ascent, not by a shortage of source material. (Author's abstract)

BARRETT, T.J. and **SHERLOCK, R.L.**, 1996a, Geology, lithogeochemistry and volcanic setting of the Eskay Creek Au-Ag-Cu-Zn deposit, northwestern British Columbia: Explor. Mining Geol., v. 5, no. 4, p. 339-368. First author at Mineral Deposit Research Unit, Dept. of Earth and Ocean Sci., Univ. of British Columbia, 6339 Stores Rd., Vancouver, BC, Canada V6T 1Z4.

Stratiform mineralization at Eskay Creek occurs within mid-Jurassic marine volcanic and sedimentary strata. Rhyolite in the vicinity of mineralized zones is altered to variable proportions of sericite, Mg-chlorite, K-feldspar, and quartz. Intense chlorite-sericite alteration is confined to the upper 20 m of rhyolite below the outline of the 21B orebody, but silica and K-feldspar-alteration extend further laterally and deeper in the rhyolite. Zones of extreme chlorite-sericite alteration probably represent vent-proximal areas in the upper rhyolite where seawater was mixed with discharging, more acidic F. The K-feldspar-silica alteration probably occurred under cooler, more neutral conditions generally peripheral to the main feeder zones. Hangingwall basalts are little to moderately altered, but unmineralized. (From authors' abstract by E.R.)

FI Th from discordant mineralized quartz veins in the footwall rhyolite and from amber-colored sphalerite in the detrital sulfide-sulfosalt beds are relatively low, ranging from 120 to 210°C (Sherlock et al., FIR 27, p. 131-132; Sherlock et al., in preparation). Boiling of the F occurred, probably at depths of about 500 to 1100 m below sea level. Some of the FI have sal and cation-anion ratios consistent with normal sea water-dominated hydrothermal F, whereas others have higher sal and cation-anion ratios which suggest that these F mixed with modified F leading to the addition of salts in proportions consistent with magmatic ratios. (From authors' text)

BARRETT, T.J. and **SHERLOCK, R.L.**, 1996b, Volcanic stratigraphy, lithogeochemistry, and seafloor setting of the H-W massive sulfide deposit, Myra Falls, Vancouver Island, BC: Explor. Mining Geol., v. 5, no. 4, p. 421-458. First author at Mineral Deposit Research Unit, Dept. of Earth and Ocean Sci., Univ. of British Columbia, 6339 Stores Rd., Vancouver, BC, Canada V6T 1ZR

The Myra Falls massive sulfide deposits have produced >7.5 Mt of Au-Ag-Cu-Zn ore. The H-W orebody is underlain by a strongly sericite ± pyrite ± quartz altered feeder zone that extends up to 60 m (or more) into the mafic footwall. The top of the feeder zone is overlain by several meters of massive pyrite which grades up into a central zone of massive pyrite with several percent disseminated chalcopyrite that forms the bulk of the orebody. FI homogenization data from PI in quartz and sphalerite in the ore and feeder zone indicate moderate T of 146 to 247°C (average 184°C) with sal ranging from 3.2 to 8.1 eq. wt.% NaCl (assuming no G phase). Whole-rock oxygen isotope data for mafic and felsic rocks are consistent with T of alteration in the 150 to 250°C range. (From authors' abstract by E.R.)

Primary G-rich CO_2-H_2O I were also found in quartz (p. 448). Tm CO_2 averages 57.7°C; Tm ice is -0.4 to 0.0°C. (E.R.)

BARTON, M.D. and **JOHNSON. D.A.,** 1996, Evaporitic-source model for igneous-related Fe oxide-(REE-Cu-Au-U) mineralization: Geology, v. 24, no. 3, p. 259-262. Authors at Dept. Geosci., Univ. Arizona, Tucson, AZ.

We propose that many igneous-related Fe oxide-rich (REE-Cu-Au-U-bearing) deposits form by hydrothermal processes involving evaporitic ligand sources, either coeval salars or older evaporites. Magmatic compositions exert only second-order control, mainly on alteration mineralogy and on element abundances. Hot S-poor brines generated by interaction with evaporitic materials are consistent with geologic settings and help rationalize the distinctive element enrichments (siderophile, lithophile) and hydrothermal alteration (sodic, locally alkaline) found in these systems. This model contrasts with immiscible oxide melt and magmatic-hydrothermal origins commonly proposed for these deposits, although all three mechanisms can occur. (From authors' abstract by E.R.)

BASSETT, W.A., 1996a, Hydrothermal studies in the diamond anvil cell (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 551. Author at Dept. Geol. Sci., Cornell Univ., Snee Hall, Ithaca, NY 14853 USA.

See next item (E.R.)

BASSETT, W.A., 1996b, Hydrothermal studies in the diamond anvil cell, (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 41-42. Author from Dept. Geol. Sci., Cornell Univ., Snee Hall, Ithaca, NY 14853 USA.

A diamond anvil cell has been developed to mark hydrothermal studies at P up to 25 kbars at T between -190°C and 1200°C. A sample chamber 0.5 mm in diameter and 0.1 mm thick is formed by a rhenium gasket between the diamond anvils. Sample chamber volume is held nearly constant and is monitored by laser interferometry. Reactions and phase transitions are observed by optical microscopy and X-ray diffraction. Resistance heaters and thermocouples provide T control with an accuracy of ±0.5°C. L nitrogen introduced into the diamond anvil cell provides low T. P is calculated with an accuracy of ±1% from the T using the equation of state of water. Studies of montmorillonite have shown that Na-, Ca- and Mg-montmorillonites retain more water to higher T under H_2O P than previously reported. (Author's abstract)

BASTRAKOV, E.N., BROOKER, Murray and **WALSHE, J.L.,** 1996, The origin of gold mineralization at Lake Cowal, Endeavour 42 (NSW): Geol. Soc. of Australia, abstracts, v. 41, p. 23. First author at Australian Nat'l. Univ., Dept. of Geol., Canberra, Australia.

Indexed under FI (E.R.)

BATANOVA, V.G., SOBOLEV, A.V., and **SCHMINCKE, H.-U.,** 1996, Parental melts of the intrusive cumulates of the Troodos massif, Cyprus: a study of clinopyroxenes and melt inclusions in plagioclase: Petrologiya, v. 4, no. 3, p. 228-239, (in Russian, translated in Petrol., v. 4, no. 3, p. 209-220). First author at Vernadsky Inst. of Geochem. and Analytical Chem., Russian Acad. of Sci., ul. Kosygina 19, Moscow, 117975 Russia.

The geochemistry of clinopyroxene from the cumulates of various intrusive suites and M I in plagioclase from the olivine gabbros of the early intrusive suite of the Troodos ophiolite massif (Cyprus) was studied. It was found that the concentrations of incompatibly elements in the glasses of M I in plagioclase are similar to those calculated on the basis of the incompatible element contents of clinopyroxene and the partition coefficients of these elements between clinopyroxene and M obtained at low T and P. The M I in plagioclases correspond to water-rich andesite, which could be formed by crystal fractionation of island-arc tholeiitic magmas parental for the lower and upper pillow lavas of the Troodos massif. The intrusive suites studied are not related to the boninitic volcanic series of the Troodos upper pillow lavas. With respect to incompatible element chemistry, the clinopyroxenes of the intrusive suites are comparable to the clinopyroxenes depleted in light REE, titanium, and zirconium that occur in the cumulates of mid-ocean ridges. (Authors' abstract.)

BEA, F., MONTERO, P., STROH, A. and **BAASNER, J.,** 1996, Microanalysis of minerals by an Excimer UV-LA-ICP-MS system: Chemical Geol., v. 133, p. 145-156. First author at Dept. Mineralogía y Petrología, Univ. Granada, Campus Fuentenueva, E-18002 Granada, Spain.

This paper is a performance evaluation of a prototype laser-ablation microanalytical system [for minerals] composed of an UV Excimer laser and a high-sensitivity inductively coupled plasma mass spectrometer (XLA-ICP-MS). (From authors' abstract by E.R.)

BEBOUT, G.E., 1996, Metamorphic petrology: Geotimes, v. 41, no. 2, p. 51-52.

Indexed under FI (E.R.)

BÉJI SASSI, Aicha, LARIDHI OUAZAA, Néjia, and **CLOCCHIATTI, Robert,** 1996a, Ilmenite, apatite and quartz melt inclusions within Tunisia phosphatic sediments: Evidences of a late Palaeocene to early Eocene alkaline volcanic activity: Bull. Soc. Géol. France, v. 167, no. 2, p. 227-234. (In French; Engl. abst. and abridged version)

The discovery of glass I in ilmenite, apatite and quartz crystals from some phosphatic levels located to the east and to the south of the Kasserine palaeo-island indicates a mainly explosive volcanic activity during the Palaeocene and Eocene. M I and host mineral compositions prove that a complete alkaline series evolved by a fractional crystallization process from basaltic to rhyolitic terms. The alkaline character of this volcanism is in agreement with global extensional tectonics. However the range of evolution of magmas and their high volatile content imply the existence of shallow magmatic reservoirs which is favoured by the existence of local stresses. Palaeocene volcanism appears to be in the continuity of the late Cretaceous activity as it shows all its petrological and geochemical characters. (Authors' abstract)

BÉJI SASSI, Aicha, LARIDHI OUAZA, Néjia, and **CLOCCHIATTI, Robert,** 1996b, Glass inclusions in ilmenite, apatite and quartz from phosphate sediments in Tunisia: witnesses of Upper-Paleocene to Eocene alkaline volcanism (abst.): 16th Earth Sciences Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 86 (in French). First author at Dept. of Geol., Faculty of Sci., Univ. of Tunis-II, Campus Universitaire, 1060 Tunis.

The discovery of glass I in ilmenite, apatite and quartz from several phosphate levels in basins east and south of Kasserine paleo-island is evidence for an essentially explosive volcanic activity of Paleocene to Eocene age. The compositions of the glass I and the host minerals show a complete alkaline series, which evolves by fractional crystallization from basaltic to trachytic and rhyolitic members. The alkaline character of the volcanism is in agreement with generally distensive tectonics. However, the degree of differentiation of the magmas and their high G contents imply the existence of superficial magma reservoirs, and thus local contraints which favor the trapping of magmas and their differentiation. The Paleocene volcanism appears to be a continuation of the Late-Cretaceous alkaline volcanism of which it has all petrochemical char-acteristics. (Authors' abstract translated by E.A.J. Burke.)

BELHADI, Eiji, WATANABE, Koichiro, and **IZAWA, Ahmed,** 1996, Geology and alteration in the western Hoshino gold area, Kyushu, Japan (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 645. Authors at Dept. of Mining, Kyushu Univ., Japan.

The study area is located in volcanic rocks of late Miocene and Pliocene age. They vary from silica-rich andesite in the north to dacite and rhyolite in the south.

Four hydrothermal alteration zones were distinguished: An inner zone represented by interstratified clay minerals and quartz, a zone of kaolinite-quartz, a zone characterized by smectite-quartz and finally a zone of smectite-cristobalite.

The shallow manifestation of this hydrothermal system is very well preserved in this area. This is shown by the presence of six groups of silica-sinters distributed at the top of Ikenoyama Conglomerate. These sinters represent the products of the hydrothermal activity at the surface. Spatially, they are closely related to the gold bearing quartz veins which are distributed at a deeper level and from which about one tonne of gold has been extracted in the past.

Most of the quartz veins are hosted in the Ikenoyama Conglomerate and to a lesser degree in the Hoshino Andesite. This quartz contains a lot of disseminated pyrite and shows lamellar structures. Th of FI from two quartz veins gave a T of about 170°C. (From authors' abstract by E.R.)

BELKIN, H.E., DE VIVO, Benedetto, LIMA, Annamaria and **TÖRÖK, Kálmán,** 1996, Magmatic (silicates/saline/sulfur-rich/CO_2) immiscibility and zirconium and rare-earth element enrichment from alkaline magma chamber margins: evidence from Ponza Island, Pontine Archipelago, Italy: Eur. J. Mineral., v. 8, p. 1401-1420. First author at U.S. Geol. Survey, MS 959, Reston, 22092 VA, USA; email (hbelkin@usgs.gov)

FI were measured from a feldspathoid-bearing syenite xenolith entrained in trachyte from Ponza,one of the Islands of the Pontine Archipelago, located in the Gulf of Gaeta, Italy. The feldspathoid-bearing syenite consists mainly of potassium feldspar, clinopyroxene, amphibole, biotite, titanite, manganoan magnetite, apatite with minor nosean, Na-rich feldspar, pyrrhotite, and rare cheralite. Baddeleyite and zirkelite occur associated with manganoan magnetite. Detailed electron-microprobe analysis reveals enrichments in REE, Y, Nb, U, Th as well as Cl and F in appropriate phases. FI observed in potassium feldspar are either silicate-M or aq I. The aq I can be further classified as (1) one-phase V, (2) two-phase (V+L) I, V-rich I with a small amount of CO_2 in most cases; homogenization of the I always occurred in the V phase between 359 and 424°C, sal vary from 2.9 to 8.5 wt.% NaCl eq.; and (3) three-phase and multiphase I (hypersaline/sulfur-rich aq I sometimes with up to 8 or more solid phases). Dm dissolve on heating before V/L homogenization. Standardless quantitative SEM X-ray fluorescence analysis has tentatively identified the following chloride and sulfate dx; halite, sylvite, glauberite, arcanite, anhydrite, and thenardite. Melting of the dx occurs between 459 and 536°C (54 to 65 wt.% NaCl eq.) whereas total homogenization is between 640 and 755°C. The occurrence of silicate-MI and high-T, solute-rich aq I suggests that the druse or miarolitic texture of the xenolith is late-stage magmatic.

The xenolith from Ponza represents a portion of the peripheral magma chamber wall that has recorded the magmatic/hydrothermal transition and the passage of high solute F enriched in chlorides, sulfur, and incompatible elements. (Authors' abstract)

BELKIN, H.E., DE VIVO, B., TOROK, K., and **WEBSTER, J.D.,** 1996a, Microthermometry and analytical chemistry of silicate melt inclusions in Vesuvius lavas (< 1631 A.D.) (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 550. First author at U.S. Geol. Survey, MS 959, Reston, 22092 VA, USA.

Lavas and pyroclastics from pre-1631 A.D. Somma-Vesuvius eruptions contain phenocrysts of clinopyroxene, olivine, leucite and plagioclase. Silicate MI of measurable size are mostly found in clinopyroxene phenocrysts, but they can be found as well in leucite, olivine and plagioclase. The MI have been studied by microthermometry and electron microprobe and SIMS analytical techniques in order to examine pre-eruptive volatile contents, magma evolution and paragenesis. Because silicate MI are contained within relatively incompressible phenocryst hosts, they may retain high concentrations of volatile elements that normally escape from magmas during degassing. As such, analysis of these I provides direct information on the volatile contents of magmatic systems.

The MI are small, usually < 60 µm and show a range of pre- and post-entrapment magma evolution. Petrographically the I in the clinopyroxene fit into three general types: (1) transparent glass, bubble ± a small opaque phase; (2) transparent glass, dxl (usually pyroxene and oxide), bubble; (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.

I in leucite are rich in birefringent crystals (plagioclase) and small opaque phases. These I do not homogenize up to 1280°C and most commonly they decrepitate. Leucite contains as well brown devitrified glass I (with no bubble visible before heating); the silicate glass melts at ~ 1200°C, but the bubbles homogenize at ~ 1280°C.

Olivine contains devitrified silicate MI with shrinkage bubble (but with no opaque phase). No Th were obtained because the I darkened during heating, obscuring homogenization at ~ 1000°C.

Plagioclase contains very tiny MI with brown glass which make the shrinkage bubble unobservable in most cases. Plagioclase-hosted I have Th from 1210 to 1230°C.

The included bubble is usually larger than that resulting from pure shrinkage and indicates the presence of volatiles. Chemistry from unhomogenized I shows a range of compositions reflecting pre- and post-entrapment processes. (Authors' abstract.)

BELKIN, H.E., DE VIVO, B., TOROK, K. and **WEBSTER, J.D.,** 1996a, Silicate-melt inclusions in Vesuvius lavas (<1631 A.D.): microthermometry and analytical chemistry (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 9-10.

See Belkin et al, FIR v. 28, p. 12, 1995 (E.R.)

BELKIN, H.E., DE VIVO, B., TOROK, K., and **WEBSTER, J.D.,** 1996b, Microthermometry and analytical chemistry of silicate melt inclusions in Vesuvius lavas (<1631 A.D.) (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 13-14. First author at U.S. Geol. Survey, Ms 959, Reston, VA 22092 USA.

See same authors, FIR 28, p. 12 and previous item (E.R.)

BELLO, R.M.d.S., FUZIKAWA, Kazuo, GANDINI, A.L., VALARELLI, J.V. and **SVISERO, D.P.,** 1996, Fluid inclusion microthermometry of imperial topaz from Capao do Lana Deposit, Ouro Preto, Minas Gerais State, Brazil: Anais da Academia Brasileira de Ciencias, v. 68, no. 1, p. 91-102. First author at Univ. de Sao Paulo, Dept. de Mineralogia e Petrologia, Sao Paulo, Brazil.

BENCHEKROUN, Fouad, BERGER, Gilles, and **MOINE, Bernard,** 1996, A mineralogical and chemical model for gold precipitation in the Salsigne deposit (Montagne-Noire): C.R. Acad. Sci Paris, v. 323, IIa, p. 129-136. (In French; Engl. abstract and abridged version)

In the Salsigne deposit most of the gold was introduced by an aq solution of low sal and deposited at about 250°C within preexisting sulphide-bearing bodies. A quantitative model for the F-mineral interaction demonstrates that a significant amount of gold can be deposited as a result of a decrease in both H_2S activity and oxygen fugacity produced by the alteration of pyrrhotite into pyrite and that of bismuth into bismuthinite as well as by the dissolution of iron-bearing silicates (biotite). (Authors' abstract)

BENISON, K.C., 1996, Surface water paleotemperatures and chemical compositions from fluid inclusions in Permian Nippewalla Group halite: American Assoc. of Petroleum Geol. Annual Meeting Abstracts, v. 5, p. 14. Author at Univ. of Kansas, Lawrence, KS, US.

Quantitative climatic data for the Permian have been determined from Nippewalla Group halite. The Middle Permian Nippewalla Group of Kansas and Oklahoma consists of several hundred feet of bedded halite, anhydrite and red beds. Study of core and surface samples suggest that this halite was deposited by ephemeral lakes. FI provide evidence for the geochemistry of these Permian saline lake waters, including T, sal, and chemical compositions. PFI are well-preserved in the Nippewalla halite. They are 5- to 30-micrometer cubic I situated along chevron and cornet growth bands. Most are one phase aq I, but some also contain anhydrite "accidental" crystals. Rare two phase L-VI may have formed by subaq outgassing or trapping of air at the water surface. FI freezing-melting behavior and leachate analyses suggest that Nippewalla halite precipitated from NaCl-rich waters with lesser quantities of SO_4, Mg, K, Al, and Si. This composition may be a product of long-term weathering. Surface water paleotemperatures were determined from one phase aq FI. Th range from 32 to 46°C in PFI and are consistent (±3°C) along individual chevrons and cornets. These Th are interpreted to represent maximum surface water T. These FI data are significant in addressing global change problems. T and chemistries in these Permian lake waters agree with some modern shallow saline lake waters and with Permian climate models. This study suggests that this Permian environment was relatively similar to its modern counterparts. (Author's abstract)

BENISON, K.C. and **GOLDSTEIN, R.H.,** 1996, Permian Paleoclimate data from fluid inclusions in halite (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 11-13. First author at Univ. of Kansas, Dept. of Geol., 120 Lindley Hall, Lawrence, KS 66045; e-mail (counter@kuhub.cc.ukans.edu)

T of Permian surface waters have been determined by homogenization of originally one-phase P FI in depositional halite. This method requires nucleation of V bubbles in all-L I by cooling to -10°C; ~10% of the I produced V bubbles. After bubble nucleation, Th to L can be measured. This study has yielded surface water paleotemperatures from P FI in mid-Permian Nippewalla Group halite from western Kansas.

Th measured in over 200 FI range from 21 to 49°C. Th are relatively consistent (within approximately 5°C) within individual FI assemblages (the finest, high-frequency FI growth bands). These Th range up to 26°C from base to top of millimeter-thick chevron bands.

Th were consistent and reproducible in both smaller and larger FI within single FI assemblages. This indicates that FI have not been altered by thermal reequilibration (Goldstein and Reynolds, 1994). Studies have shown that large halite I tend to undergo alteration much more than small I (Petrichenko, 1979; Roedder, 1984; Roedder and Belkin, 1980). The small range of Th from various sized FI within the same FI assemblage is strong evidence that this method is valid and that I are unaltered.

We interpret the Th measured in this study to represent surface water paleotemperatures. The range in T from base to top of thick chevron bands may reflect daily (or perhaps seasonal) temperature variations. These Permian surface water T fall within the same range as some modern evaporative surface waters, suggesting that this Permian environment may have been relatively similar to its modern counterparts.

Surface water paleotemperatures are direct measurements of paleoclimate. Studies of modern evaporative environments show that surface water T correlate closely with average air T. A method identical to the one employed herein, using Th of originally all-LI in halite, has recently been used to interpret paleoclimate from the Pleistocene of Death Valley (Roberts and Spencer, 1995). Further application of this method to other ancient halites may result in a wealth of quantitative local paleoclimate data. (From authors' abstract by E.R.)

BENNING, L.G. and **SEWARD, T.M.,** 1996, Hydrosulphide complexing of Au(I) in hydrothermal solutions from 150-500°C and 500-1500 bar: Geochimica et Cosmochimica Acta, v. 60, no. 11, p. 1849-1871. Authors at Inst. Mineral. and Petrography, Swiss Federal Inst. of Tech., ETH-Zentrum, 8092 Zürich, Switzerland.

The solubility of gold has been measured in aq sulphide solutions at T between 150°C and 500°C and P of 500-1500 bar over a wide range of pH and total dissolved sulphur concentrations. (From authors' abstract, by E.R.)

BERDNIKOV, N.V. and **KARSAKOV, L.P.,** 1996a, Fluid inclusions in the Mashan series granulites, Jiamusi block (northeast China): Tikhookeanskaya Geologiya, v. 15, no. 6, p. 129-132 (in Russian).

Cryometric studies of metamorphic rocks of the Jiamusi block in northeast China were made. I were examined in quartz, garnet and sillimanite from typical granulites (T = 800 - 850°C, P = up to 4.3 kbar) and granites intruding the granulites. Preliminary data were obtained on diaphthoresis T-P conditions of these rocks. By a number of features (geological and peterological properties, similarity between their formation parameters, the presence of an admixture of low-boiling G), Jiamusi low-depth granulites are similar to the granulites of the Khankaisky block. The revealed distinctions are most likely explained by the difference in the depth of erosion. (Engl. abst. courtesy of Dr. Berdnikov).

BERDNIKOV, N.V. and **KARSAKOV, L.P.,** 1996b, Thermobarogeochemical study of Precambrian complexes of Russia's Far East: Tikhookeanskaya Geologiya, v. X, no. 4, p. 34-42 (in Russian).

A review was made of a nearly 20-year study of I in minerals of ancient metamorphic and magmatic complexes of Russia's Far East, conducted at the Inst. of Tectonics and Geophysics, Far East Branch, Russian Acad. of Sci. (65 Kim Yu Chen St., Khabarovsk 680063, Russia).

The bulk of investigations were carried out on the highly metamorphosed Archean assemblages of the Stanovoi fold system, where the most deep-level parageneses are characterized by the presence of bronzite and sillimanite with sapphirine, sapphirine with quartz, and spinel with quartz. For different blocks of unaltered granulites estimated parameters of their formation were found to be T = 980 - 1100°C, P = 7.2 - 10 kbar, with basically pure CO_2 FI composition. Repeated metamorph-ism of these rocks took place at T = 630 - 670°C and P = 6 - 8 kbar (Stanovoi stage, AR_2) and T = 460°C, P up to 2.3 kbar (Gilyui stage, AR-PR). The I had marked amounts of water and dissolved salts along with CO_2; I of liquified nitrogen were also observed. Anorthosites and gabbrides of the East Asian anorthosite belt are closely related to granulites of the Stanovoi area. Parameters of the formation of autonomous anorthosites – T = 1200 - 13000°C [1300?] and P = 5 - 5.5 kbar, with CO_2 F composition of the I – appeared similar for all the studied massifs. Water as a free F appears only at the final stages of crystallization, during the formation of anorthosite - pegmatites. Other G – liquefied nitrogen and methane – were found in younger gabbrides and charnockitoids. Besides, thermobarogeochemical study involved:

1. Omolon median massif granulites (T = 800 850°C), P up to 8 kbar, with CO_2 in the I);

2. Granulites of the Danquinshan Range in Inner Mongolia (T = 750 - 850°C, P = 7.7 kbar, with CO_2 in the I);

3. Khankaisky massif granulites (3-stage metamorphism at T = 950 - 1000°C and P = 8 - 9.3 kbar; 750 - 830°C and 4.5 - 6.7 kbar; 650 - 750°C and 3 - 4.7 kbar, with CO_2 in the F with an admixture of low-boiling G at the earlier stages):

4. Mashansky series granulites in the basement of the Jiamusi massif (2-stage metamorphism at T = 800 - 850°C and P = 4.3 kbar, with CO_2 in the F with an admixture of low-boiling G at the earlier stages);

5. Chegdomynsky block gneisses (T = 650°C, P = 3.1 - 5.7 kbar, with the F evolving from methane into water - dioxide composition).

A great number of other metamorphic and magmatic complexes were also analyzed, and correlation of the conditions of their formation was made. (Engl. abst. courtesy of Dr. Berdnikov)

BERDNIKOV, N.V., KARSAKOV, L.P. and **MIKHALEVSKY, A.N.,** 1995, Fluid inclusions in the gabbro-anorthosites and charnockitoids of the Kalarsky massif: Tikhookeanskaya Geologiya, v. 14, no. 6, p. 98-102 (in Russian).

By the cryometry method were studied FI in labradorite, andesine and hypersthene of the Kalarsky massif gabbro - anorthosites, and also in quartz of the Altaulsky massif charnockitoids, which intrude them. Crystallization of plagioclase of the gabbro - anorthosites started at T = 1210 - 1300°C and P = 5.5 kbar in the presence of a free F phase of CO_2 composition. According to our data, these parameters are typical of autonomous-type anorthosite massifs. The cooling and autometamorphism of the massif, which contributed to the formation of an andesine association, were taking place under subisobaric conditions. Charnockitoids which intrude the gabbro - anorthosites have a different and specific F specialization characterized by both CO_2 and nitrogen - methane mixtures. These results support the geological and geochronological data on the genetic heterogeneity of the gabbro - anorthosites and charnockitoids of the Kalarsky massif. (Engl. abst. coutesy of Dr. Berdnikov)

BERGER, W.H., BICKERT, T., YASUDA, M.K. and **WEFER, G.,** 1996, Reconstruction of atmospheric CO_2 from ice-core data and the deep-sea record of Ontong Java plateau: The Milankovitch chron: Geol. Rundsch, v. 85, p. 466-495. First author at Scripps Inst. of Oceanography, Univ. of California, San Diego, California 92093-0215.

We provide a reconstruction of atmospheric CO_2 from deep-sea sediments, for the past 625,000 years (Milankovitch chron). Our database consists of a Milankovitch template of sea-level variation in combination with a unique data set for the deep-sea record for Ontong Java plateau in the western equatorial Pacific. We redate the Vostok ice-core data of Varnola et al. (1987). To make the reconstructions we employ multiple regression between deep-sea data, on one hand, and ice-core [FI] CO_2 data in Antarctica, on the other. The patterns of correlation suggest that the main factors controlling atmospheric CO_2 can be described as a combination of sea-level state and sea-level change. For best results squared values of state and change are used. The square-of-sea-level rule agrees with the concept that shelf processes are important modulators of atmospheric CO_2 (e.g., budgets of shelf organic carbon and shelf carbonate, nitrate reduction). The square-of-change rule implies that, on short timescales, any major disturbance of the system results in a temporary rise in atmospheric CO_2. (Authors' abstract)

BERNDT, M.E., ALLEN, D.E., and **SEYFRIED, W.E., Jr.,** 1996, Reduction of CO_2 during serpentization of olivine at 300°C and 500 bar: Geology, v. 24, no. 4, p. 351-354. Authors at Dept. Geol. and Geophysics, Univ. Minnesota, Minneapolis, MN 55455.

CO_2 reduction processes occurring during experimental serpentization of olivine at 300°C and 500 bar confirm that ultramafic rocks can play an important role in the generation of abiogenic hydrocarbon G. Data reveal that conversion of Fe(II) in olivine to Fe(III) in magnetite during serpentization leads to the production of H_2 and conversion of dissolved CO_2 to reduced-C species including methane, ethane, propane, and an amorphous carbonaceous phase. Hydrocarbon G generated in the process fit a Schulz-Flory distribution consistent with catalysis by mineral reactants or products. Magnetite is inferred to be the catalyst for methanization during serpentization, because it has been previously shown to accelerate Fischer-Tropsch synthesis of methane in industrial applications involving mixtures of H_2 and CO_2. The carbonaceous phase was predominantly aliphatic, but had a significant aromatic component. Although this phase should ultimately be converted to hydrocarbon G and graphite, if full thermodynamic equilibrium were established, its formation in these experiments indicates that the pathway for reduction of CO_2 during serpentization processes is complex and involves a series of metastable intermediates. (Authors' abstract)

BERNDT, M.E., SEAL, R.R. II, SHANKS, W.C. III, and **SEYFRIED, W.E., Jr.,** 1996, Hydrogen isotope systematics of phase separation in submarine hydrothermal systems: Experimental calibration and theoretical models: Geochimica and Cosmochimica Acta, v. 60, no. 9, p. 1595-1604.

Hydrogen isotope fractionation factors were measured for coexisting brines and V formed by phase separation of NaCl / H_2O F at T ranging from 399-450°C and P from 277-397 bars. It was found that brines are depleted in D compared to coexisting vapors at all conditions studies. (From authors' abstract, by E.R.)

BEVINS, R.J., HILLIS, R.R. and **ROBINSON, D.,** 1996, The South Wales Coalfield; low grade metamorphism in a foreland basin setting?: Geol. Magazine, v. 133, no. 6, p. 739-749. First author at Nat'l. Museum and Galleries of Wales, Cardiff, UK.

Indexed under FI (E.R.)

BÉZIAT, Didier, MONCHOUX, Pierre, and **TOLLON, Francis,** 1996, Cobaltite-gersdorffite solid solution as a primary magmatic phase in spessartite, Lacaune Area, Montagne Noire, France: Canadian Mineralogist, v. 34, p. 503-512. Authors at Lab. Mineral. and Cristallography, Univ. Paul Sabatier, France.

A cobaltite-gersdorffite solid solution occurs in spessartite sills from the Lacaune area, Montagne Noire, southern France. Textural evidence and compositional data support an igneous rather than S origin. Cobaltite-gersdorffite$_{ss}$ can crystallize by separation of an early immiscible sulfarsenide L from a calc-alkaline lamprophyric magma. These sills could represent an attractive target for Au prospecting in the Montagne Noire area. (From authors' abstract, by E.R.)

BEZMEN, 1996, Fluid differentiation of fluid magmatic melts (experiment, theory, and petrological applications) (abst.): 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 23. Author at Inst. of Experimental Mineral., Russian Acad. of Sci., Chernogolovka, Moscow Region, Russia)

BI, Siwen, 1996, A universal theory of system science for fluids in the earth: Earth Sci. Frontiers, v. 3, no. 3/4—Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 1-8. Author at Dept. of Geol., Peking Univ., Beijing 100871.

A philosophical review of F in the earth. (E.R.)

BIERLEIN, F.P., ASHLEY, P.M. and **SECCOMBE, P.K.,** 1996, Origin of hydrothermal Cu-Zn-Pb mineralisation in the Olary Block, south Australia: evidence from fluid inclusions and sulphur isotopes: Precambrian Research, v. 79, p. 281-305. First author at School of Earth Sci., Univ. of Melbourne, Parkville, Vic, 3052, Australia.

A FI and sulphur isotope study was undertaken to examine the nature of F associated with epigenetic mineralisation in the Olary Block, to determine possible genetic relationships between sulphides in epigenetic veins and stratabound mineralisation, and to evaluate possible sources of sulphur in each of these occurrences.

FI in epigenetic assemblages can be classified in general terms of CO_2-rich, CH_4-rich, NaCl-rich and H_2O-rich types. Dense and moderately saline CO_2 and CH_4-rich F prevailed during or shortly after peak metamorphism, possibly as a result of metamorphic decarbonatisation and dehydration reactions at deeper levels as well as oxidation of graphite during retrograde metamorphism in shallower levels. Due to rehydration reactions and infiltration of metamorphic F from deep-seated hydrothermal reservoirs during retrogression and uplift, these F became increasingly saline and thus suitable to transport significant amounts of metals in solution. Near surface-derived F entered F conduits during further uplift and cooling, resulting in compositional dilution of the brines and decreasing FT.

The distinct sulphur isotopic signature of epigenetic vein mineralisation in the Olary Block precludes simple derivation from pre-existing deposits by remobilisation processes. It rather implies extraction from the same source region at a later stage, possibly induced by tectonic pumping and hydrothermal venting of a deep-seated crustal reservoir. (From authors' abstract by E.R.)

BILAL, E., MARCIANO, V., FUZIKAWA, K. and **CORREA NEVES, J.M.,** 1996, Hydrothermal alteration of monazite from pegmatites in the Santa Maria de Itabira District (Minas Gerais, Brazil) (abst.): 16th Earth Sci. Meeting (Abstracts), published by Soc. Géol. Fr., Paris, p. 97 (in French). First author at Ecole des Mines, 158 Cours Fuariel, F-42023 Saint-Etienne Cedex 2, France.

The monazites contain variable amounts of cheralite and thorite in solid solution; the Th and L contents of the monazite are characteristic for each pegmatite body. The enrichment in L, accompanied by a depletion in Th, is due to alteration of monazite during late-stage albitization affecting the pegmatites. During this stage the hydrothermal F was enriched in Ca, Y, P and REE. The U contents of these monazites clearly separate the pegmatites with U minerals from other pegmatites. Presence or absence of U-bearing minerals is due to the diversity of sources. Precipitation of F or unmixing of CO_2 (F^- and CO_3^{2-} complexing Na from the F) may lead to supersaturation of Na in the F, producing albitization in a late-magmatic stage. These F (rich in complexing ions as F^-, CO_3^{2-} and PO_4^{3-}) alter the existing minerals rich in REE, U and Th, flush out these elements and cause their later deposition. The deposition of uranium happens after the maximum stage of albitization. Microthermometric study of P minerals shows that the crystallization T was between 650 and 450°C. The T of late albitization was probably lower than 450°C, compatible with transport and deposition conditions of the uranium. (From authors' abstract by E.A.J. Burke)

BIN, Liu and **KUN, Shen,** 1996, Calculation of thermodynamic conditions under various petrogenetic circumstances by using fluid inclusion data (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 481. First author at Dept. of Geotechnical Engineering, Tongji Univ., [Shanghai] China.

The authors established an equation for paragenetic minerals at equilibrium and a thermodynamic equation for P FI trapped in these minerals and simultaneously solved them to obtain the formation T and P for the rocks in which the solid minerals and FI were formed at the same P-T conditions (e.g. magmatites, high-grade metamorphic rocks and ductile tectonites). For the rocks in which the S FI and their host minerals were formed at different times, i.e. at different P-T conditions (e.g. detrital rocks, low-grade metamorphic rocks and brittle tectonite) the method mentioned above cannot be used. (From authors' abstract by E.R.)

BIRD, B.C. and **DARLING, R.S.**, 1996, Fluid inclusion study of the Long Lake calcite-fluorite vein, Central Adirondacks (abst.): The Geological Society of American, 31st Annual Northeastern Section, 1996 Abstracts with Programs, v. 28, no. 3, p. 39, February 1996. Authors at Dept. of Geol., State Univ. College at Cortland, Cortland, NY 13045.

A road cut on NYS Route 30 (11.4 km north of Long Lake village) contains post-metamorphic, hydrothermal veins cutting quartz-feldspar gneiss. The veins range in width from 10 to 25 cm and contain well-developed fluorite octahedra in calcite. Epidote, quartz and kainosite occur locally (Richards and Robinson, 1996).

The fluorite octahedra contain P FI (defined by isolated clusters and rare growth zones) which, at room T, contain: H_2O (V), H_2O (brine), and a single dx of halite. Identification of halite is based on cubic habit, high positive relief with respect to brine, and dissolution sluggishness at T < 100°C (i.e. steep liquidus surface). At low T, the I incompletely freeze between –90 and –76 only upon warming from T < –100°C. Freezing of I is characterized by slow dendritic growth of ice. At these T, ice is the only recognizable solid phase other than halite. Identification of ice is based on shrinking of V bubble upon freezing, hexagonal habit and high negative relief with respect to brine. Furthermore, hydrohalite failed to nucleate as either separate grains or as rims on halite. Final ice melting T average –40.9 ± 1.0°C (1 σ, n = 19). The V bubbles homogenized to L at +133.5 ± 3.0°C (1 σ, n = 17). Final halite dissolution T average +172.3 ± 9.4°C (1 σ, n = 17).

The low T phase behavior is characteristic of $CaCl_2$-$NaCl$-H_2O F that are particularly enriched in the divalent cation (Davis et al, 1990). The final ice melting T modeled on an interpolated ice-halite metastable cotectic (Yanatieva, 1946) coupled with final halite dissolution T modeled on the halite liquidus surface (Vanko, et al, 1988) yield brine compositions of 20.5 ± 1.0 wt.% $CaCl_2$ and 15.0 ± 1.3 wt.% NaCl. The Ca/Na weight ratios, geologic setting and elevated T suggest that the Long Lake calcite-fluorite vein formed from heated F similar in composition to Canadian Shield brines described by Frape et al. (1984) (Authors' abstract)

BISCHOFF, J.L. and **ROSENBAUER, R.J.**, 1996, The alteration of rhyolite in CO_2 charged water at 200 and 350°C: The unreactivity of CO_2 at higher temperature: Geoch. Cosm. Acta, v. 60, no. 20, p. 3859-3867. Authors at U.S. Geol. Survey, Menlo Park, California 94025.

BISCHOFF, J.L., ROSENBAUER, R.J., and **FOURNIER, R.O.**, 1996, The generation of HCl in the system $CaCl_2$-H_2O: Vapor-liquid relations from 380-500°C: Geochimica et Cosmochimica Acta, v. 60, no. 1, p. 7-16. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

We determined V-L relations (*P-T-x*) and derived critical parameters for the system $CaCl_2$-H_2O from 380-500°C. Results show that the two-phase region of this system is extremely large and occupies a significant portion of the *P-T* space to which circulation of F in the Earth's crust is constrained. Results also show the system generates significant amounts of HCl in the V phase buffered by the L at surprisingly high P, presumably by hydrolysis of $CaCl_2$. (From authors' abstract by E.R.)

BOBROV, A.B., SIVORONOV, A.A., LYAKHOV, Y.V., PAVLUN, N.M., and **MALYUK, B.I.**, 1996, Ore-petrological model for Lower Precambrian complexes of the Ukrainian Shield (based on fluid inclusion studies) (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 531. Authors at Dept. of Geol., Lviv State Univ., Lviv, Ukraine.

The earliest processes of metamorphism and ultrametamorphism in granulite facies condition were superimposed on the stratified volcanic and sedimentary rocks of the Lower Archean. Data on L_S+V+S_S-type (here and below: L-liquid, V-vapour, S-solid, s-silicate) FI in quartz, garnet and hyperstene suggest for high-T (900-1000°C) and moderate P (500-700 MPa) conditions and mainly water-poor-CO_2-rich solutions. The presence of characteristic crystal-FI (L_S+V+S_S) suggests for partial melting up to 10%.

On the second stage the matter of the earliest granulite complexes as well as later deposited in mobile belts volcanogenic-sedimentary formation were strongly reworked. Metamorphism (in granulite complexes–dynamometamorphism) and ultrametamorphism has developed in amphibolite-facies conditions. Data on $L_{H_2O}+L_{CO_2}$ +Na(K)Cl-type FI suggest for T interval of 600-850°C and moderate P. The F system have had CO_2-H_2O-salt composition with estimated NaCl+KCl concentration about 30-40%; ratio of partial P of volatile components can be expressed as $P_{H_2O} \sim (P_{CH_4} + P_{CO_2} + \ldots)$.

Tectono-metamorpho-magmatic activization of the previously consolidated crust on the third (Early Proterozoic) stage were accompanied by processes of potassic metasomatism and selective anatectic melting. From I studies metasomatic F system ($V_{CO_2}+L_{H_2O}$) have had water-CO_2 composition, T of 500-600°C and P of 300-400 MPa. (From authors' abstract by E.R.)

BODINIER, J.-L., MERLET, C., BEDINI, R.M., SIMIEN, F., REMAIDI, M. and **GARRIDO, C.J.**, 1996, Distribution of niobium, tantalum, and other highly incompatible trace elements in the lithospheric mantle: the spinel paradox: Geoch. et Cosmo. Acta, v. 60, no. 3, p. 545-550. First author at Geofluides, Bassins, Eau, URA. 1767, CNRS, ISTEEM, Univ. di Montpellier 2, 34095 Montpellier Cedex 05, France.

A very thin reaction layer (<10 µm thick) coats the surfaces of spinel crystals and concentrates Rb, Ba, Nb, and Ta, and accounts for 45-90% of the whole-rock budget for these elements. The spinel rims are attributed to a metasomatic process involving pervasive percolation of silica-rich and K-rich small M fractions in the lithospheric mantle. This process bears major implications for the genesis of the continental crust and Nb-Ta-depleted magmas such as arc lavas. (From authors' abstract by E.R.)

BODNAR, R.J., 1996a, Fluid inclusion evidence for the source of metals in porphyry deposits and epithermal precious metals systems (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A402. Author at Fluids Research Laboratory, Dept. of Geological Sci., Virginia Tech, Blacksburg, VA 24061; e-mail (bubbles@vt.edu)

It is now generally accepted that epithermal precious-metals deposits hosted by silicic volcanic rocks represent the upper portion of a larger magmatic-hydrothermal system. However, much controversy remains concerning the "size" of the entire system, the nature of the plumbing system that connects deeper magmatic activity with shallower hydrothermal activity, and the extent and significance of input of metals and other components from the deep system into the shallower system. FI and stable isotopic studies of epithermal systems show clearly that the majority of the *water* associated with mineralization is of meteoric origin. This observation has led some to suggest that contemporaneous magmatic activity contributes only thermal energy to the system, and that all ore-forming components (other than water) are derived from surrounding wallrocks.

Results of analyses of FI from several porphyry copper deposits provide convincing evidence that many metals of interest (Cu, Fe, Zn, Pb) are derived from the crystallizing magma. Moreover, analyses of FI trapped in the L + V field show that Fe, Zn and Pb are quantitatively partitioned into the L phase, whereas a significant portion of the Cu is partitioned into the V. Heinrich et al. (1992) observed similar behavior, and suggested that Cu may form stable complexes with sulfur species at magmatic conditions, and thus would be partitioned into the V along with sulfur. By analogy, metals that are highly volatile (Hg, As, Tl) will also be partitioned into the V phase, along with other metals that are transported as sulfide complexes (Au, Ag). Numerical models and FI studies of hydrothermal systems show that the V phase migrates to the top of the hydrothermal system, while the more dense L tends to "pool" in and around the pluton. The rising V phase condenses and mixes with meteoric water as it migates upwards. Later phase separation ("boiling") in the near-surface environment leads to precious-metal mineralization and the characteristic suite of trace elements associated with such deposits. Thus, although the water associated with epithermal precious-metal deposits is indeed of meteoric origin, the metals and other volatile components in the deposits likely originated in the underlying magma. (Author's abstract)

BODNAR, R.J., 1996b, Fluid inclusion evidence for a magmatic source for metals in hydrothermal systems (abst.): AIME 126th Annual Meeting Prog., p. 43. Author at Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.

FI provide one of the most direct means of determining the source(s) of components in hydrothermal ore deposits. Results of synchrotron XRF analyses of individual FI from various paragenetic stages in porphyry copper deposits show clearly that many metals of interest (Cu, Fe, Pb, Zn) are sourced in the magma and are introduced into the hydrothermal system when aq F exsolve from the crystallizing magma. The results also indicate the volatile elements such as As, Hg, T1 as well as Au, Ag and some Cu are partitioned into the V phase and transported into the near-surface where precipitation and mineralization occurs. (Authors' abstract.)

BODNAR, R.J., SZABÓ, Cs., SHILOBREEVA, S.N. and **NEWMAN, S.**, 1996, Quantitative analysis of H_2O-CO_2 fluid inclusions by Raman spectroscopy (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 14. First author at Fluids Research Laboratory, Dept. of Geological Sci., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA 24061; e-mail (bubbles@vt.edu)

Laser Raman spectroscopy (LRS) has been used very successfully in recent years to obtain quantitative analyses of the non-aq volatile components in FI. LRS has also been used with less success to identify and quantify dissolved species in aq I, and to identify dm in FI. However, quantitative determinations of the H_2O / (non-aq volatiles) ratios have not been reported because (1) H_2O is a very poor Raman scatterer and, (2) at ambient temperatures the I contains multiple phases, with H_2O and the other volatiles of interest occurring in different phases.

Using synthetic H_2O-CO_2 I as standards, a preliminary empirical calibration curve for determining the H_2O/CO_2 ratio of individual FI has been developed. During analysis, the I were heated above their Th using a Chaixmeca heating stage, and the intensities of the H_2O (3219 cm^{-1}) and CO_2 (1388 cm^{-1}) peaks were measured using a Dilor X-Y system equipped with a CCD detector. For compositions ranging from 0 to about 25 mol% CO_2, the relative intensity of the CO_2 peak to the water peak [I_{CO_2} / (I_{CO_2}+I_{H_2O})] increases linearly with increasing CO_2 content according to the relation:

mole fraction $CO_2 = 0.4 \times R$ (1)

where R is equal to the ratio [I_{CO_2} / (I_{CO_2}+I_{H_2O})], and is valid for R values <0.66 (which corresponds to a CO_2 content of approximately 26 mol%). For higher CO_2 contents, the composition is given by the relation:

mole fraction $CO_2 = 0.87 - 2.96 (R) + 3.09 (R^2)$ (2)

For CO_2 contents < 26 mol%, equation (1) fits the analytical data within a few mol% CO_2. For higher CO_2 contents, equation (2) fits the data within about 5 mol%.

As a test of the calibration results, a synthetic rhyolite glass containing H_2O-CO_2 bubbles of known composition was analyzed. The resulting Raman spectra gave a composition of 87 mol% CO_2, which is identical to the value obtained from manometric analysis of the V phase trapped in the capsule with the glass (M) sample. The V was released by piercing the capsule in vacuum. The effect of salts or other volatile components on the intensity ratios used to develop the calibration curve is unknown, but is currently under investigation. (Authors' abstract)

BOER, R.H., REIMOLD, W.U., KOEBERL, Christian and **KESLER, S.E.**, 1996, Fluid inclusion studies on drill core samples from the Manson impact crater; evidence for post-impact hydrothermal activity, in The Manson impact structure, Iowa; anatomy of an impact crater, C. Koeberl and R.R. Anderson, eds.: Geol. Soc. of America Special Paper, v. 302, p. 377-382.

BOEV, B., and **SERAFIMOVSKI, T.**, 1996, General genetic model of the Alshar deposit: Plate tectonic aspects of the Alpine metallogeny in the Carpatho-Balkan region, Proceedings of the Annual Meeting, Sofia, UNESCO-IGCP Project No. 356, c. 1, p. 75-84.

The Alshar deposit is located in the Mount Kozuf intermediate-to-acid volcanic complex of Pliocene age along the Macedonian-Greek border. Mineralization includes Cu, Pb-Zn and Au in the central parts and Sb, As, Tl, Au and Ba in the margins. Reference is given to fluid inclusion studies from realgar. Th = 280/250°C - 120°C, salinities are between 7.9 and 12.9 NaCl eq. wt. %. Sulfur isotope data: realgar: -1.64 - -3.77‰; orpiment: -3.69‰; stibnite: -5.60 - +0.351‰; marcasite: -6.84‰. (Abstracted by F. Molnar)

BOGOMOLOV, Alex, 1996, Mantle relicts in coalbearing sediments (abst.): 30th Int'l Geol. Cong., Abstracts, V. 2, p. 862. Author at MSU Russia.

It has been found that G-L I in calcite and quartz taken from the of tectonic relaxation of Donbass coal beds contain hydrocarbons and sulphides which are known as direct evidence of active infiltration of young peat basin with hydrocarbons and ore components. (From author's abstract, by E.R.)

BOIRON, M.C., BANKS, D.A., CATHELINEAU, M. and **RAMANAIDOU, E.**, 1996, Contrasted fluid chemistry in quartz veins from the Ouro Fino Syncline (Brazil): A multidisciplinary chemical characterization of sulfate-volatile rich brines (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 15-17. First author at CREGU, BP 23, 54501 Vandoeuvre les Nancy cedex, France; e-mail (boiron@cregu.cnrs-nancy.fr)

The Precambrian banded iron formation (BIF) from the Quadrilatero Ferrifero and from the Ouro Fino syncline (Minas Gerais, Brazil) display different quartz veins crosscutting the itabirites. Systematic FI studies using microthermometry, Raman spectroscopy and crush leach analysis have been carried out on the different quartz veins, in order to characterize the P-V-T-X conditions of the F circulation in the fault network. Two vein types have been identified:

-type 1: barren quartz-specularite veins crosscut the itabirite series and do not show any ductile deformation.

- type 2: quartz veins containing rare native gold particles, mostly located in the metamorphic series surrounding the itabirites.

Type 1 veins display three kinds of I with unknown chronology:

a) two-fluid phase aq I: Tm ice ~−8.5 to −10.5°C; Te~−60°C. The Th (L-V)L is 63 to 137°C.

b) two types of sulfate rich I:

1) multiphase hypersaline CO_2-rich I which contain 10 vol.% of an hexagonal solid identified by Raman as a sulfate, and Tm~140 ± 15°C; CO_2-dominant V phase plus small amounts of N_2. Th CO_2 (L or V) is from 1 to 17.8° C but mainly between 7 and 14°C, Tm CO_2 −56.6 to −57.0° C; and L with SO_4^{2-} dominant (Raman), and lesser HSO_4^-. Tm ice −4.3 to −5.7°C.

All studied I decrepitated at 160 to 280°C.

2) bisulfate rich I containing a small dm: most Tm ice −1.5 to−4.5° C; some Th (L-V)L around 230°C whilst most others have decrepitated at T up to 290°C.

The L phase contains both SO_4^- and HSO_4^- ions in rather similar concentrations. Using calibration with experimental solutions (Moissette et al., 1990), (SO_4^{2-}) was estimated to be around 0.32 ± 0.05 molal in the bi-sulfate rich I, and the pH around -0.3 ± 0.2 at 25° C in such I. This is the first occurrence of such acid F in natural FI.

c) aqueous vapours. The V phase occupies around 80-90 % of the I. No volatile species has been identified by Raman spectroscopy. No Th could be obtained due to decrepitation. The sal is estimated to be very low from the rare observation of ice melting near 0.0° C in some I.

The F compositions, especially in type c I are rather unusual: low pH at room T, sulfate rich [yet very low in sal?] aq solutions, some of them being mixed with volatiles (CO_2). The coexistence of aq V together with hypersaline F are probably indicative of boiling which probably led the crystallization of the quartz-hematite assemblage. The observed compositions reveal highly oxidizing conditions, and T above 200-300° C.

Type 2 quartz veins contain volatile rich F mostly borne by FI trails. Each trail is characterized by rather homogeneous phase relationships at roomT. Especially, the water filling which varies from nearly 0 up to 70% in the whole set of I, is nearly constant within a given FI plane.

Tm CO_2 −56.7 to 57.2°C (mode −56.8°C); Tm ice −1.5 to −11.5°C (mode −2.7°C); Th CO_2 (L-V)L varies greatly but rather constant values within a given trail, −11.5 to +29.8°C, with modes at −7, +3, +17, and + 27°C. Most I decrepitate at T ranging from 180 to 320° C. Some Th to V in 320-400°C range. Raman reveals CH_4, C_2H_6 and N_2 in the volatile phase, suggesting much lower fO_2 than for type 1 veins.

Crush-leach analyses of the two types of quartz vein are completely different and somewhat unusual. Type 1 veins contain K-Na-Ca-B-SO_4-Cl with K/Na ~2, Ca/Na ~0.15 and SO_4/Cl ~25 while type 2 veins contain an Ca-Na-K-Fe-Cl SO_4 with K/Na ~0.4, Ca/Na ~1.3 and SO_4/Cl ~0.1. However the Br/Cl ratios, which are considered a good indicator of the F origin, are ~0.012 in both cases and could be interpreted as evolved sea water from which halite has precipitated. This indicates that originally the 2 F had the same composition and that the differences in chemistry are likely to have been caused by intense F-rock interaction. Such high K and SO_4 values are unusual and are normally only found in acid geothermal waters where feldspars have been completely destroyed and no longer buffer the K/Na ratio.

The F from the barren veins seem to have been incompatible with gold transport or deposition; gold deposition seems to be restricted to the veins characterized by the presence of carbonic F (type 2) characterized by rather low fO_2 and moderate pH. (From authors' abstract by E.R.)

BOIRON, M.-C., CATHELINEAU, M., BANKS, D.A., YARDLEY, B.W.D., NORONHA, F. and MILLER, M.F., 1996, *P-T-X* conditions of late Hercynian fluid penetration and the origin of granite-hosted gold quartz veins in northwestern Iberia: A multidisciplinary study of fluid inclusions and their chemistry: Geochimica et Cosmochimica Acta, v. 60, no. 1, p. 43-57.

Two major changes in the chemical and physical environment have been identified: (1) a progressive change in the bulk chemical composition from early CO_2-rich, C-H-O-(N) F, equilibrated with graphitic metamorphic host rocks, to late H_2O-dominated F, inferred from their halogen signature to result from an influx of meteoric or upper crust F affecting the basement at the end of Variscan orogenesis, and (2) changes in the *P-T* conditions from early stage sulphide deposition in quartz veins, at ca. 450°C and 150-300 MPa, towards epithermal conditions, ca. 260-310°C and <75 MPa, at the stage of gold mineralization.

Several chemical trends are shown by FI: (1) dilution of the early volatile-rich F, (2) a break of graphite buffering activity demonstrated by the CH_4 content increase in the volatile fraction of the latest As mineralizing F, and (3) increasing contribution of a relatively oxidizing F enriched in sulphate and bromide during the last stages of F percolation (Au stage). These latest F stages are interpreted as indicative of extended F penetration downward in the crust enhanced by late brittle deformation and decompression, and played an important role in mass transfer at the end of the Hercynian orogeny, especially in transport of metals. (From authors' abstract, by E.R.)

BOIRON, M.C., CATHELINEAU, M., NORONHA, F., BANKS, D.A., VINDEL, E. and **LOPEZ, J.A.**, 1996, From retrograde Hercynian metamorphism to granite related geothermal fields : A fluid chemistry and P-Tt-depth reconstruction based on fluid inclusions (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 18-20. First author at GS CNRS-CREGU, BP 23, 54501 Vandoeuvre-les-Nancy Cedex, France; e-mail (boiron@cregu.cnrs-nancy.fr)

The major objective of this work is to document the evolution in the F chemistry and the P-T conditions during the uplift of two distinct segments of the Hercynian belt. Main objectives were the identification of the processes at the origin of the chemical features of the F and the identification of F sources using the data from FI and mineral assemblages.

F synchronous or slightly predating the syntectonic granite intrusions were found in microfissured metamorphic rocks. These belong to the C-H-O-N system and have high densities which indicate they were trapped at relatively deep structural levels. F are mostly dominated by CO_2-H_2O and display a high density of these volatile phase (Fig.1). It is thought that CHON F result from the circulation of waters through metamorphic rocks and acquire a part of their chemical features (CO_2 / CH_4 ratios for instance) during water-rock interaction.

Post-tectonic granites generally intrude the metamorphic series at a slighly higher structural level than those above described. The first stage of W deposition is always characterized by the presence of aquo-carbonic fluids.

A progressive enrichment in water and CH_4 content and decrease in the density of the volatile phase is demonstrated by a series of F compositions recorded in Au deposits as well as in W ones.

A brittle microfracturing stage is then well developed allowing aq F to circulate in relatively shallow crustal levels (less than 5 km). They are associated with the main stage of gold deposition, and Pb-Ag sulphosalts. These late F stages are ubiquitous, and attest of a significant microfissural F migration.

Results show that the Hercynian granites may be regarded as playing a different role in ore forming processes than previously thought. The main role of the granites was to supply a heat source rather than metal or F, as no typical magmatic signature have been found except the earliest stages associated with the post-tectonic granites.

The halogen chemistry shows that most F found in quartz veins (containing Au, or W) display features similar to F equilibrated with upper crustal rocks. (From authors' abstract by E.R.)

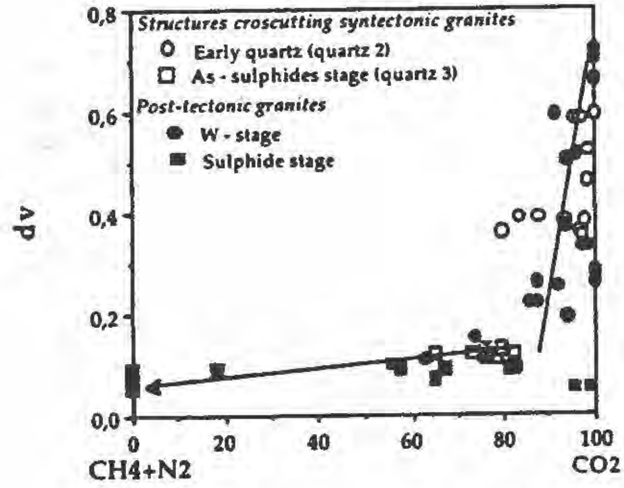


Fig.1 : Summary of the evolution of the fluid composition (density of the volatile phase versus composition)

BORISENKO, A.S., SOTNIKOV, V.I., BOROVIKOV, A.A., BERZINA, A.N. and **GIMON, V.O.**, 1996, Carbon in rare-metal ore-magmatic systems: *in* Proceedings, Geodynamics and Evolution of the Earth, Russian Acad. of Sci., Siberian Branch, p. 149-xxx. First author at Inst. of Geol., UIGGM, SB RAS.

Endogenous F in the ore-forming systems of Sn - W, Mo - W, and Cu - Mo - porphyry types significantly differ by redox potential and the presence of different carbon forms: Sn-W deposits are characterized by reduced methane-bearing F, Mo - W and, especially, Cu - Mo – oxydized F enriched in CO_2. The presence of specific carbon forms in F is one of the estimation criteria for metallogenic specialization of granitoid complexes. (Authors' abstract)

BORROK, D.M., KESLER, S.E., BOER, R.H. and **CROCKER, I.T.**, 1996, Fluid inclusion chemistry of the Vergenoeg massive iron oxide/fluorite deposit, Bushveld layered igneous complex, South Africa (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 21. First author at Univ. of Michigan, Dept. of Geological Sci., Ann Arbor, Michigan 48109.

The Vergenoeg massive iron oxide/fluorite deposit is a 600 m deep cylindrical pipe with many similarities to other iron-rich deposits such as Kiruna in Sweden, El Laco in Chile, and Iron Mountain in Missouri. It is genetically related to younger granites that intruded the intermediate layered mafic phase. The main Vergenoeg pipe consists of primary fluorite, magnetite, ilmenite, fayalite, and quartz and is surrounded by hematite-fluorite tuff-like bodies, that appear to have been erupted from the pipe. Two models have been proposed for deposits of this type: 1) separation of an immiscible iron-rich M from a felsic silicate magma and 2) deposition from an iron-rich hydrothermal F. Vergenoeg provides a good opportunity for FI study because, unlike Kiruna, etc., it has transparent coarse-grained fluorite that is coeval with all stages of magnetite.

A few iron-rich mineral I were found in fluorite. These consisted of fayalite and magnetite in a ratio of about 5 to 1, but did not appear to be M I because they were not circular and were extensively altered to secondary ferro-actinolite and ferropyrosmalite. Instead large populations of highly saline, aq I were found in fluorite throughout the deposit. Th/Th tot was determined on 402 FI in fluorite. About 10% contained halite, hematite, and/or several other salt and opaque dm. Homogenization of I took place by V disappearance, and dxl persisted after homogenization through decrepitation. Th ranged from 80 to 463° C with sal ranging from 1 to 38% NaCl eq., forming two populations (one averaging 7% NaCl equivalent and another averaging 21% NaCl eq.). The two sal populations are not distinguishable optically, but some V-rich I have been observed. Analysis of G by quadrupole mass spectrometry yielded high values of CO_2, Ar, and He above 300 m depth and high values of CH_4, and N_2 below 300m depth. H_2S and SO_2 are negligible below 300 m and have slightly higher concentrations above this mark.

The results of this study show that Vergenoeg ore was probably deposited from an iron-rich hydrothermal F rather than an immiscible iron melt. Based on sal differences, two F seem to have been present during ore formation. Fractionation of the underlying granites could have been responsible for the higher sal brine and the low sal F was likely meteoric or formation water. (From authors' abstract by E.R.)

BORROK, David, KESLER, S.E. and **ESSENE, E.J.**, 1996, Geochemistry of the Vergenoeg magnetite-fluorite deposit, Bushveld igneous complex, South Africa (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A152–A153. First author at Dept. of Geological Sci., Univ. of Michigan, Ann Arbor, MI 48109; e-mail (dborrok@umich.edu)

The Vergenoeg deposit is a cylindrical pipe consisting largely of fayalite, magnetite and fluorite, surrounded by tuffs (?) containing fragments of iron oxides, fluorite, and silicate rock. It is hosted by rhyolites of the Rooiberg

Group in the upper part of the Bushveld Igneous Complex, but could be related to late-stage Bushveld granites. Vergenoeg is of interest because of its similarity to Kiruna and Olympic Dam-type deposits and the insights that might be obtained from FI in its fluorite. FI data from main-stage minerals is needed from these deposits to determine whether they formed from an immiscible iron oxide magma or a hydrothermal F.

At the maximum drilled depth (600 m), Vergenoeg ore consists of fayalite, fluorite and magnetite with lesser ilmenite, apatite, quartz, sulfides, and rare-earth minerals. Small laths of ferroactinolite and grunerite (?) cover fayalite locally. Above about 300 m, the assemblage changes to fluorite, S magnetite, stilpnomelane, and minor biotite, with local sulfides; S apatite, and quartz. Later siderite and ferropyrosmalite cut this assemblage. Strong evidence for I of magma have not yet been found, and water-rich FI are common. V bubbles in these I disappear at 80 to 464°C, although about 10% of the I contain halite, sylvite, and hematite daughters that persist to higher T. Sal of these I form two groups that average 7% and 21% eq. wt.% NaCl. G in the I show a large increase in non-H_2O G content and a shift to CH_4-rich compositions below a depth of about 300 m. d18O and dD values for I water in the deeper part of the ore body range from –0.9 to –10.8‰ and –80 to –54‰, respectively, and cluster in a zone between magmatic and meteoric water compositions, suggesting that Vergenoeg formed from magmatic hydrothermal solutions that mixed with meteoric water in the upper parts of the system. (Authors' abstract)

BORTNIKOV, N.S., PROKOF'YEV, V.Y. and **RAZDOLINA, N.V.**, 1994, Dual nature of the fluid in the mesothermal ore-forming system in the Charmitan gold deposit, western Uzbekistan: Dok. Ross. Akad. Nauk, 1994, v. 336, no. 4, p. 521-524 (in Russian, translated in Russ. Acad. Sci., v. 338, no. 7, p. 114-119, 1995 pub. 1996). First author at Inst. of Economic Geol., Petrography, Mineral. and Geochem., Russian Acad. of Sci., Moscow.

We give the results of our study of the mineral associations, FI and stable isotopes in minerals of the Charmitan vein deposit, a characteristic representative of mesothermal gold-ore deposits in this region.

The deposit resulted from a multistage process. In it five ore-mineral associations of different age are identified: 1) quartz-feldspar with scheelite, b) quartz-gold-telluride with pyrrhotite and maldonite [Au_2Bi], c) pyrite-arsenopyrite with native gold, d) pyrite arsenopyrite-sphalerite-fahlore-complex sulfoantimonides, e) quartz-antimonite with berthierite, gudmundite and native antimony.

The FI showed that the early mineral associations containing gold were deposited at 280 to 410°C and 0.8 to 2.7 kb from aq F that was rich in CO_2 and contained methane and nitrogen, as well as dissolved sodium and magnesium chlorides in concentrations ranging from 10.7 to 18.5 wgt.% NaCl eq. In that F, the $CO_2 + CH_4$ mole fraction increased from 0.05 to 0.2 while its CO_2 / CH_4 ratio decreased from 16 to 6 and, in rare cases, to 2.

Our find of syngenetic I consisting essentially of water and gaseous CO_2 indicates that during ore genesis the F was heterogeneous [and that the] minerals were deposited from a "boiling" solution. Thus, the Th I can be taken as the T of ore deposition. The late mineral associations containing gold were deposited at 145 to 275°C from an aq salt solution that contained chiefly sodium and magnesium chlorides in concentrations ranging from 0.9 to 10.4 wgt.% NaCl eq.

Oxygen, carbon dioxide and methane fugacities were calculated to fall within the following ranges: f_{O_2} from 10^{-29} at 380°C to 10^{-38} at 270°C, f_{CO_2} from $10^{2.6}$ to $10^{1.5}$ and f_{CH_4} from $10^{1.5}$ to $10^{2.6}$. At 350°C and 2 kb, and at 200°C and 1kb, sulfur fugacity ranged from $10^{-8.5}$ to $10^{-7.8}$ and from 10^{-12} to 10^{13} bars, respectively. (From authors' text by E.R.)

BORTNIKOV, N.S., PROKOFYEV, V. Yu, and **RAZDOLINA, N.V.**, 1996, Origin of the Charmitan gold-quartz deposit (Uzbekistan): Geol. Rud. Mesto., v. 38, no. 3, p. 238-257 (in Russian).

Many data on Th, Th CO_2, Th CO_2 G-L, CO_2, CH_4, and sal. (E.R.)

BOTTAZZI, P., NEUMANN, E.-R., OTTOLINI, L., VANNUCCI, R., and **WULFF-PEDERSEN, E.**, 1996, Origin of silicic glass inclusions in refractory mantle xenoliths from the Canary Islands (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 481. First author at Min.-Geol. Museum, Univ. Oslo, Norway.

Refractory spinel harzburgite, spinel lherzolite, and Mg-rich spinel dunite xenoliths from the Canary Islands contain highly silicic glass as mineral I and interstitial M. Within each island glass compositions show a systematic relation to type of host rock. Glass I in spinel harzburgite generally have higher silica contents than I in spinel dunite (60-70% versus 44-60%). The silicic glass is enriched in strongly, and depleted in moderately incompatible trace elements relative to primordial mantle (e.g. 131 ppm Rb, 420 ppm Ba, 5 ppm La). High potassium content appears not to be related to the rock type, but rather to the presence of hydrous minerals like phlogopite and amphibole in the host rock (e.g. La Palma and Tenerife xenoliths). Glass compositions also vary with mode of occurrence. Glass I in orthopyroxene and olivine are generally richer in SiO_2 and poorer in TiO_2 than interstitial glass (<1% and ≤4%, repectively). The presence of small, euhedral Cr-diopside and olivine (Fo_{90-92}) crystals coexisiting with highly silicic glass in polyphase I with similar compositions to Cr-di and ol in the peridotitic wall rock testifies to equilibrium between highly silicic M and refractory peridotite. The less silicic, more Ti-rich interstitial M, in contrast, may contain augite and Fe-rich olivines (Fo_{80-85}). The most striking variation in glass composition is seen in veined spinel xenoliths from La Palma. These show a gradual transition in phase assemblage and glass composition. In broad veins basaltic glass (45 wt% SiO_2) relatively rich in incompatible elements (e.g. 993 ppm Ba, 180 ppm La, 3,4% TiO_2) coexist with amph + aug + ap + ox ± phl ± ol. As the veins grow narrower, the glass becomes gradually richer in silica and alkalies, and poorer in Ti, Fe, Ca and REE; the typical phase assemblage is glass + phl + di + sp. The narrowest veinlets contain a silicic, alkaline glass (SiO_2>60%, K_2O>7%, Na_2O>6%) and phlogopite. This highly silicic glass has similar concentrations of highly incompatible elements as the basaltic glass in the broad veins (e.g. 973 ppm Ba), but is relatively depleted in moderately incompatible elements, such as the REE (e.g. 64 ppm La, 0,8% TiO_2). We interpret the observed change in M composition to be the result of a combination of fractional crystallization and reaction with peridotite wall-rock.

These data strongly suggest that the most highly silicic glass found as I in orthopyroxene and olivine and refractory spinel harzburgite, lherzolite and dunite represent M in equilibrium with the host rock. Such M may form by *in situ* partial melting involving incongruent melting of orthopyroxene or crystallization/reactions between basaltic initial M and peridotite wall-rock. The less silicic and more Ti-rich interstitial glass, most likely represent infiltrated M that have not reached equilibrium with the wall-rock. (Authors' abstract.)

BOUCHOT, Vincent, FAN, Hongrui, VANDERHOR, Fop, MIKUCKI, Edward and **GROVES, David,** 1996, Temporal relationships between barren calc-silicate and auriferous quartz-sulphide veins at the Nevoria gold deposit, Yilgarn block, Australia: evidence for both pre- and post-peak metamorphic hydrothermal events (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 760. First author at BRGM, Orleans, France and Key Centre for Strategic Mineral Deposits, Univ. of Western Australia, Nedlands, Australia.

The Nevoria gold deposit (12t contained Au) is located in a greenstone belt, close to the contact of this belt with a syn-orogenic granitic dome.

Two mineralogically different and spatially separate vein sets are present at Nevoria: 1) gold-bearing pyrrhotite-arsenopyrite-quartz veins related to stratabound ore zones within BIF and; 2) gold-barren calc-silicates vein and vein selvages containing an assemblage of diopside and variable amounts of hornblende, grossular garnet, plagioclase, quartz, calcite and scheelit. Using the D2 fabric as a reference, structural and textural studies indicate that these two vein sets represent different and temporally distinct generations of veins.

This chronology is confirmed by FI studies which indicate that F of different compositions were involved in the formation of the two groups of veins. F associated with the gold-rich veins consisted of a CO_2-CH_4-H_2O solution, and were similar to auriferous F reported from other gold deposits in the Yilgarn block. In contrast, garnets in early calc-silicate veins contain unambiguous P aq, CO_2-poor or -absent FI which are interpreted to represent F composition at the time of metamorphism when precursors to the calc-silicate veins were deformed and partly recrystallized. Thus the timing, mineral assemblages and likely F compositions of the calc-silicate veins differ considerably from those responsible for gold mineralization. Although the nature of the P veins is not known, they possibly relate to sea floor alteration, given the stratabound nature of the veins in weakly deformed metatuffs. (From authors' abstract by E.R.)

BOULVAIS, P., CUNEY, M., MOINE, B., GRUAU, G., and **FOURCADE, S.,** 1996, Fluid circulation and chemical transfer in granulites: the example of Madagascar (abst.): 16th Earth Sciences Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 97 (in French). First author at Géosciences Rennes, Campus de Beaulieu, F-35042 Rennes Cedex, France.

In the South of Madagascar intense F circulation, synchronous with metamorphism of granitic crust has caused transfer of elements (Mg, Th, REE, Zr, U . . .) The resulting skarns and their associated mineralizations near synmetamorphic granitic intrusions have been studied. Isotope study (O, C, Sr, Nd) on the calcian and magnesian marbles permits determination of the source of the F and the origin of the transported elements.

The small variation in $\delta^{13}C$ implies a crustal origin for the F. These F contain radiogenic Sr and can transport REE, Th, U, Zr . . . FI and mineral equilibria show that these F are rich in CO_2 and F. They are moreover in equilibrium with the intrusions, the probably source of the elements in question, as shown by the Sr-isotope profiles which are centered on these intrustions. The affected rocks do not show a single mantle signature. (From authors' abstract translated by E.A.J. Burke.)

BRAKE, S.S. and **ROMBERGER, S.H., 1996,** Precious metal transport and deposition: A case study of fluid inclusions and alteration assemblages at the new Savage Mine, Comstock District, Nevada (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A152. First author at Dept. of Geography, Geology, and Anthropology, Indiana State Univ., Terre Haute, IN 47809.

The New Savage mine is located in the central portion of the Comstock district in western Nevada. Mineralization was structurally controlled, and deposits are localized in a stockwork zone that has been intensely silicified and repeatedly veined by quartz. Although spatially associated, precious and base metal mineralization appears to be related to separate events. Within the stockwork ore body, disseminated pyrite, adularia, and sericite were co-deposited with precious metals and are present in varying amounts. Sericite is also observed as an accidental mineral trapped within P FI in precious metal-stage quartz. The presence of sericite in FI, and in the stockwork zone where it occurs with pyrite and adularia, suggests that this mineral assemblage was in equilibrium with the precious metal-bearing hydrothermal solutions.

Microthermometry of P FI in quartz from the mineralized stockwork zone reveals Th between 260 and 270°C and sal of approximately 1 wt.% NaCl eq. The low sal coupled with the presence of adularia, pyrite, and sericite suggest that the precious metals were transported under reduced conditions in near neutral to slightly alkaline solutions. Under these conditions, Ag and Au are transported as bisulfide complexes and can be precipitated as the result of an increase in the activity of oxygen, and/or a decrease in the activity of sulfur species. These physicochemical changes may result either from boiling of hydrothermal solutions or from mixing of hydrothermal F with cooler, more oxygenated ground water. Detailed FI studies of mineralized samples show no evidence of solution boiling. Consequently, Ag and Au mineralization is thought to have resulted from mixing of up-welling precious metal-rich hydrothermal solutions with cooler, more oxygenated ground water. If, as suggested by other studies, precious metals in the Comstock system were contributed by a magmatic F, both the low sal and the lack of boiling documented in samples from the mine suggest a very high degree of mixing with a nonmagnetic F source. (Authors' abstract)

BRANDON, A.D., CREASER, R.A., SHIREY, S.B., and **CARLSON, R.W.,** 1996, Osmium recycling in subduction zones: Science, v. 272, p. 861-864.

The observations suggest that osmium can be partitioned into oxidized and chlorine-rich slab-derived F of M. These results place new constraints on the behavior of osmium (and possibly other platinum group elements) during subduction of oceanic crust by showing that osmium can be transported into the mantle wedge. (From authors' abstract by E.R.)

BRANNON, J.C., COLE, S.C., PODOSEK, F.A., RAGAN, V.M., COVENEY, R.M., Jr., WALLACE, M.W., and **BRADLEY, A.J.,** 1996, Th-Pb and U-Pb dating of ore-stage calcite and Paleozoic fluid flow: Science, v. 271, p. 491-493.

Thorium-232-lead-208 and uranium-238-lead-206 radiometric ages for ore-stage calcite show that Mississippi Valley-type (MVT) ore deposits can form in distinct tectonic settings. An age of 251 ± 11 million years for the Jumbo Mine in Kansas, United States, is in agreement with other ages for MVT deposits in the midcontinent of North America. The similarity of ages of these deposits supports the concept that they formed in response to F flow during the late Paleozoic Alleghenian-Ouachita orogeny. An age of 351 ± 15 million years for Twelve Mile Bore and Bloodwood-Kapok deposits in Australia indicates that these MVT ores were deposited in a rifting environment. (Authors' abstract)

BREIT, JR., F.J., SILBERMAN, M.L., NOBLE, D.C., HARDYMAN, R.F., SNEE, L.W. and **PERCIVAL, T.J.,** 1995, Structural and temporal relationships and geochemical characteristics of the East Brawley Peak acid-sulfate and adjacent Aurora adularia-sericite systems (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A14. First author at Mackay School of Mines and Santa Fe Pacific Gold Corp.

The East Brawley Peak system is inferred to be centered above a coeval, genetically related hypabyssal intrusive. An unaltered dacite dome on West Brawley Peak dated at 11.2 ± 0.3 Ma (Silberman and McKee, 1973) may represent a younger but related extrusive event. The presence of a subjacent intrusive is supported by FI data. High T (>500°C), S hypersaline (as many as eight dm, including halite, hematite, and anhydrite?) and CO_2-rich FI occur in quartz fragments, apparently from depth, contained in thin chalcedonic quartz veins cutting pervasively silicified andesite in the dilational step-over zone. Trains of various types of I, many V-dominated, are present and hypersaline and V-dominated I are associated. It is inferred that the source of the hot, hypersaline, and CO_2-rich F was a cooling porphyry body, the cupola of which periodically hydrofractured, releasing magmatic F and G. (From authors' abstract by H.E.B.)

BRENAN, J.M., SHAW, H.F., RYERSON, R.J. and **PHINNEY, D.L.,** 1995, Mineral-aqueous fluid partitioning of trace elements at 900°C and 2.0 GPa: constraints on the trace element chemistry of mantle and deep crustal fluids: (citation lost). Authors at Lawrence Livermore Nat'l. Lab., P.O. Box 808, L-202 Livermore, CA 94551.

To constrain the trace element composition of aq F in the deep crust and upper mantle, mineral-aq F partition coefficients ($D^{min/fluid}$) for U, Th, Pb, Nb, Ba and Sr have been measured for clinopyroxene, garnet, amphibole, and olivine in experiments at 2.0 GPa and 900°C. Comparison of mineral/F partition coefficients with mineral/basaltic M values from the literature reveals notable distinctions in partitioning behavior for F vs. M. Mineral-M and mineral-F partitioning for elements such as Ba, Pb, and Sr are similar, but in contrast, U, Th and Nb are more strongly partitioned into silicate M than aq. F. Such differences may provide a means of discerning the products of M vs. F-mediated metasomatism.

Bulk eclogite- and lherzolite-aq F partition coefficients, calculated from mineral/aq F values, are used to illustrate how partitioning data can constrain (1) the trace element composition of what may be a product of dehydration of basaltic oceanic crust and (2) the effect of the subarc mantle on trace element fractionation processes. In addition to constraints on the composition of the F liberated during slab dehydration, our data allow us to estimate the trace element composition of the material returned to the deep mantle during subduction. (From authors' abstract by E.R.)

BRENNAN, S.T., 1996a, Preliminary results documenting conditions of fluid migration in an exhumed petroleum reservoir, the Abra Limestone (Mid Cretaceous), NE Mexico (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 24. Author at Univ. of Kansas, Dept. of Geol., 120 Lindley Hall, Lawrence KS 66045.

An ancient petroleum reservoir is exposed as oil stains in the "El Abra" quarry.

Thin section petrography was used to determine the paragenetic sequence (Fig. 1). Charging the reservoir with hydrocarbons is not the final diagenetic event, it is post-dated by megaquartz and a later equant calcite cement. I occur in the early equant calcite, the fibrous cement and the megaquartz cement.

Three FI types occur in the Abra Limestone. 1) clear, two-phase, L-rich, S, petroleum I, a fairly consistent ~85% L, and Th L at 74°-116°C; in UV epi-fluorescence illumination, these fluoresces blue, or yellow. 2) Clear, two-phase, V-rich, S, non-fluorescent, G-condensate, hydrocarbon I, with Th V 70° to 79°C. 3) Amber to brown/black, single-phase, non-fluorescent, hydrocarbon I both P and S. The P FI define growth bands in the megaquartz cement.

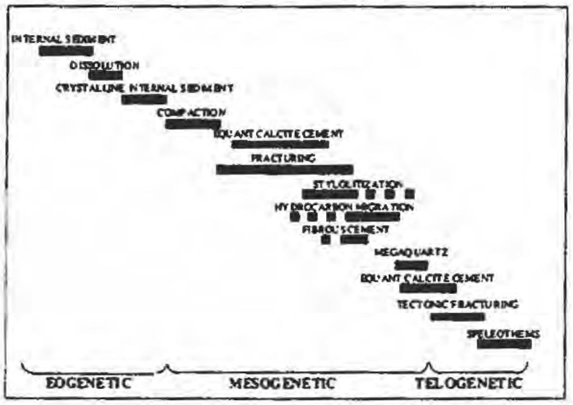


Figure 1. Paragenetic sequence of diagenetic events within the Abra Limestone.

The FI present in these samples indicate a complex F history. Hydrocarbons are only found as S I in the early calcite cement, suggesting that the charging of the reservoir post-dates precipitation of the early equant calcite. The hydrocarbon I in the calcite may record the evolution of the hydrocarbons in the reservoir. The reservoir was most likely charged with volatile-rich petroleum which constitutes the L-rich, fluorescent, two-phase I. As the hydrocarbons in the reservoir evolved, the volatile hydrocarbons may have separated from the heavier hydrocarbons which could have resulted in the G condensate I (light hydrocarbons) and the amber to brown/black inclusions (heavy hydrocarbons). Later, most of the volatiles would have been lost from the reservoir. The final stage of the reservoir was the precipitation of the megaquartz cement, which incorporated the amber to brown/black heavy hydrocarbons as P I.

Microthermometric analyses yield Th values which range from 70 to 116°C. Within individual FI assemblages the range of Th values is within 10°C, arguing against significant thermal reequilibration or other alteration of the FI. The minimum estimate for the maximum T of the reservoir is 116°C.

When combined with compositional data on the hydrocarbons for modeling PVT relationships, this record could provide a new insight into migration and compositional evolution of hydrocarbons in petroleum reservoirs. From author's abstract by E.R.)

See also next item. (E.R.)

BRENNAN, S.T., 1996b, Heterogeneities of a low permeability exhumed petroleum reservoir, El Abra formation, Sierra el Abra, NE Mexico: American Assoc. of Petroleum Geologists Annual Meeting Abstracts, v. 5, p. 18. Author at Univ. of Kansas, Dept. of Geol., Lawrence, KS, US.

See previous item (E.R.)

BRIL, Hubert, PAPAPANAGIOTOU, Photinie, PATRIER, Patricia, LENAIN, J-F and **BEAUFORT, Daniel**, 1996, Fluid-rock interaction in the geothermal field of Chipilapa (El Salvador): contribution of fluid-inclusion data: Eur. J. Mineral., v. 8, p. 515-531. First author at URA 721 du CNRS, Lab. d'Anal. Struct. et Hydroth., 123 Ave. Albert Thomas, 87060 Limoges Cedex, France.

Alteration petrology and FI studies were performed on 8 drill samples from the Chipilapa geothermal field (El Salvador), located in a Quaternary volcanic pile. These studies indicate a vertical zoning of alteration with an (1) early propylitic type (epidote + chlorite + quartz), followed by (2) a clay-carbonate alteration with calcite + mixed layers illite/smectite and chlorite/saponite whose expandibility regularly decreases with depth. Presently (3), crystallization of di- and trioctahedral smectites occurs at the walls of the active faults.

FI were studied by microthermometry in quartz (Q), epidote (E) and calcite (C); three types of I were found: types Q1, E1 or C1 are two-phase L-rich P FI; Q2 and C2 are V FI on S trails; Q3 and C3 are two-phase SI.

F composition did not change significantly since the initiation of the field. Crystallization of host minerals for [based on?] FI occurs from ≈270°C (quartz) to ≈230°C for calcite and does not depend upon the depth; T recorded in P and S FI are higher than the present T measured in drillhole, showing that the field is in a cooling stage. The presence of V-rich S FI is an indication of S boiling. Coupling alteration and FI data allows a reconstruction of the geothermal history of the Chipilapa geothermal field. During the first stage, a conductive thermal gradient developed the zoned propylitic alteration; the second stage was initiated by intense fracturing of the upper part of the system, then by large influxes of meteoric water which caused boiling and promoted calcite and mixed-layer crystallization. Decreasing permeability (third stage) allowed the formation of a new geothermal gradient and conversion of mixed-layers toward illite or chlorite according to depth. Active circulations (present-day stage) are controlled by active faults where smectites nucleate independently of T (Authors' abstract)

BROOK, E.J., SOWERS, Todd and **ORCHARDO, Joe**, 1996, Rapid variations in atmospheric methane concentration during the past 110,000 years: Science, v. 273, p. 1087-1091.

A methane record from the GISP2 ice core reveals that millennial-scale variations in atmospheric methane concentration characterized much of the past 110,000 years. (From authors' abstract by E.R.)

BRUHN, Frank, BRUCKSCHEN, Peter, MEIJER, Jan, STEPHAN, Andreas, RICHTER, D.K. and **VEIZER, Ján**, 1996, Cathodoluminescence investigations and trace-element analysis of quartz by micro-pixe: Implications for diagenetic and provenance studies in sandstone: Canadian Mineralogist, v. 14, p. 1223-1232.

Pertinent to many studies of FI in quartz. (E.R.)

BUICK, I.S. and **CARTWRIGHT, Ian**, 1996, Fluid-rock interaction during low-pressure polymetamorphism of the Reynolds Range Group, central Australia: J. of Petrol., v. 37, no. 5, p. 1097-1124. First author at School of Earth Sci. and Victorian Inst. of Earth and Planetary Sci. (VIEPS), La Trobe Univ., Bundoora, Vic 3083, Australia.

Marbles and metapelites from the Reynolds Range Group (central Australia) were regionally metamorphosed at low P during M_2 at ~1.6 Ga. Mineral assemblages in the marbles define a trend of increasing X_{CO_2} with increasing grade from < 0.05 (greenschist facies) to ~0.7-1.0 (granulite facies). This, together with the lack of regionally systematic resetting of oxygen isotope ratios, implies that there was little F-rock interaction during prograde regional metamorphism. (From authors' abstract by E.R.)

BULAKH, A.G. and **IVANIKOV, V.V.**, 1996, Carbonatites of the Turiy Peninsula, Kola: Role of magnetism and of metasomatism: The Canadian Mineralogist, v. 34, p. 403-409.

The main processes are fractional crystallization accompanied by accumulation and L immiscibility. Early (magmatic) carbonates are easily modified by metasomatic hydrothermal alteration. (From authors' abstract by E.R.)

BULNAEV, K.B., 1996, Origin of the fluorite-bertrandite-phenakite deposits: Geol. Rud. Mesto., v. 38, no. 2, p. 147-156 (in Russian, translated in Geol. Ore Deposits, v. 38, p. 128-136). Author at Russian Acad. Sci., Siberian Div., Buryat Geol. Inst., Ul Sakhyanovoi 6, Ulan Ude 670042, Russia.

The mechanism and conditions of the formation of hydrothermal fluorine-beryllium deposits in regions of tectono-magmatic activization are reviewed. The proposed modeling is based on the assumption that these deposits have a paragenetic association with allochthonous intrusive massifs of alkaline and subalkaline granitoids. It is shown that deeply generated F caused the palingenetic formation of ore-bearing intrusive bodies. The F containing K, H_2O, and CO_2 penetrated from the mantle along zones of deep-seated faults. Beryllium and accompanying rare earth elements were extracted from the crustal substratum during its melting. The process of the accumulation of ore and volatile components in granitoid M is reviewed in the context of known models of the formation of hypabyssal intrusive massifs with elevated contents of volatile elements and of a petrological model of endogenous ore formation. Hydrothermal solutions originated as a result of crystallizing differentiation and liquation of granitoid M and transferred the main ore components (F and Be) as fluorine berylates and hydroxyl-fluorine berylates. In the carbonate medium, the latter were decomposed with the deposition of fluorite and beryllium minerals. The high grade ores were formed at shallow depths (to 1.5 km) at medium and low T (350-140°C). (Author's abstract)

BURLINSON, Kingsley, 1996, Fluid inclusion decrepitation–an overview of exploration applications (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 25. Author at

P.O. Box 37134, Winnellie NT, 0821, Australia; e-mail (kgb@it.ntu.edu.au)

A computer-controlled (decrepitation) instrument is used to collect the data as a histogram of audible inclusion bursts versus T. This method can be applied to opaque minerals and to materials which contain I too small for microthermometric analysis as no optical observation is involved. The method is useful as a qualitative means of discriminating between samples of similar appearance or mineralogy and can assist in identifying different stages of quartz vein formation in a deposit. It also provides information on the CO_2 content of mineral forming F as CO_2-rich FI decrepitate at unusually low T near 200° C. Both of these methods can assist in gold exploration where CO_2-rich F and multiple overlapping quartz vein sets commonly occur. [A series of] examples of exploration studies where decrepitation data can be usefully employed are displayed in this poster.

These examples include the small Cranovitch gold deposit in the Robinson district, Nevada; gold and copper mineralization at Tennant Creek, NT, Australia; gold-magnetite deposit at Upper Beaver, Ont., Canada, Victory mine, Kalgoorlie, WA., Victoria and Pine Creek, NT., Australia. (From author's abstract by E.R.)

BUSSEY, S.D., 1995, Gold mineralization and associated rhyolitic volcanism at the Hog Ranch Mine, northwest Nevada (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A16. Author at Western Mining Corp. (USA), Reno, NV 89502.

FI measurements indicate that gold deposition was associated with upwelling dilute hydrothermal F that were boiling. Gold deposition took place between 100 and 200 m beneath the paleowater table as the F cooled from 210 to 175°C. The asymmetric distribution of alteration zones and hydrothermal breccias suggest that upwelling hydrothermal F were influenced by local hydrologic conditions which imparted a significant east-to-west component of lateral flow through the north Hog Ranch area. The association of gold mineralization and clay-rich acidic alteration assemblages suggests that interaction between an acid-sulfate condensate and upwelling hydothermal F may have been responsible for much of the gold deposition. (From author's abstract by H.E.B.)

BUSSEY, S.D., 1996, Gold mineralization and associated rhyolitic volcanism at the Hog Ranch District, northwest Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 181-207. Author at Western Mining Corp., 4750 Longley Lane, Suite 106, Reno, Nevada 89502 USA.

The Hog Ranch district contains six deposits developed in a hot spring environment in rheomorphic comenditic tuffs.

Alteration associated with the mineralization affected a large area surrounding the deposits. Alteration in the north Hog Ranch area is dominated by clay minerals and exhibits a zoning from kaolinite-bearing assemblages near the present surface (estimated to be <100 m from the paleosurface) to illite-bearing assemblages at depth. Pyrite and stibnite are the most common sulfides in the ore zones. Realgar, stibnite, cinnabar, and native sulfur occur in minor amounts at the periphery of the ore zones. Alteration in the Bell Springs deposit is dominated by silicified tuffs that contain abundant fine-grained adularia and where unoxidized, several percent pyrite.

FI measurements indicate that gold deposition was associated with upwelling dilute hydrothermal F that were boiling. Gold deposition took place between 100 and 200 m beneath the paleowater table as the F cooled from 210 to 175°C. The asymmetric distribution of alteration zones and hydrothermal breccias suggest that the upwelling hydrothermal F were influenced by local hydrologic conditions which imparted a significant east-to-west component of lateral flow through the north Hog Ranch area. The association of gold mineralization and clay-rich acidic alteration assemblages suggests that interaction between an acid-sulfate condensate and upwelling hydrothermal F may have been responsible for much of the gold deposition. (From author's abstract by E.R.)

CAI, Jinhong, ZHOU, Weining and ZHANG, Jinzhang, 1996, Typomorphic characteristics of sphalerites in the Yinshen copper, lead and zinc polymetallic deposit, Jiangxi: J. of Guilin Inst. of Tech., v. 16, no. 4, p 370-375. (in Chinese; Engl. abst.)

The positive ion is the Na+-K+-Ca^{2+}+Mg^{2+} type for the [FI] composition in sphalerite, which indicates that the ore-forming material sources of the deposit are related to the volcanism. (From author's abstract by H.E.B.)

CAIL, Tracy, 1996, Fluid chemistry and hydrological regime of a fossil geothermal system in the Antigonish Highlands, Nova Scotia (abst.): pub. in Atlantic Geol., v. 32, p. 282. Author at Dept. of Geol., St. Francis Xavier Univ., Antigonish, Nova Scotia B2G 1C0, Canada.

A series of hydrothermal veins, which can be traced intermittently over 10 km of coastal exposure in the northern Antigonish Highlands, Nova Scotia, were studied in order to identify the hydrologic controls and physico-chemical conditions of vein formation. The veins of interest consist mainly of calcite and minor amounts of euhedral quartz, sulfides and zeolites. In general, they occur within steeply dipping dextral faults that are parallel to the adjacent northeast trending Hollow fault.

The conditions of vein formation and the composition of the hydrothermal F were constrained using data obtained from hydrothermal minerals, alteration assemblages and FI microthermometry. Microthermometric measurements of FI in minerals from the vein and alteration assemblage were performed with a Linkham THMSG 600 heating and freezing stage. Petrographic and mineralogical analyses were done by transmitted and reflected light microscopy and powder X-ray diffraction techniques. Calcite crystals from open spaces within the veins contain two phase aq FI of P or pseudosecondary origin. Recorded eutectuc T indicate that the FI can be modeled in the system H_2O-$CaCl_2$-NaCl. Freezing point depression yields bulk sal between 25 and 30 wt% NaCl eq. CO_2 clathrate was not observed in the freezing measurements, however crushing techniques revealed small amounts of condensed G, most probably CO_2. Estimated trapping T for the inclusions range between 125 and 165°C. These T are consistent with the presence of analcite in the veins, and with propylitic alteration associated with an earlier vein set.

Analysis suggest that the veins are the product of a geothermal system formed by infiltration, heating and circulation of meteoric waters within an extensive permeable zone produced by the Hollow fault. The system was driven by heat supplied by deep circulation of fluids within the faults or by tectonic uplift of hot basement rocks. Interaction of F with evaporites and possibly connate brines within the early Carboniferous Windsor group sedimentary rock may account for the high sal of the F. The absence of V-rich I suggests that heating of the F, rather than phase separation, was largely responsible for precipitation of calcite. However, local concentrations of quartz and sulphides indicate that boiling occurred sporadically due to fluctuations in P or F sal. A modern analogue of the studied system is the Salton Sea geothermal field, California. (Author's abstract.)

CAINE, J.S., GRAY, G.G. and **POTTORF, R.J.,** 1996, Deformation and fluid flow in a brittle normal fault, Traill Island, East Greenland (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A-255. First author at Dept. of Geol. and Geophysics, Univ. of Utah, WBB 606, Salt Lake City, UT 84112; e-mail (jscaine@mines.utah.edu)

Apatite fission track dating, FI analyses, and burial history modeling indicate that deformation took place when the section was at maximum burial, ~5400 m and ~130°C, between ~41 Ma and ~11 Ma. The timing of faulting was independently determined using Illite Age Analyses of syntectonic fault core clays (~18.6 ± 0.5 Ma). FI, XRD, XRF, and textural data indicate that the fault zone initially acted as a syntectonic conduit for fresh water F flow. Oxygen isotopic data from fault-related quartz veins, carbonate veins, and clays from the fault core, all indicate extremely light, meteoric, syntectonic F interactions. No evidence for L hydrocarbon migration was found in spite of regional evidence for migration during the time when Fault 6 was active. (From authors' abstract by H.E.B.)

CAMERON, G.H., WALSHE, J.L., HEINRICH, C.A. and **WALL, V.J.,** 1996, Gold mineralization at the Porgera gold mine, Papua New Guinea, in response to adiabatic decompression and fluid mixing along the Roamane Fault: Geol. Soc. of Australia Abstracts, v. 41, p. 74. First author at Australian Nat'l. Univ., Canberra, Australia.

Indexed under FI (E.R.)

CAMPBELL, W.R. and **BARTON, P.B., Jr.,** 1996, Occurrence and significance of stalactites within the epithermal deposits at Creede, Colorado: The Canadian Mineralogist, v. 34, p. 905-930. First author at 11 Manzanita, Littleton, CO 80127.

Here we describe stalactites of silica, sphalerite, galena, or pyrite formed in a V-dominated setting, below the paleowater table, and except possibly for pyrite, as part of the hypogene mineralization. In contrast with common carbonate stalactites, the growth mechanism for the sulfide and silica stalactites requires extensive evaporation. Stalactitic forms have also been reported from other deposits, mostly epithermal or Mississippi-Valley-type occurrences, but we caution that stalactite-like features can form by alternative processes. (From authors' abstract by E.R.)

CANALS, A., and **CARDELLACH, E.,** 1996, Fluid characterization in successive faulting episodes in the Catalonian Coastal Ranges and their record in the Ba-F low temperature veins: Geogaceta, v. 20, p 696-699. (in Spanish; Engl. abstract).

In the F-Pb-Zn Berta mine (Catalonian Coastal Ranges), FI, stable and radiogenic isotope data have allowed to recognize two different and temporally separated hydrothermal events. The first is characterized by mixing two F of contrasting sal (from 3% to 20% NaCl eq.) and T (80 to 200°C). The F having the lower sal and higher T has a $\delta^{18}O$ around −1.2‰, suggesting a surficial origin. The second event is dominated by low sal (up to 5% NaCl eq.) and low T (120°C) meteoric waters, chemically similar to the nearby La Garriga-Samalus geothermal waters. Strontium isotopes in fluorites suggest a relationship of the hydrothermal episodes to rifting periods of Triassic-Jurassic and Miocene age respectively. (From author's abstract by E. R.)

CAO, Junchen and **LI, Shiqin,** 1996, Geochemical characteristics of the Sumechaganaobao superlarge hydrothermal sedimentary deposit of fluorite in Inner Monggol [sic], China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 77. First author at Guangzhou Inst. of Geochem., Chinese Acad. of Sci.

The Sumochaganaobao deposit is a volcanic hydrothermal sedimentary-extensively reformed deposit. The formation sequence of these types of ores is lamellar-sucrosic-banded-pegmatitic ores. The lamellar ore remains obvious sedimentary features.

All types of fluorites in the deposit have low contents of REE (less than $50x10^{-6}$). The REE distribution patterns are flat dipping towards to right.

The studies on FI of the fluorites from various ores indicate that the lamellar fluorites have two ranges of Th (300-360°C and 120-266°C). The sucrosic fluorite has a Th of 470°C, banded ones 315-418°C (a few of them 225-280°C) and pegmatitic ones 114-275°C. It can be seen that the deposit was formed at high T and the Th decrease with the reformed extent. The I compositions show that different types of deposits have different G compositions. The hydrothermal sedimentary-extensively reformed deposit has lower CO_2, H_2 and CH_4 in comparison with the volcanic sedimentary-weakly reformed deposit. The calculated pH is 4.67-7.0. The sal of the ore-forming F is 2-3 NaCl wt%. In δD-$\delta^{18}O$ diagram, the fluorite plots are close to the low-right side of the meteoric water line. These facts indicate that the ore-forming F is mainly composed of meteoric water. Based on the G compositions of I, the fO_2 and Eh are calculated and the $\log fO_2$-T and Eh-pH diagram are constructed. The results show that the Sumochaganaobao fluorite deposit was formed under weak oxidation condition. (From authors' abstract, by E.R.)

CAO, Ronglong, 1996, Frontiers of research on the mantle fluid: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 161-171. Author at Guangzhou Inst. of Geochem., Chinese Acad. of Sci., Guangzhou, 510640.

After a general review, the author indicates that new priorities in the study of mantle F should be given to the following problems: the gaseous cracking and diamond origin, non-biogenic mantle hydrocarbons, mantle F and metallogeny, as well as crustal remelting during the influx of mantle volatiles. (From author's abstract by E.R.)

CAO, Zhimin, LUO, Yaonan, WEN, Chunqi, and **LI, Baohua,** 1995, A genetic discussion of the first independent tellurium deposit: Science in China, (Series B), v. 38, no. 11, p 1370-1378.

The first independent Te deposit discovered in China occurs at northern plunging end of Dashuigou thermal dome (diapiric granite) in central part of Daduhe ductile shear zone. The deposit is represented by an assemblage of Te, Bi, Se, Au, Ag, and Cu, in which Te is a main mineralizing element. The orebody occurs as vein form, oblique to Triassic metamorphic rocks. Studies of mineralogy, FI and stable isotope geochemistry suggest that Te has been concentrated during the early period of the mineralization, and mineralization F may be related to hydrothermal solution from granitic magma and meteoric water is consequent upon the F in the late period of Au mineralization. Preliminary study suggests that Dashuigou deposit represents a type of independent mesothermal Te deposit, which is mostly related to granitic hydrothermal origin. (From author's abstract by E. R.)

CARRIÈRE, J.J. and **SANGSTER, D.F.**, 1996, A progress report on Mississippi-type deposits of the Mackenzie Platform: fluid inclusion studies in sphalerite, quartz, and dolomite from the Bear deposit, Northwest Territories: Current Research 1996-E, Geological Survey of Canada, p 87-96.

FI, petrographic, CL, and microprobe studies were conducted on gangue and sulphide minerals. Primary I in dolomite contain a F representative of the original hot, moderately high saline brine (20.7 to 25 eq. wt.% NaCl, 210°C average homogenization temperature (Th)). In sphalerite, F trapped in pseudosecondary I is probably a sample of the mineralizing F (14.2 to 19.4 eq. wt.% NaCl, average Th 188°C), which was diluted and/or reset by later tectonic events. Temperatures of the first recognized L + ice + V in FI range from -35°C to - 52°C, indicating the presence of salt(s) other than NaCl. The presence of CO_2 is conformed in single phase I in quartz and dolomite, and the presence of CH_4 is suggested thru indirect evidence in the single phase I. CL revealed three textural varieties of dolomite. Microprobe analyses identified dolomite and calcite, and characterized the CL zonation in the saddle dolomite. (From author's abstract by E. R.)

CARRINGTON, D.P., and **HARLEY, S.L.**, 1996, Cordierite as a monitor of fluid and melt H_2O contents in the lower crust: An experimental calibration: Geol. v. 24, p. 647-650. First author at Dept. of Geol. and Geophysics, Univ. of Edinburgh, West Mains Rd., Edinburgh EH9 3JW, Scotland.

Cordierite can contain variable amounts of H_2O and CO_2, and the total amount and relative proportions of these volatiles reflect the environment in which the cordierite was formed. In this study, cordierite has been experimentally equilibrated with a peraluminous granite melt, and the H_2O contents of the phases have been determined by S-ion mass spectrometry (SIMS). The results show that cordierite can have a range of H_2O contents at a single P and T, in this case 900°C, 5.0 kbar. The maximum H_2O contents occur at saturation, when H_2O V is also present, at which point cordierite contains 1.69 ± 0.05 wt% and the melt contains 10.0 ± 0.42 wt%. However, as the system becomes progressively more water-undersaturated, the phases contain less H_2O, and the partitioning coefficient ($Dw{=}H_2O^{melt} / H_2O^{cordierite}$, in wt.%) decreases from 5.9 ± 0.3 to 4.4 ± 0.6. The experiments show that the equilibration with a volatile-undersaturated M provides an alternative to leakage as a mechanism for producing volatile-poor cordierites. Application of this experimental calibration to cordierites from granulite migmatites predicts that the M with which they last equilibrated contained only 2.7-3.8 wt% H_2O. (From author's abstract by E.R.)

CASEY, J.F., MAGAKYAN, R., SMITH, S.E., SILANTYEV, S. and **BRYAN, W.B.**, 1996, Variations in the compositions of basalt glasses, glass inclusions, and melts in equilibrium with oceanic gabbro and peridotite clinopyroxenes along the MAR, 0-45N: 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F833, November 12, 1996. First author at e-mail (jfcasey@uh.edu).

The mineral chemistry of clinopyroxene can be used to calculate Mg-number, Na_2O and TiO_2 content of equilibbrium M within oceanic gabbros and peridotites. These can be used to examine the range of M compositions in equilibbrium with the residual and cumulate ultramafic and plutonic assemblages. Large glass MI within primitive olivine phenocrysts and xenocrysts along the Mid-Atlantic Ridge can likewise be used to examine the compositions of pre- and post- hybridization M fractions that mix to form MORB. We examine the nature of calculated M and measured glass I compositions along the Mid-Atlantic Ridge (0-45°N) and compare them to compositions of basalt glasses at the same localities.

MI show a wide range of Na_2O and TiO_2 compositions at a constant and primitive Mg-number when compared to the MORB matrix glass. Variations in the compositions of peridotites, gabbros and glass I help to resolve the nature of the M being liberated from the mantle and entering subaxial magma chambers. They also allow examination the hybridization process that leads to the formation of MORB at each locality. (From authors' abstract by E.R.)

CASSINI, C.T. and **da COSTA, M.L.**, 1994, The amethysts of Pau d'Arco: Mineralogy, chemistry and fluid inclusions: Bol. Mus. Para. Emílio Goeldi, sér. Ciênc. da Terra, v. 6, 1994, p. 3-17 (in Brazilian Portugese; Engl. abst.). First author at Universidade Federal do Pará. Centro de Geociências, Caixa Postal, 1611, CEP 66075-900, Belém-PA.

The Pau D'Arco amethysts occur as rolled crystals, in several sizes (up to 1.2 m in diameter), present well-defined [or worn] faces. I in the form of almost-fibrous fine tube, filled sometimes with reddish-colored opaque material are frequent in these crystals. The rutile needles and color zoning within the amethysts may reduce its utilization in lapidary. On the other hand, its intense violet color makes them very appreciated in the international gem market. (From authors' abstract by E.R.)

CASTOR, S.B. and **HULEN, J.B.**, 1995, Gold and hydrocarbons at the Gold Point Mine, Currant Mining District, Nevada (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A18. First author at Nevada Bureau of Mines and Geol., Reno, NV

Gold-rich electrum is intimately associated with hydrocarbon in quartz veins at the inactive Gold Point mine near the town of Currant in northeastern Nevada. The geologic setting of mineralization at Gold Point is similar to that of Carlin-type gold deposits in the region, but also resembles that of geothermally active oil fields in nearby Railroad Valley.

The electrum-bearing veins at Gold Point occur in crudely stratiform jasperoid masses that mainly occur along the contact between Mississippian Joana Limestone and Mississippian Chainman Shale. The hydrocarbon, which occurs in a specific stage of vein quartz at Gold Point, consists of at least two types: pyrobitumen and "live" oil. The pyrobitumen is locally intergrown with electrum and occurs in cavities that have globular to spherical shapes similar to those in epithermal gold and mercury deposits in California and in veins in reservoir rock in the Grant Canyon/Bacon Flat oil field system in Railroad Valley. The oil occurs as FI along with aq FI in quartz. Organic geochemical analyses of the pyrobitumen and oil from Gold Point indicate that these hydrocarbons were derived from the Chainman Shale. FI and stable-isotopic analyses demonstrate that the vein quartz was precipitated at approximately 175°C from dilute, isotopically light, evolved meteoric waters that were similar to the 120°C waters still circulating in the Grant Canyon/Bacon Flat geothermal system.

Mineralization at Gold Point is unlike that of most hydrocarbon-bearing, Carlin-type gold deposits which show no evidence of a direct hydrocarbon-gold association and typically lack visible gold and significant amounts of vein quartz. Mineralized Gold Point samples have low concentrations of trace elements such as As and Hg that are characteristically enriched in Carlin-type deposits, and have higher Ag/Au than most Carlin-type deposits.

The direct association between gold and hydrocarbons at Gold Point suggests that the organics influenced mineralization. The mineralizing F were reducing, contained hydrocarbons at different levels of maturity, and may have transported gold as bisulfide or organic-metallic complexes. Microscopic textural relationships among quartz, electrum, and pyrobitumen suggest that the latter helped concentrate gold from solution. The hydrocarbon-bearing quartz veins at Gold Point and similar occurrences in the region indicate that hydrothermally generated, transported, and entrapped hydrocarbon may be common in the Great Basin. (Authors' abstract)

CASTOR, S.B. and **HULEN, J.B.,** 1996, Electrum and organic matter at the Gold Point Mine, Currant Mining District, Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geol. and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 547-565. First author at Nevada Bureau of Mines and Geol., Mackay School of Mines, Univ. of Nevada, Reno.

Gold-rich electrum is intimately associated with organic matter in quartz veins at the inactive Gold Point mine. The geologic setting of mineralization at Gold Point is similar to that of some Carlin-type and porphyry-related gold deposits in the region, and also resembles that of geothermally active oil fields in nearby Railroad Valley.

The organic matter, which mostly occurs in a specific stage of vein quartz, consists of at least two types: solid bitumen and "live" oil. The solid bitumen is locally intergrown with electrum and occurs in cavities that have irregular to spherical shapes. The oil occurs as FI along with aq FI in quartz. Organic geochemical analyses of the solid bitumen and oil from Gold Point suggest that these organic compounds were derived from the Chainman Shale. FI and stable-isotopic analyses demonstrate that the vein quartz was precipitated at approximately 175°C from dilute, isotopically light, unevolved meteoric waters that are similar to lower T waters still circulating in the Grant Canyon/Bacon Flat geothermal system.

Although the geologic setting is similar, mineralization at Gold Point is unlike that of Carlin-type and porphyry-related gold deposits in the region. The Carlin deposits show no evidence of a direct organic-gold association and typically lack visible gold and significant amounts of vein quartz. Mineralized Gold Point samples have low concentrations of trace elements that are characteristically enriched in Carlin-type and porphyry-related gold deposits. (From authors' abstract by E.R.)

CATHELINEAU, D.B., BANKS, D., OUGOUGDAL, M.A., BOIRON, M.C. and **POTY, B.,** 1996, Fluid penetration and faulting in Alpine granites (Mont Blanc and Aar Massifs): A multidisciplinary study of fluid inclusions and their chemistry (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 26-28. First author at CREGU, BP 23, 54501-Vandoeuvre-lès-Nancy, France.

The objectives of this work were: i) to examine the spatial distribution of the P-T conditions and F features at the scale of a granite massif (e.g; the Mont-Blanc massif), i) to describe the F migration nearby major channels, and to determine if the microfissural permeability around the cleft networks has played a significant role in the F transfer, iii) to obtain constraints on the source of waters implicated in the strong water-rock interaction processes which affected the granites, iv) to compare the nature of the F and F migration processes with other zones of the alpine chain (reference to the Aar massif) subjected to similar geodynamic events.

Quartz, fluorite, epidote, and calcite crystals from fault infillings and oriented blocks of fresh and altered granites have been systematically sampled in 20 localities.

The methodology used optical and scanning electron microscopy (back scattered electron mode, CL imaging), systematic 3D measurements of microfractures using an Image Analyser, microthermometry, Raman spectroscopy and FT-IR, crush-leach, ion chromatography for halogens and FES, ICP-AES and GF-AA for major and trace elements using the method of Yardley et al. (1993).

Two main stages are identified:

-**quartz-chlorite(adularia-albite) stage**: The P-T conditions derived for Mont Blanc from Na / K geothermometry and isochore reconstruction are estimated to be around 300-400°C, 1.5 to 4 kb. These conditions are significantly lower than in sampled clefts in Aar granodiorite where the P-T path is estimated to be from 3.5 –4 kb ; 420-440°C to 2.5-3 kb : 370-400°C.

- **amethyst/ankerite-phengite stage**: The P-T conditions are estimated to be around 300-350°C, 1.3 to 3 kb , thus similar to the first F stage. P fluctutations result from the probable seismic activity of the faults, where periods of P decrease has alternated with restoration of lithostatic P pressure.

The F chemistry data documents the interactions between the F and the basement rocks, and give further constraints on the model of mass transfer and equilibria between percolating F and the granites. However, the F chemistry at the scale of most alpine granites is rather similar indicating that the processes governing the interaction between the percolating F and the granite have similar causes and produce the same effects at the scale of the alpine belt. However, the significant differences ob-served at the scale of the Mont Blanc massif show that in spite of intense fracturing, mixing between the two end members was heterogeneous and that no homogenization of the F occurred even at the kilometer scale. (From authors' abstract by E.R.)

CESS, G.R. and **KUMAR, Ravindra**, 1996, The role of fluid path-ways and dehydration melting reactions in gneiss-charnockite transformations in the Kerala Khondalite belt of south India (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 555. Authors at Trivandrum, India.

Recent field and petrological studies in south Indian granulite belt have shown the F play a decisive role in the lower crustal processes and granulite growth. The change of F composition from H_2O-rich in amphibolite-facies condition to CO_2-rich in granulite-facies condition has been well documented. F channelled mineral-F reactions [were] determinants in changing the metamorphic aspects of the rock within the lower crustal conditions (~20-30 km corresponding to P of 5-7 kbar and T of 750-850°C). This has emphatically suggested further that F were the powerful transient source of heat and path-ways were the immediate zones of dehydration, partial metling and LILE depletion.

In this paper movements, controls and effects of F related to dehydration of the host rock and the phenomena of dehydration melting noted in KKB are discussed. The study reiterates that various types of gneiss-charnockite transitions in rocks of broadly similar bulk compositions are due to varying types of F path-ways and conduits, and between different bulk compositions due to varying aspect of F-rock interaction. The discreet patches of charnockites developed independent of any visible pathways are argued as cases of dehydration melting pockets. Spatio-temporal relations judged based on field and petrologic data document that granulite formation in south India was largely limited by the F transport mechanism and not to fundamentally different processes. (From authors' abstract by E.R.)

CHANDRA, R., 1996, Sub-crustal liquid immiscibility in Ijolitic Series of Girnar Layerd Complex (GLC), India (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 434. Author at Dept. of Geol., Banaras Hindu Univ., Faculty of Sci., Varanasi 221 005, India.

CHANGKAKOTI, A., GAO, Z., GREEN, N., KWAK, T. A.P., GRAY, John and **KROUSE, H.R.**, 1996, Contrasting origins of Au- and Sb-bearing fluids, Central Victoria, Australia: N. Jb. Miner. Mh. Jg 1996, H6, p. 271-285.

The Bendigo-Ballarat (BB) and Melbourne Trough (MT) metallogenic provinces of Central Victoria, Australia, contain major turbidite-hosted mesothermal gold and epithermal antimony-gold deposits.

FI studies have revealed aq and CO_2-bearing F during Au- and Sb-Au mineralization in both provinces. In the BB province Th and sal of aq and CO_2-bearing FI in Au-bearing quartz range from 140 to 356°C and 3.0 to 10.1 wt% NaCl eq. and 219 to 356°C and 2 to 4 wt% NaCl eq., respectively. Th and sal of aq and CO_2-bearing FI in Sb-bearing quartz range from 160 to 200°C and 2.9 to 5.9 wt% NaCl eq. and 190 to 230°C and 1.9 to 5.5 wt% NaCl, respectively.

In the MT province Th and sal of aq and CO_2-bearing FI in the Sb-bearing quartz range from 145 to 215°C and 2.9 to 5.9 wt% NaCl and 180 to 260°C and 1.9 to 5.5 wt% NaCl eq., respectively. Laser Raman microprobe analyses of FI revealed the presence of CH_4, N_2, and H_2S from a number of deposits.

Measured δD and calculated $\delta^{18}O$ values of the F suggest an evolved meteoric water origin for the Sb-bearing ore-F in both provinces. In contrast, the measured δD and calculated $\delta^{18}O$ values suggest a metamorphic origin for the F responsible for depositing the quartz hosting Au-mineralization in the BB region. The sulfur isotope data suggest variable sources of sulfur for the BB and MT deposits. (From author's abstract by E.R.)

CHARLOU, J. L., 1996, Mineral and gas chemistry of hydrothermal fluids on an ultrafast spreading ridge: East Pacific Rise, 17° to 19° (Nadur cruise, 1993) phase separation processes controlled by volcanic and tectonic activity.

CHARLOU, J.L., DONVAL, J.P., JEAN-BAPTISTE, Phillipe, DAPOIGNY, Arnaud and **RONA, P.A.**, 1996, Gases and helium isotopes in high temperature solutions sampled before and after ODP Leg 158 drilling at TAG hydrothermal field (26°N, MAR): Geophysical Research Lett., v. 23, no. 23, p. 3491-3494. First author at Dépt. Géosci. Marines, IFREMER Centre de Brest, Plouzané, France.

Hydrothermal F were sampled for dissolved G at TAG (26°N–MAR) during two Alvin dive series. $CH_4/^3He$ and ^{13}C values both point to a mainly magmatic (abiogenic) origin of the carbon species in the system. Overall comparison of the 1993 and 1995 data suggests that the hydrothermal circulation is continuing through the basaltic layer carrying helium, CO_2 and CH_4 of magmatic origin, even if some thermogenic CH_4 contribution seems likely in the 1995 samples collected in the new active area. (From authors' abstract by E.R.)

CHARLOU, J.L., FOUQUET, Yves, DONVAL, J.P., AUZENDE, J.M., JEAN-BAPTISTE, Philippe, STIEVENARD, Michel and **MICHEL, Stephane**, 1996, Mineral and gas chemistry of hydrothermal fluids on an ultrafast spreading ridge: East Pacific Rise, 17° to 19° (Nadur cruise, 1993) phase separation processes controlled by volcanic and tectonic activity: J. Geophys. Res., v. 101, no. B7, p. 15,899-15,919. First author at Dépt. Géosci. Marines, IFREMER Centre de Brest, Plouzané, France.

The F exhibit a very wide range of T, chemical, and G compositions. On the 17°25'S and 18°25'S segments, F have quite uniform compositions, low chlorinities, are G-enriched and are low in dissolved metals relative to F from the 18°15'S segment which show high chlorinities, are less G-enriched and show high-metal concentrations. Chloride and metal depletion associated with G enrichment is consistent with phase separation. Whereas CH_4 end members show large variations between sites, the $^{13}CH_4$ data are very similar, with ^{13}C values in a narrow range -22.0 to -23.9‰, versus (PDB) $\delta^{13}CO_2$ measured in F within the 18°15'S and 18°26'S segments are, respectively -7.9 and -5.8‰ versus PDB, similar to ^{13}C of CO_2 trapped in mid oceanic ridge basalts, suggesting a magmatic origin. The variability in F composition is linked to the variability of the accretion process observed on the three segments. The uniform venting of low-chlorinity F in the 17°25'S and 18°26'S segments is connected with volcanic activity which causes boiling with preferential venting of V-enriched F. High-sal F are emitted on the 18°15'S segment where the ridge is tectonics-dominated and subseafloor circulation controlled by faults. Phase-separated effluents induced by volcanic and tectonic activity are delivered to the deep ocean in this area, as previously observed on the Juan de Fuca Ridge or in the North Fiji Basin Ridge. (From authors' abstract by E.R.)

CHAROY, Bernard, DE DONATO, Philippe, BARRES, Odile and **PINTO-COELHO, Cristina**, 1996, Channel occupancy in an alkali-poor beryl from Serra Branca (Goias, Brazil): Spectroscopic characterization. American Mineralogist, v. 81, p 395-403.

Spectroscopic (micro FTIR, Raman, MAS NMR) and mass spectroscopic techniques have been used to examine, on both single-crystal and powder samples, the behavior of H_2O and CO_2 molecules in the structural channels of an alkali-poor, volatile-rich beryl from Brazil. There is, contrary to what is generally claimed in the literature, no relation between the alkali and type II H_2O contents. Mass discrimination of volatiles released by prolysis under vacuum confirms the weak mobility of H_2O and CO_2 molecules in channel sites, although the plugging effect of the alkalis in the channels can be neglected for such an alkali-poor beryl. The volatile vs. alkali content ratio in beryl could possibly be used as an environmental indicator. (From author's abstract by E.R.)

CHAROY, B., and **NORONHA, F.**, 1996, Multistage growth of a rare-element, volatile-rich microgranite at Argemela (Portugal): J. of Petro., v. 37, no. 1, p. 73-94. First author is at ENSG and CRPG-CNRS, BP 20, 54501 Vandoeuvre-Les-Nancy, Cedex, France.

The microgranite shows extreme enrichment in incompatible elements such as F, P, Rb, Cs, Li, Sn and Be, and extreme depletion in Sr, Ba, Zr and Ree. It is highly sodic and strongly peraluminous. The microgranite overall is interpreted as a mixture of two components: a crystal mush injected from below (seen in narrow dykes intersected during drilling, composed of quartz, albite, and phengite) and interpreted as 'feeders', overprinted by a second highly evolved component dominated by Li, F, P (Rb, Cs, Be, Sn, Nb, Ta, etc.) considered as a 'lubricant' medium for ascending mush and occasionally quenched (quartz, albite, skeletal lepidolite and amblygonite). This second component has the mineralogical and chemical characteristics of rare-element pegmatites. All of the petrological characteristics are magmatic. Only a few narrow cross-cutting veinlets with quartz, K-feldspar and F-poor amblygonite are considered as F derived. (From author's abstract by E. R.)

CHAZOT, Gilles, MENZIES, Martin, and **HARTE, Ben,** 1996a, Silicate glasses in spinel lherzolites from Yemen: origin and chemical composition: Chem. Geol, v. 134, p. 159-179. First author at Dept. of Geol., Royal Halloway Univ. of London, Egham, Surrey, TW20 0EX, UK.

Comparison of the glasses in the Yemen lherzolites with published chemical compositions for mantle glasses shows a dichotomy between glasses produced by (a) in-situ melting of amphibole or clinopyroxene (+ phlogopite) either in closed-system or during reaction with a metasomatic F at low F/rock ratios, and (b) glasses resulting from interaction between the peridotite and a metasomatic melt or F at higher F/rock ratios. (From author's abstract by E. R.)

CHAZOT, Gilles, MENZIES, Martin and **HARTE, Ben,** 1996b, Determination of partition coefficients between apatite, clinopyroxene, amphibole, and melt in natural spinel lherzolites from Yemen: Implications for wet melting of the lithospheric mantle. Geochem. et Cosmo. Acta, v. 60, no. 3, p 423-437.

Plio-Quaternary basaltic volcanic fields along the south coast of Yemen contain mantle xenoliths of anhydrous and metasomatized amphibole (± apatite) bearing spinel lherzolites. Partial melting of clinopyroxene and/or amphibole in a closed system produced silicate glass from which a new clinopyroxene, olivine, and spinel have crystallized. Partition coefficients between mineral phases in the matrix and particularly those (apatite, clinopyroxene, amphibole) formed during the metasomatic event, and between glass and the new clinopyroxene crystallized from it have been calculated by analyzing trace element composition with an ion microprobe.

Partition coefficients between apatite and clinopyroxene or amphibole are large (e.g., >1) for the REEs, Ba, Sr, Y, and Hf and confirm that apatite, when present in the mantle, is an important in the repository for these elements. On the other hand, partitioning between amphibole and clinopyroxene is very close to unity for most of the analyzed trace elements, except for Ba, Nb, Zr, and Hf. Trace element ratios such as Zr/Nb, Ba/Zr, or Ba/Nb can thus be used in basaltic rocks to access the presence of amphibole in their mantle sources.

Partition coefficients between clinopyroxene and M are within the range of published values for most of the analyzed elements, with some low values for Zr (e.g., 0.030-0.353) and near unity for the HREE. Using partition coefficients between amphibole and clinopyroxene and $D^{cpx/melt}$ obtained are lower than most of the published values, but are in good agreement with recent values measures in experiments at 1.5 GPa and 1100°C. The partition coefficient for Nb between amphibole and melt is always low (< 0.20), which indicates that residual amphibole during partial melting in hydrated mantle (amphibole-bearing peridotite) cannot account for Nb depletion in arc magmas. (Authors' abstract)

CHEILLETZ, A., and **GIULIANI, G.,** 1996, The genesis of Colombian emeralds: a restatement, Mineral. Deposita v. 31, p 359-364. First author is at ENSG and CRPG-UPR 9046, BP 20, Vandoeuvre les Nancy Cedex, France.

New studies of Colombian emerald deposits favour a hydrothermal-sedimentary genetic model. A comprehensive model is presented which integrates both chemical and structural aspects and invalidates some aspects of the model recently printed by Ottoway et al. (From author's abstract by E. R.)

CHEN, Daiyan, REN, Dayin, and **WANG, Hua,** 1996, The discovery of independent thallium deposit in China and its significance (abst.): 30th Int'l Geol.. Cong., Abstracts, v. 2, p. 719. Authors at Guizhou Inst. of Technol., China.

Thallium deposit at Lanmuchang, Xingren county, Guizhou province, China, contains lorandite and christite associated with cinnabar, realgar, orpiment, pyrite, marcasite, kaolinite and barite etc. Low-grade ore Tl ranging 0.02~0.2%, rich-Tl ore Tl>1%. The alterations of host-rock include silicification, pyritization, kaolinization and baritization et al. Th ranging 91~266°C, and average 159°C. Sal 10.73~11,64 NaCl wt%. The composition of sulphur isotope $\delta S(\Sigma^{34}S)$ 17.77~20.34‰, origin of sulphur is [in] conformation with strata. REE abundance patterns of ore are similar to the ore-bearing strata. (From authors' abstract by E.R.)

CHEN, Dianfen, AI, Yongde, and **LI, Yinqing,** 1996, Characteristics of metallic minerals from the Wunugetushan porphyry copper-molybdenum deposit (abst.): Acta Petrologica et Mineralogica, v. 15, no. 4, p. 346-354. [in Chinese; Engl. abst.] Authors at Inst. of Mineral Deposits, Chinese Acad of Geological Sci, Beijing 100037.

The Wunugetushan deposit is a large porphyry copper-molybdenum deposit with pyrite as the most abundant metallic mineral. The average [FI] decrepitation T of pyrite for three major ore-forming stages (molybdenum, copper, lead-zinc) are 331°C, 228°C, and <200°C, which on the whole represent main ore-forming T of three major mineralization stages. Pyrite is characterized by low Co (64.84×10^{-6}) and Ni (15.6×10^{-6}) but very high As (588.6×10^{-6}), diametrically different from pyrite in porphyry copper-molybdenum deposits of China whereas similar to pyrite of sedimentary or stratabound origin in features of trace elements. This suggests to certain extent that some ore-forming substances of the ore deposit had nothing to do with mantle materials. Molybdenite, the only important molybdenum mineral, is dominantly of 2H type and occurs mainly in the quartz-potash feldspathization zone. Different from most porphyry copper-molybdenum deposits in China, this ore deposit contains very low Re, implying not only high differentiation degree of the rock body but also the derivation of Mo from biotite granite of upper crust remelting origin. Copper minerals are mainly chalcopyrite and subordinately Zn-tennantite and bornite, which mainly occur in the quartz-sericite-hydromus-covitization [sic] zone. The differences in trace elements of chalcopyrite of different generations reflect variation in ore-forming solutions. Galena and sphalerite mainly occur in the quartz-illite-hydromuscovite zone, with sphalerite deficient in iron (X_{FeS} = 4 mol%-8 mol%), and galena containing Ag (0.01%-0.35%). (Authors' abstract)

CHEN, Feng, 1996, Hydrogen–the important source of fluid in earth interior: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 72-79. Author at Inst. of Geochem., Guiyang, 550002.

Recent studies of F in the diamonds, particularly the dis-covery of molecular hydrogen and hydroxy, are presented in the paper. The hydrogen discovered in the mantle demonstrates its existential form in the earth interior. The existence of hydride in earth core and mantle is supported by experiments at high P and low T, geophysical and astrophysical measures. It is proposed that hydrogen is [a] P hot material in mantle plumes. The hydrogen released from hydride at the core-mantle boundary or mantle had been reacting chemically, yielding mantle F to promote earth evolution. The mantle plume is really the hydrogen plume. (Author's abstract)

CHEN, F., DING, Z., WANG, S., WANG, M., WANG, Z., LEI, P., ZHANG, Y., and GUO, Jiugao, 1996, Discovery of sphalerite inclusions in diamond, Chinese Sci Bulletin, v. 41, no. 19, p. 1623-1625. (in Engl.)

Diamond No. S149, bearing sphalerite I, occurred in Shengli No. 1 pipe in Shandong Province. The diamond sample is octohedral with fused prisms and no fissure is observed on its surface. It contains many black and greenish inclusions. Ultraviolet spectrum shows that the diamond is of type II_a with N9 absorptive peaks. After the sample was broken, the sphalerite occurs in the form of thin tabular single crystal, measuring about 40 μm × 60 μm in size, and does not interlink with other minerals. The composition of the sphalerite was determined by KYKY-1000 scanning electron Microscopy and TN-5400 energy dispersive spectrometry (ED). (From author's abstract by H.E.B.)

CHEN, Honghan and LI, Sitian, 1996, New development in active thermal fluids and hydrocarbon accumulation and mineralization: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 259-262. Authors at China Univ. of Geosci., Wuhan, 430074.

This paper mainly reviews the new relation of thermal F to diagenesis and hydrocarbon migration-accumulation in sedimentary basins. Some views about thermal F affecting hydrocarbon and rare G accumulation and basin dynamic evolution studied by the authors in Ying-Qiong basins. South China Sea is also discussed here. (From authors' abstract by E.R.)

CHEN, Honghan, SUN, Yongchuan, LI, Sitian, ZHANG, Qiming, DONG, Weiliang, and ZHANG, Guohua, 1996, Relation of active thermal fluid to dynamic natural gas replenishment in reservoir in Ying-Qiong basins, South China Sea (abst.): 30th Int'l Geol. Cong., Abstracts, v. 1, p. 345. First author at China Univ. of Geosci., Wuhan, 430074.

Yinggehai and Qiongdongnan basins in northwestern shelf of South China Sea have widely distributed over-pressured systems due to the rapid subsidence and high thermal gradient from Pliocene. The thermal F bearing hydrocarbon and CO_2 were oscillatorily expulsed from the superpressured confines to drive a forced convection which controlled the natural G dynamic migration and accumulation in reservoirs.

The coupling field analysis of thermal, pressured and chemical fields indicates that two basic models of gaseous replenishment occur, which are related to the active thermal fluids movements in the basins; supporting data to choose include Th, vitrinite reflectance, and $\delta^{13}C$, of methane isograms. (From authors' abstract, by E.R.)

CHEN, Huashan and BI, Fuke, 1996, The geological feature and ore-genetic model ofYuernie gold ore deposit in Hebei, China (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 772. Authors at Hebei Bureau of Prospecting and Development of Geol. and Minerals, China.

Yuernie gold deposit is a magmo-hydrothermal (ore) occurring in Yanshan stage granite. The vertical zonal distribution of the natural ore type display as gold-bearing pyrite-quartz veiin type in up part of the ore bodies and quartz veinlet-disseminated gold-bearing pyrite-type in the middle and lower parts with the main ore minerals pyrite, sphalerite, chalcopyrite and native gold and alteration of silicification, pyritization and sericitization. Composition of I is mainly K^+, Na^+, Ca^{2+}, Mg^{2+}, F^- and Cl^-; G phase mainly H_2O and CO_2, K^+/Na^+ ratio <1, F^-/Cl^- ratio <1, pH value 6.2-6.8 and rich in Ca^{2+} and Mg^{2+}. The isotopic feature of the ore ["δ^{18}" values for O, C, and S [sic] and for Pb], which show the metallogenic condition of 340°C and 220-260 x 10^{-5} Pa. (From authors' abstract by E.R.)

CHEN, Peirong, CHEN, Xiaomong, NI, Pi, WANG, Rucheng, SHEN, Weizhou and XU, Shijin, 1996, Discovery of chalcopyrite daughter mineral in polyphase fluid inclusions from Yanyaun porphyry copper deposit, Sichuan Province: Chinese Sci. Bulletin [Engl. edition], v. 41, no. 15, p. 1281-1283; (Chinese edition, p. 632-635). Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing 210093, China.

The authors start with a statement: "In the early 1980's, the chalcopyrite dm in the FI was recorded...in the porphyry copper deposits of west America. However, such a study was poorly reported." [referring to Roedder's 1984 book]

The samples for FI analyses were collected from the endocontact part of No. 80 intrusive body. Quartz in veinlet contains many kinds of FI, mainly polyphase FI with dm which may coexist with a few VI. The polyphase FI often contain two types of dm. One is light green halite with a cube shape, the other is an opaque mineral identified as chalcopyrite on the basis of its tetrahedron shape and electron beam response. Chalcopyrite often occurs in the wall of I cavities, or in NaCl crystals. A few of them were enveloped by halite. We have measured the volumes in various phases for tens of polyphase FI, and calculated the volumes percentages of individual phase. They are respectively 11-17% V, 44-51% L, 33-40% halite and about 2% chalcopyrite. The constancy of phase percentages suggests that these are true dm. (From authors' abstract by H.E.B.)

CHEN, Renyi, 1996, Study on fluid inclusions of quartz from Xincheng gold deposit, Shandong province, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 486. Author at Bureau of Geological Survey, Ministry of Geology and Mineral Resources, P.R. China.

The Xincheng superlarge gold deposit was controlled by a regional fracture and the contact of Linglong granite and Guojialing granodiorite. FI in quartz include G-L, L CO_2, and pure CO_2.

Study on the Th show that the primary T of the post-magmatic thermal F is more than 425°C, and the two peak ranges of the total Th, i.e. 320-300°C and 220-200°C, indicate the T ranges of the stage of intense CO_2 action and the principle ore-forming stage, respectively. Sal vs. Th diagram displays that the T dropped as sal increased, which was a result of CO_2 bleeding led by boiling, that is, forming immiscible phases of $NaCl\text{-}H_2O$ and CO_2. Moreover, dilution led to the gradual reduction of both T and sal of the $NaCl\text{-}H_2O$ system which caused precipitation of ore.

Trapped P of FI demonstrates that the L CO_2-bearing I formed under a relative closed system, i.e. early ductile shear structure; but G-L I and pure CO_2 I formed under a open system after decompression boiling, i.e. brittle extensional fracture during the principal ore-forming stage. The internal pressure after boiling mainly represents the static pressure of the thermal F, inferred ore-forming depth is about 1000 m, even several hundred metres, belonging to ultrashallow-seated deposit.

Besides, the P difference between the average P of the L CO_2-bearing I (107 MPa) and the maximum P of G-L I (10.5 MPa) is 96.5 MPa, coinciding with the additional structural hydrostatic P (96.36 MPa) of Jiaojia gold ore field (Li Guxian et al, 1993), which further confirms that the Xincheng gold deposit was controlled by premineralizing ductile shear zone and metallogenic brittle extension fracture. In fact, NW-trend regional ductile shear action was widespread over the northwest of Jiaodong Peninsula. (From author's abstract, by E.R.)

Composite xenoliths in alkali-basaltic lavas on La Gomera (Canary Islands) consist of clinopyroxene-spinel-dunites cut by 3 mm up to 2 cm wide clinopyroxenite veins. The xenoliths are crosscut by a complex system of mainly intracrystalline veinlets, filled by microcrystalline aggregates and glass remnants.

CHEN, Yanjing, 1996a, Fluidization model for intracontinental collision and its metallogenic significance: theoretical inference and evidences from gold deposits, the Eastern Qinling Mountains: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 282-289. Author at Dept. of Geol., Peking Univ., Beijing, 100871.

The oxygen and hydrogen isotopic analyses and the thermometric data for ore-forming F of several representative gold deposits show that the features, source and evolution of the ore-forming F agree extremely [well] with a theoretical model developed by the author for fluidization in intracontinental collision. (From author's abstract by E.R.)

CHEN, Yanjing, 1996b, Skarn gold deposits in China: Resource Geol., v. 46, no. 6, p. 369-376. Author at Dept. of Geol., Peking Univ., Beijing 100872, China.

Loci where F sal ranges from 5 to 25 wt.% eq. NaCl and the T from 200 to 350°C are usually the locations of intense gold mineralization. (From author's text by E.R.)

CHEN, Yaoguang and **YANG, Yunsong,** 1996, The metallogenetic condition of the gold deposits in Limin area, Gansu Province, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 765. Authors at Gansu Geological Exploration Bureau of CNNC, China.

Two large deposits, Liba and Jinshan, and more than ten medium-small gold deposits were discovered in the medium T contact metamorphic zone surrounding the Indosinian-Yanshan granites.

Ore-forming T ranges between 250-170°C. The genetic type of the deposits is classified as the underground thermal water (brine) leaching gold deposit, being similar to the generalized Carlin type deposit in the United States. (From authors' abstract by E.R.)

CHEN, Ziying, XIA, Weihua, and **WILLIAMS-JONES, A.E.,** 1996, The genesis of rare element mineralized granites in southern China: evidence from melt and fluid inclusions (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 13. (Note: this abstract was distributed at the I.G.C. Workshop/Shortcourse, but was not printed in the official 30th I.G.C. Abstracts volumes. E.R.) First author at Dept. Mineral Resources, China Univ. of Geosci.

Rare element mineralized granites of the Yanshan period in southern China are characterized by high contents of SiO_2, Na_2O, K_2O, and F and are enriched in Nb, Ta, REE, W, Sn, Be and Li. Opinions have differed over whether they are of metasomatic or magmatic origin. In this paper, we present results of a study of MI and FI in topaz-albite feldspar granite, from limo [sic] Nb-Ta-W-Sn granite and 414 Ta-Li albite granite. Our data, which come from 15 mineralized granites, provide strong support [for a] magmatic origin.

MI have recognized in topaz and quartz, and are associated with P G-rich I. Crystallites of a Nb(Ta)-bearing mineral and cassiterite are also commonly present as I in the topaz. Multiphase MI and FI have been observed in some quartz from granites and granite-related pegmatite.

MI start to melt at approximately 540°C in topaz and 650°C in quartz. Final Th is 700-900°C in quartz, 700-800°C in topaz and 440-550°C for P G-rich I coexisting with MI in topaz.

The FI data show that there was a continuous evolution of the F from Nb-Ta granites and pegmatites to W-Sn hydrothermal veins. The coexistence of M, V-rich FI, and rare element crystallites in topaz and quartz indicates that these minerals crystallized from a V-saturated M enriched in Na, K, F, and rare elements (Li, Be, Nb, Ta).

Electron microprobe analysis for MI in topaz (using CAMEBOX Electron microprobe in McGill Univ.) indicates that the medium in which topaz crystallized is eq. to albite silicate M. This result is in accord with the fact that albite is the dominant rock-forming mineral, especially in the strong mineralized granite.

The evidence from FI study shows that the possible genesis of the rare element mineralization in Li-F granites of Yanshan period in southern China results from magmatic differentiation. (Authors' abstract.)

CHIPLEY, Don and **KYSER, T.K.,** 1996, Ages, Sr and Pb isotopic compositions of halites from the middle Devonian Prairie Formation evaporites in Saskatchewan) (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual Meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A17. First author at Dept. of Geol., Univ. of Toronto, Toronto, Ontario, M5S 3B1.

The Prairie Formation is a Middle Devonian age evaporite succession composed predominantly of anhydrite, halite, sylvite and carnallite. Halite contains FI with sylvite and carnallite dm. Dissolution T of the dm and solid phas-es precipitated by cooling the I, texture of halite and δD values of I waters distinguish groups of halites that did not likely form at the same time. Ages of these groups of halites, determined by Rb-Sr systematics, are between 371 and <35 Ma. Chevron-texture halite was precipitated as a result of recrystallization at T between 35 and 40°C by water with δD values near –92‰ at 371 and 284 Ma. At 214 Ma when the evaporite was at a T near 45°C, halite was again recrystallized by water with δD values near –83‰ that also precipitated chevron-texture halite. More recent recrystallization events involving water with δD values as low as –120‰ resulted in precipitation predominantly of clear halite at T as high as 75°C. Ages of recrystallization events correspond roughly to those of tectonic events that occurred in the adjacent Cordillera suggesting that tectonic events initiated recrystallization events in the basin.

Initial $^{87}Sr/^{86}Sr$ ratios of halites are between 0.7097 and 0.7200, higher than expected for halite precipitated from Devonian seawater. Therefore, some strontium incorporated into halite during recrystallization was likely resident in phases with higher Rb/Sr ratios, such as sylvite and carnallite, prior to recrystallization. These results suggest that halite recrystallization was accompanied by recrystallization and dissolution of sylvite and carnallite but other sources of Sr cannot be discounted as contributors.

Uranium contents of halites are too low to effect a change in lead isotopic ratios in the time since original deposition of the Prairie Formation so that measured lead isotope ratios are considered initial ratios. Isotopic compositions of lead from most halites are similar to those of shales and dolomites deposited during Cambrian to Devonian time in what is now British Columbia suggesting that lead was incorporated predominantly during original deposition. However, some of the lead has unusually high $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ ratios but not $^{208}Pb/^{204}Pb$ ratios. Lead with similar isotope ratios is found in uranium deposits in northern Saskatchewan. (Authors' abstract)

CHOI, Sang-Hoon, YUN, Seong-Taek, and **SO, Chil-Sup,** 1996, Fluid inclusion and stable isotope studies of gold- and silver- bearing vein deposits, South Korea: Geochemistry of a Te-bearing Au-Ag mineralization of the Imcheon mine: N. Jb. Miner. Abh, v. 171, p. 33-59

FI and stable isotope data indicate a complex history of boiling and later cooling and dilution of ore F. Stage I mineralization occurred from dominantly aq (but containing little CO_2) F with a wide range of temperature (200°-430°C) and sal (0.5-10. wt% NaCl eq.) under a depth of about 1 km below the paleosurface. Early Fe-sulfide was deposited at T of 350°-430° C from boiled [boiling?] magmatic F ($\delta^{34}S_{\Sigma S}$ @ 3‰, $\delta^{18}O_{water}$ = 7.1 to 8.5 ‰, δD_{water} = -70 to -74‰). Middle base-metal sulfides + Au mineralization resulted from lower T F (260° - 350°C, $\delta^{18}O_{water}$= 2.3 to 4.2‰, δD_{water} = -76 to -82‰) through continued boiling and concomitant meteoric water mixing. Gold precipitation was mainly a result of a decrease of activity of reduced sulfur by sulfide precipitation and/or H_2S loss accompanying boiling.

Late telluride mineralization resulted from the continued cooling and concomitant increase in f_{Te2} of ore F, likely due to the meteoric water inundation. (From the author's abstract be E. R.)

CHOMIAK, Beverly and **LINDBLOM, Sten,** 1996, Metamorphic fluid inclusions in quartz from the Zinkgruvan Basin, South-Central Sweden-some new ideas (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 29-30. First author at Dept. of Earth & Environmental Sci., New Mexico Inst. of Mining & Tech., Socorro, NM, USA 87801; e-mail (bchomiak@mailhost.nmt.edu.us)

Many generations of re-equilibrated, dominantly aq, S FI have been preserved in quartz phenocrysts (now porphyroclasts) in the metaporphyry of the Zinkgruvan Basin (Chomiak & Lindblom, 1995). All the phenocrysts were deformed by crystal-plastic processes. The extent and style of recrystallization, however, varies between locations and reflects different peak T attained during amphibolite grade metamorphism. Differences in the microstructural setting of the I allows us to establish relative ages for the different generations and to subdivide the multimodal T_h histogram into [several] meaningful subsets of FI.

Pretectonic (type I) fluid inclusions predate peak metamorphism, and were stretched and necked down during prepeak (T<600°C) deformation. The I do not homogenize below 600°C, and we deduce that they were reequilibrated at T higher than their entrapment.

Synrecrystallization (type III) fluid inclusions Circumstantial evidence suggests to us that at least some of the FI planes originated as microfractures in β-quartz, at near peak metamorphic conditions. Deformation structures (eg. prism lamellae) in the P recrystallized grains support this idea. I morphology suggests re-equilibration with internal overpressures (Sterner & Bodnar, 1989). However, calculated isochores plot on the higher density (lower molar volume) side of peak metamorphic PT conditions constrained by mineral equilibria (Rickard, 1988). This suggests reequilibration with internal underpressures if the FI originated during or after peak metamorphism. This discrepancy will be addressed in future.

Retrograde (type V) fluid inclusions have average T_h lower than those for the last synrecrystallization I, but T_h overlap in part. Morphological features indicative of reequilibration are lacking. (From authors' abstract by E.R.)

CHOU, I-Ming, 1996a, Pressure determinations in hydrothermal diamond-anvil cells (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, August 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 555. Author at 959 Nat'l. Center, U.S. Geol. Survey, Reston, VA 22092, USA.

Any meaningful visual observations, as well as *in-situ* sample characterizations by advanced spectroscopic methods in a hydrothermal diamond-anvil cell (HDAC), require accurate control and measurement of both T and P. This contribution describes methods for controlling and measuring P in the HDAC. The P calibrants [discussed] will be very useful for the acquisition of equations of state of various geologic F. (From author's abstract by E.R.)

CHOU, I-M., 1996b, Precautions on the use of the hydrothermal diamond-anvil cell for the acquisition of volumetric and phase relation data of geologic fluids (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 31-32. Author at 959 Nat'l. Center, U.S. Geol. Survey, Reston, VA 22092; e-mail (imchou@rgborafsa.er.usgs.gov)

As the hydrothermal diamond-anvil cell (HDAC, Bassett et al., 1993) gradually gains popularity in FI related research (Chou et al. 1994), the following precautions and procedures may be helpful for new users:

(1) **the use of pressure calibrants**:

Currently available calibrants include quartz (Shen et al., 1993), $PbTiO_3$ (Chou and Haselton, 1994), $Pb_3(PO_4)_2$ (Chou and Nord, 1994), and $BaTiO_3$ (Chou et al., 1993), and their applicable P-T ranges are shown in Fig. 1. The exact P-T relations for the phase transitions used in these calibrants depend on the purity (and therefore, the source) of the material. It is necessary to calibrate these materials before use, and the use of the equation of state of H_2O

(Haar et al., 1984; Saul and Wagner, 1989) for this purpose is convenient and reliable for pressures up to 10 kbar and T up to 850°C (see Fig. 1). Also, the question of chemical compatibility of the calibrants with the sample system (e.g., solubility and possible chemical reactions) needs to be considered.

(2) **the isochoric assumption**:
When Re is used as a gasket material to house the sample between diamond anvil faces, it is very difficult, if not impossible, to keep the sample chamber at constant volume during the first heating. However, during cooling and the subsequent heating, the volume change can be small. The interferometric method described by Chou et al. (1994) is recommended for monitoring the volume change; a change of about 1% is to be expected.

(3) **the loading of samples of known compositions**:
It is straight forward and routine for loading stable compounds (e.g., H_2O, CO_2, NH_3, etc.) in the HDAC. However, loading F mixtures of known compositions is a challenging task. This is because, in some cases, it is not easy to prepare the mixtures (e.g., H_2O-CO_2, H_2O-CH_4), and in other cases, when such a mixture is available, the composition of the sample may change before sealing (e.g., H_2O-NaCl). Therefore, it is important to develop methods for determining sample composition after sealing. For example, in dealing with samples in the system H_2O-NaCl-CO_2, where a certain amount of $Ag_2C_2O_4$ is sealed together with an NaCl solution in the sample chamber. The NaCl / H_2O ratio can be determined by the freezing point depression before the generation of CO_2, whereas the CO_2 content after the decomposition of $Ag_2C_2O_4$ can be determined by the melting point of either ice or clathrate, if L CO_2 is not present (see Fig. 1 of Barton and Chou, 1993). However, for samples containing L CO_2, a more involved procedure is required (Diamond, personal communication, 1996).

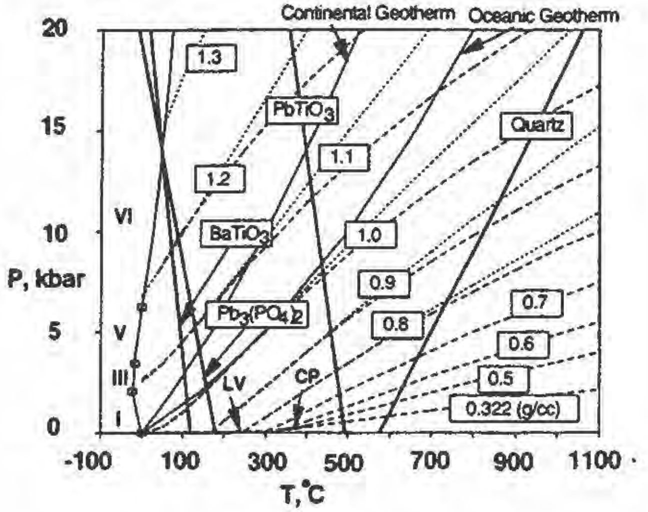


Fig. 1. A P-T plot showing the phase relations in pure H_2O and four pressure calibrants (quartz, $PbTiO_3$, $Pb_3(PO_4)_2$, and $BaTiO_3$). I, III, V, and VI are ice polymorphs, and their melting data are from Wagner et al. (1994); the open rectangles are triple points along the melting curves; LV is the liquid-vapor curve of H_2O; CP is critical point of H_2O; the dashed and dotted curves are isochores of H_2O derived from equations of state formulated by Haar et al. (1984) and Saul and Wagner (1989), respectively.

CHRISTENSEN, J.N. and **HALLIDAY, A.N.**, 1996, Rb–Sr ages and Nd isotopic compositions of melt inclusions from the Bishop Tuff and the generation of silicic magma: Earth and Planet. Sci. Lett., v 144 (1996) p. 547-561. Authors at Dept. of Geological Sci., Univ. of Michigan, 2534 C.C. Little Building, Ann Arbor, MI 48109-1063

Rb–Sr ages of M I in quartz have the potential to provide a unique and illuminating record of the differentiation and accumulation history of silicic magmas. Here we report the first Sr and Nd isotopic measurements of M I bearing quartz (MIBQ), extracted from the Bishop Tuff (BT), representing what is arguably the world's most controversial yet classic zoned silicic magmatic system. We find no evidence for differentiation younger than ~1.0 Ma in any samples from the Bishop Tuff (or Glass Mountain), confirming the view that over the > 300,000 years that elapsed before eruption of the Bishop Tuff, the stratified magmatic system remained largely stable. (From authors' abstract by E.R.)

CHU, Tongqing, ZHU, Haiyan and **LIU, Deliang,** 1996, A study of inclusions from the ductile shear belt type gold deposits in Huangtuling, Henan: J. of Chengdu Inst. of Tech., v. 23, no. 1, p. 57-64. First author at Dept. of Earth Sci., Nanjing Univ.

From the study of the I in the mineral fissures, the paper indicates that the ore-forming F from the ductile shear belt type gold deposits in Huangtuling are low sal (<10%), moderate T (192~274°C), high sulphur, rich in HCO^-_3, Cl^- and base cations. There are three types of FI: CO_2, CO_2-H_2O and H_2O. They coexist in minerals and have different sal and densities. This shows that the phase separation and effervescence occurred when the I were trapped. The isotopic compositions of the water in the I indicate that the hydrothermal solution is mainly metamorphic water, mixing with some rain water and geothermal water. It is considered that the key factors of gold mineralization are phase separation and effervescence. So abundant CO_2 I, and high CO_2 and sulphur can be used as good exploration guides to the gold deposits. (Authors' abstract)

CHUNG, Jae-Il, 1996, Geology and mineralogy of Buckchang mine, Korea (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 760. Author at Dept. of Geol., College of Natural Sci., Chonbuk National Univ., Chonju, Korea.

Paragenetic studies of the Buckchang deposit suggest two stages of hydrothermal mineralization: stage I: base-metal sulfides stage, stage II: late base-metal sulfides, electrum and silver-bearing sulfosalts stages. The T, sal and P estimated from FI and sulfur isotope geothermometry are as follows: stage I: 174~250°C, 0.35~4.01 NaCl eq. wt.%, 0.40~1.00 Kbar, stage II: 138-222°C, 1.9~8.4 NaCl eq. wt.%, 0.22~0.53 kbar. The estimated oxygen and sulfur fugacity during first stage mineralization, based on phase relation of associated minerals, range from $10^{-39.7}$~$10^{-44.7}$ atm. and $10^{-13.4}$~$10^{-18.1}$ atm., respectively. All these evidences suggest that the Buckchang deposits are polymetallic epithermal ore deposits. (From author's abstract by E.R.)

CHUPIN, S.V., CHUPIN, V.P. and **KUZ'MIN, D.V.,** 1996, Melt inclusions in zircon from the Archean pararocks of the South Africa: Geodynamics and Evolution of the Earth, Proceedings of conference of Russian Foundation of Basic Research, Inst. Geol., Geophysics and Mineral., Novosibirsk, (1996) p. 131-134 (In Russian; Engl. abst.). Authors at Inst. of Mineral. and Petrography UIGGM, SB RAS

We studied the M I in detrital zircons from the following Archean pararocks of the South Africa: OGQ quartzites (3.33 Ga) from the Witwatersrand deposit; as well as paragneiss of the Singelele Formation (about 3.0 Ga) and quartzites (about 3.2 Ga) from the Limpopo belt. Zircons from OGQ quartzites crystallized from tonalite-trondhjemite M (content of Cl < 0.10 wt.%) and potassium-sodium rhyodacite-rhyolite M (Cl - 0.43-0.64 wt.%). Zircons from the paragneiss crystallized from potassium-sodium trachydacite and trachyrhyodacite M (content of Cl 0.11-0.49 wt.%). Zircons from quartzites of the Limpopo belt crystallized from trondhjemite and potassium-sodium rhyodacite-rhyolite magmas of the S-type (content of Cl 0.07-0.09 wt.%). These data support the opinion of E.S. Barton et al. [1989] that the rocks of tonalite-trondhjemite composition were one of the sources for the Witwatersrand sediments. (Authors' abstract)

CLINE, J.S., HOFSTRA, A.H., RYE, R.O., and **LANDIS, G.P.,** 1996a, Carlin-type gold deposits–products of magmatism? (abst): AIME 126th Annual Meeting Prog., p. 43. First author at Univ. of Nevada, Las Vegas, NV.

Although gold production from Carlin-type deposits has made Nevada one of the world's leading gold producers, the geologic processes that generated these systems are poorly understood. To address questions concerning the source and evolution of ore F, the chemical and isotopic composition of FI from the Getchell gold deposit have been examined. Microthermometric measurements and quadrupole mass spectrometer G analyses show that ore stage F are H_2O-dominant and contain significant CO_2 and H_2S. High δD_{H_2O} (-50 to -97%) and $\delta^{18}O_{H_2O}$ (+12 to 0%) values of ore stage F provide clear evidence for a deep-sourced ore F at Getchell that is either magmatic or metamorphic, or both. (Authors' abstract.)

CLINE, J.S., HOFSTRA, A.H., RYE, R.O. and **LANDIS, G.P.,** 1996b, Stable isotope and fluid inclusion evidence for a deep sourced ore fluid at the Getchell, Carlin-type, gold deposit, Nevada (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 33-35. First author at Univ. of Nevada, Las Vegas, Dept. of Geosci., 4505 Maryland Parkway, Box 454010, Las Vegas, Nevada, 89154-4010;e-mail (jcline@nevada.edu).

The Getchell deposit is one of several large, low-grade, sediment-hosted gold deposits located in northern Nevada, USA. Although production from these deposits has made Nevada one of the world's leading gold producers, the genetic relationship of mineralization to magmatism and tectonism is poorly understood. Many of these deposits are proximal to intrusive rocks; however, a genetic link connecting mineralization and magmatism has not been established. Previous studies of these systems have shown the water in ore F to be predominantly meteoric in origin. To address questions concerning the source and evolution of ore F in these deposits, the chemical and isotopic composition of FI in pre-ore, ore stage, and post-ore stage minerals were examined using FI microthermometry, quadrupole mass spectrometer (QMS) analyses of I gases, and stable isotope analyses of the water in FI.

FI gas compositions (Table 1) and Th were determined by QMS and microthermometry. Pre-ore quartz contains a variety of F present in one-phase V, two-phase L-rich, and three-phase, halite-bearing I. Trapped F are dominated by H_2O, CO_2, or CH_4, with lesser N_2 and H_2S. Three-phase I contain as much as 33 wt.% eq. NaCl and homogenize at 190-240°C. Ore-stage F trapped by quartz, fluorite, and orpiment are generally H_2O-dominant, moderately saline, and contain significant CO_2 and H_2S. Primary, two-phase I delineating growth zones in fluorite contain ~4 wt.% NaCl eq. and homogenize at 150-160°C. Large, S, three-phase I in fluorite contain abundant CO_2 V, lesser CO_2 L and H_2O, and have low sal. G analyses show that minor N_2, trace hydrocarbons (HC), and trace H_2S are present. Final Th range from ~ 210 to 260°C. I in ore-stage quartz are generally small, two-phase, and L-rich; rare V-rich I are present. Sal of both P and S, L-rich I range from 5.5 to 6.0 wt.% NaCl eq.; Th generally vary from 180 to 220°C. The formation of clathrate indicates that CO_2 is present in some L-rich I. Recognizable CO_2 melting in rare V-rich I shows that CO_2 is the dominant component. G analyses confirm the presence of CO_2 in ore-stage quartz; additionally, non-detectable to minor N_2 and HC, and ubiquitous, trace H_2S are present. Late-ore realgar contains predominantly S, single-phase I. G analyses show I to be H_2O-dominant with minor CO_2, non-detectable to minor HC, and trace H_2S and N_2. I in late-ore calcite generally exhibit inconsistent L/V ratios or appear empty, indicating I necking.

The high δD_{H_2O} and $\delta^{18}O_{H_2O}$ values of main-ore stage F provide clear evidence for a deep-sourced ore F at Getchell that is either metamorphic or magmatic, or both. The wide range of isotope values can be explained by mixing between the deep-sourced F and variably exchanged meteoric water. The deep-sourced F was moderately saline and contained appreciable CO_2 and H_2S. CO_2 concentrations diminish in late-ore and post-ore stage F, paralleling the trend toward lower isotope values.

The results suggest that F mixing and reaction with host rocks were important processes during the evolution of the hydrothermal system at Getchell. Deeply sourced metamorphic or magmatic ore F moved upward through fractures in the Getchell fault zone. Reactions between the acidic CO_2- and H_2S-rich ore F and the host rocks resulted in carbonate dissolution, volume loss, and increased porosity and permeability.

F/rock reaction further caused argillization of silicate minerals and sulfidation of host rock iron, leading to gold deposition. Precipitation of quartz, fluorite, orpiment, realgar, and gold in open spaces likely resulted from cooling and dilution of ore F with indigenous meteoric ground water. (From authors' abstract by E.R.)

COLLINS, C.J. and **HATTORI, Keiko,** 1996, The role of magma mixing in the 1200 ybp eruption of Galeras Volcano, Colombia: evidence from melt inclusion, groundmass glass and mineral geochemistry (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 428. Authors at Ottawa-Carleton Geoscience Centre & Univ. of Ottawa, Ottawa, Ont., Canada KIN 6N5.

Olivine compositions indicate that it crystallized from a melt with a Mg# of ~45 which is consistent with the composition of its M I under relatively high fO_2 ($\Delta FMQ \geq +1$). M I from various phenocryst phases show a fractional crystallization trend from andesite to dacite and rhyolite. Clear to light coloured groundmass glass has a composition near the high silica end of this trend (SiO_2 = 70-78%) while light brown groundmass glass has a less felsic composition (SiO_2 = 60-69%). The groundmass glass compositions define a linear trend, from felsic to a more mafic composition, which is different from the trend defined by M I. The higher CaO, MgO and FeO of the brown groundmass glasses and bulk rock require the addition of a mafic component that was more primitive than the M from which the olivine crystallized. (From authors' abstract by E.R.)

CONRAD, P.G., HEMLEY, R.J., MAO, H.-K., HU, Jingzhu, SHU, Jinfu, FINGER, L.W. and **HARTE, Ben,** 1996, In situ identification of crystalline inclusions in natural diamonds with synchrotron micro-x-ray diffraction (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F774, November 12, 1996. First author at Geophysical Laboratory & Ctr. for High Pressure Research, Washington, D.C. 20015; e-mail (conrad@gl.ciw.edu)

We have developed a micro x-ray diffraction technique to characterize I in diamonds non-destructively using energy dispersive synchrotron x-ray diffraction. Structural information is essential for distinguishing between low and high P polymorphs with the same stoichiometry. An additional advantage of this technique is the possibility of measuring whatever confining P may still be present in the diamonds.

We have used the technique on I in natural diamonds from the São Luiz alluvial deposit of Mato Grosso State, Brazil. Electron microprobe analysis has been conducted by Harte et al., (Min. Mag. 58A, p. 384-385, 1994) on I in other diamonds from this locale and a suite of I has been chemically characterized, including (Mg, Fe)O, almandine-pyrope garnets, $CaSiO_3$ and (Mg, Fe)SiO_3. (From authors' abstract by E.R.)

COOK, David R., KITTO, Paul A., and **LARGE, Ross R.,** 1996, Rension tin mine-hydrothermal system, western Tasmania (abst.): 30th Int'l Geol.. Cong., Abstracts, v. 2, p. 797. Authors at Geol. Dept./CODES, Univ. of Tasmania, Australia.

Deposition of a high T Stage 1 oxide-silicate vein assemblage (qz-asp-cass) was associated with initial faulting. FI Th for this stage from >400°C at the base of the Federal-Bassett Fault to 300°C near the top of the mine workings. These early NaCl-KCl-H_2O brines had average sal between ~8 and 12 eq, wt.% NaCl, and F P of 250 bars (hydrostatic). CH_4 was detected by Raman spectroscopy in the V phase of P FI throughout the Federal-Bassett Fault. Alternatively, CO_2 V was only detected in CH_4-bearing FI (CO_2 /CH_4=0.5) in the upper sections of the Federal-Bassett Fault where dolomite horizons are intersected. $\delta^{18}O_{fluid}$ values of 9% and $\delta^{34}S_{fluid}$ values between 5 and 6% characterize the entire fault for Stage 1 mineralization.

Stage 2 sulfide vein assemblage occurred over a T range from <350°C, immediately above the Pine Hill Granite, to ~200°C at the top of the mine workings. The deep-level NaCl-KCl-H_2O-rich brines evolved to $CaCl_2$-$MgCl_2$-NaCl-H_2O-rich F during F-rock reactions with carbonates in the upper mine level. Sal averaged between 8 and 12 eq. wt.% NaCl throughout the Stage 2 sulphide mineralisation. CH_4 was detected by Raman spectroscopy in the V phase of P Stage 2 FI throughout the Federal-Bassett Fault. Contoured tin values and Th from FI clearly outline two high T tin-rich dilational jogs on the Federal-Bassett Fault, as do variations in $\delta^{34}S_{mineral}$ values, $\delta^{34}S_{fluid}$ values remained constant at ~5% throughout the sulfide stage.

Minor uneconomic Stage 3 base metal veins (rhos - gn - sph - qz), associated with minor fault reactivations, overprint the earlier vein stages, as do Stage 4 vug-fill carbonate-quartz veins (qz - carb ± flu ± py), Stage 3 and 4 veins were associated with low T (150° to 200°C), bimodal sal (<2 and 10 eq.wt% NaCl), NaCl-KCl-H_2O brines. Raman spectroscopy detected CH_4 in the V phase of P FI associated with Stage 3. However, variable CO_2, CH_4 and N_2 was detected in the V phase of S FI from Stage 4. The only FI evidence for phase separation at Renison occurs in the late stage veins, $\delta^{34}S_{fluid}$ values (~5‰) remained constant within the Federal-Bassett Fault during base metal mineralisation.

FI microthermometry, Raman spectroscopy and stable isotope studies indicate that Sn mineralisation at Renison was associated with NaCl-KCl-H_2O-rich (CH_4-bearing) magmatic-hydrothermal F derived from the underlying Pine Hill Granite. Minor uneconomic late stage mineralisation occurred from NaCl-KCl-H_2O-rich brines that formed via mixing of contemporary meteoric groundwaters derived from N-bearing sediments with (CH_4-bearing) magmatic hydrothermal F. (From authors' abstract by E.R.)

COOKE, D.R., BULL, Stuart, ROGERS, J.R. and **DONOVAN, Serena,** 1996, K-metasomatism and Cu-Zn-Pb depletion in the Tawallah Group volcanics, McArthur Basin; implications for base metal mineralization: Geol. Soc. of Australia Abstracts, v. 41, p. 95. First author at Univ. of Tasmania, Codes Key Centre, Hobart, Tasmania, Australia.

Indexed under FI (E.R.)

COOKE, D.R. and **McPHAIL, D.C.,** 1996, Telluride mineralisation in low sulfidation epithermal veins; contributions of magmatic volatiles (abst.): Geol. Soc. of Australia Abstracts, v. 41, p. 96. First author at Univ. of Tasmania, Codes Key Centre, Hobart, Tasmania, Australia.

Indexed under FI (E.R.)

COOKE, D.R. McPHAIL, D.C. and **BLOOM, M.S.,** 1996, Epithermal gold mineralization, Acupan, Baguio District, Philippines: Geology, mineralization, alteration, and the thermochemical environment of ore deposition: Economic Geol., v. 91 (1996) p. 243-272. First author at Centre for Ore Deposit and Exploration Studies, Geol. Dept., Univ. of Tasmania, GPO Box 252C, Hobart, Tasmania 7001, Australia.

A large gold-rich adularia-sericite-style epithermal vein system formed at 0.65 Ma at Acupan, Baguio district, Philippines, during a period of high K magmatism. Low-sal (~0.5 wt % NaCl equiv), gassy (up to 0.41 m CO_2) meteoric F with T of up to 300°C or more were focused into a series of steeply dipping interconnected faults and joints in the Virac granodiorite, Balatoc diatreme, Lucbuban gabbro, and Zig-Zag Formation. Prolonged and varied geothermal activity resulted in the formation of a series of composite banded epithermal veins with an average width of 1 m that extend to depths of at least 1 km (relative to the present-day surface). The epithermal event was characterized by periods of hydrothermal brecciation interspersed with more quiescent periods when delicate to coarsely banded vein material was precipitated. Five distinct mineral assemblages have been defined in the epithermal veins: type A (characterized by fine-grained chalcedony), type B (fine-grained gray quartz), type C (coarse-grained white quartz), type D (coarse-grained calcite), and type E (coarse-grained anhydrite). Electrum and Au-Ag tellurides have been recognized in type B, C, and D bands. Interaction of ascending chloride brines with the wall rocks over the lifetime of the system produced intense, symmetrical, meterwide halos of altered rock characterized by sericitic, silicic, and sericite-chlorite mineral assemblages that grade out to a weak, diffuse widespread propylitically altered zone. Minor adularia alteration is restricted to the deeper mine levels.

Sulfide-oxide-silicate-carbonate phase relationships in the Acupan vein system constrain the mineralizing F to values of log $f(O_2)$ between -28 and -33 log $f(H_2)$ between -1.5 and -3.7, and log $f(H_2S)$ between -0.6 and -1.8 at 300°C. Abundant quartz-K mica-pyrite alteration and vein mineralization are consistent with silica-saturated, reduced, weakly acidic to weakly alkaline F compositions. Boiling caused the F to evolve to more alkaline conditions, leading to the sporadic precipitation of adularia in the veins and altered wall rocks. Dissolved CO_2 concentrations were sufficiently high (up to 0.41 m) to stabilize calcite at the expense of calc-silicate minerals. Mg^{2+} concentrations were low in the mineralizing F but increased during dissolution of P hornblende and biotite in the country rocks, resulting in the development of a sericite-chlorite alteration assemblage in the deep mine levels. H_2S and H_2CO_3 were the predominant sulfur- and carbon-bearing species, and the low-sal, gassy nature of the F favored gold and silver transport as bisulfide complexes. H_2Te and HTe^- were the predominant aq tellurium species. Entrainment of minor amounts of magmatic volatiles during type C and D mineralization is responsible for Te enrichment in the dominantly meteoric F, and $\log f(_{Te_2})$ ranged between -7.8 and -8.6 at 300°C during periods of hessite deposition. Magmatic contributions also account for the CO_2 and H_2S-rich nature of the F and for magmatic helium isotope signatures. (Authors' abstract)

CORADOSSI, N., GARAVELLI, A., SALAMIDA, M. and **VURRO, F,** 1996, Evolution of Br/Cl ratios in fumarolic salammoniac from Vulcano (Aeolian Islands, Italy): Bull. Volcanol, v. 58, (1996) p. 310-316. First author at Dept. of Earth Sci., Univ. of Florence, Via G. La Pira, 4, I-50121, Florence, Italy.

Br/Cl increases, which occurred from 1977 to 1979, in 1983-1984 and in 1992-1993, have been connected to an increased input of magmatic G. (From authors' abstract by E.R.)

COSTAGLIOLA, Pilar, BENVENUTI, Marco, LATTANZI, Pierfranco and **TANELLI, Giuseppe,** 1994, Uplift path of metamorphic terranes in the Apuane Alps: evidence from fluid inclusions in the Pollone deposit: Proceedings of the 76th Summer Meeting of the Societa Geological Italiana, the Northern Apennines, Florence, Sept. 21-23, 1992, Part 2, published in Mem. Soc. Geol. It., v. 48, p. 719-723. First author at Museo di Mineralogia e Litologia, Univ. di Firenze, via G. La Pira 4, I-50121 Firenze.

In the Pollone barite-(pyrite) deposit (St. Anna tectonic window, SE Apuane Alps), a number of barite-bearing veins were presumably emplaced synchronously with the last main deformation event of the Apenninic orogeny (Late Miocene). Taking into account the mechanical properties of barite, the post-metamorphic uplift of rocks in the area should have followed a P-T path not far from the isochores of the FI in barite. Such a P-T path is compatible with independent evidence on the uplift of the Apuane Alps. (Authors' abstract)

COYNER, A.R. and **FAHEY, P.L.,** eds., 1996, Geology and ore deposits of the American Cordillera: Geol. Soc. Nevada Symposium Proceedings, Reno/Sparks, Nevada, April, 1995. Three volumes.

Pertinent items abstracted in this volume (E.R.)

CRAW, D. and **CHAMBERLAIN, C.P.,** 1996, Meteoric incursion and oxygen fronts in the Dalradian metamorphic belt, southwest Scotland: a new hypothesis for regional gold mobility: Mineralium Deposita, v. 31, (1996) p. 365-373. First author at Geol. Dept., Univ. of Otago, P.O. Box 56, Dunedin, New Zealand.

Post-metamorphic quartz veins which occur over hundreds of square kilometres in the biotite zone of the Dalradian metamorphic belt consist of three principal types: anhedral quartz with pyrite, anhedral quartz with hematite, and prismatic quartz with hematite or rutile. Anhedral quartz veins formed from an aq F with up to 5 wt% dissolved salts and 16 wt% CO_2 at about 300°C. Texturally later prismatic quartz crystals formed from a compositionally similar F which was undergoing phase separation at the H_2O-CO_2 solvus at 160-200°C and 500 to 1200 bars F pressure. Oxygen isotope ratios for quartz from the veins range from 12.0 to 15.3‰, with hematite-bearing veins generally isotopically heavier than pyrite-bearing veins. Calculated F oxygen isotope ratios range from +8‰ for pyrite-bearing veins to -2‰ for late prismatic crystals. The mineralizing F contained a substantial component of meteoric water whose isotopic and chemical composition evolved with progressive water-rock interaction. Evolution of meteoric F composition involved migration of oxidation and oxygen isotope fronts in the down-flow direction as head-driven water passed through structurally controlled fractures in the schist pile. A gold solubility trough occurs for the observed F in the oxidation frontal zone. Gold remobilization and reprecipitation occurred progressively as the oxidation front migrated through the schist pile. (From authors' abstract by E.R.)

CRISCI, G.M. and **HERVIG, R.L.,** 1996, Glass inclusions in Aeolian magmatism (southern Italy): implications about the genetic model (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 482. First author at Dip. Scienze della Terra, Univ. Calabria, Rende, Italy.

The Aeolian volcanic archipelago, made of a series of seven islands, is situated on the southern margin of the Tyrrhenian Sea. The abundance of calc-alkalic and shoshonitic volcanism in several of the islands has been explained in terms of a regular subduction zone tectonic invoking partial M as the main evolution process. However recent works have hypothesized the presence of two new factors on isotopic geochemistry and petrographic bases. The new factors are: 1) important involvement of the low continental crust in Aeolian magmatic genesis; b) magma hybridization (by mixing and mingling), which seems the most important genesis process of evolved magmas. These new evidences have allowed to correlate the melting process to the opening of the Tyrrhenian Sea. In fact the Aeolian magma genesis can be related to the quick rising of the isotherms and contemporaneous melting and mixing of two mantle-derived components, on subalkaline and the other alkaline, in addition to crustal M and/or crustally derived components.

A detailed exam of glass I, studied by electron and ion microprobe techniques, has pointed out a wide and systematic compositional heterogeneity of the whole Aeolian magmatic system. In many samples the glass included in minerals appears compositionally different whether among I, belonging to the same mineralogical species, or between included glass and the glass in the groundmass. Once completely different glasses occurred in the same olivine sample. By compositional differences a connection among different glasses, derived from partial M processes, can be excluded. In some samples, studied in detail (in a very detailed way), the glasses composition is so wide as to represent the 80% of the whole Aeolian archipelago magmatic system. Glassy I in same clinopyroxene crystals showed the same composition of the magma belonging to the Roccomonfina high-K series (Roman co-magmatic region). This kind of magma, whose existence has already been hypothesized, had never been discovered. The extreme compositional heterogeneity, ever on a small scale, displayed whether by the study of I or by the study of glasses in the groundmass, causes the following genetic implications:

a) genetic connection between Aeolian magmas and high-K magmas of Central Italy.

b) presence of all magmatic series (both calc-alkaline and potassic) both primitive and evolved, which are peculiar to the Aeolian system, in the same place and time.

c) presence of a very high number of magmatic masses frequently and easily interacting one another at different depth, in the crust-mantle portion below Aeolian Islands. This situation could be designated as "sponge-structure".

These last evidences can be more easily correlated to a genetic model related to a continental magmatism by the opening of the Tyrrhenian Sea than to the classic subductive model. (Authors' abstract.)

CUI, Yanhe, and **QI, Shaomei, 1996,** The genesis of the Detiangou gold deposit, Beijing: Mineral Deposits, v 15, No. 2 (1996) p 156-164 (in Chinese; Engl. abst.) Authors at Inst. of Mineral Deposits, Chinese Acad. of Geol. Sci., Beijing 100037.

The Detiangou ore deposit consists of gold-polymetallic quartz veins in Archean migmatized granulites, etc.; the hydrogen and oxygen isotope data of FI in quartz veins indicate that ore-forming F were mainly composed of magmatic water mixed with some meteoric water. The sulfur isotope composition ($\delta 34 = -0.9‰\sim 2.8‰$) of sulfides from the ore veins is close to that of meteoric sulfur, suggesting that the sulfur came from deep magma. The ore lead isotopes are similar to lead isotopes of syenite dikes, indicating characteristics of mantle-derived materials. Ore-forming substances are also considered to have come from the mantle.

FI in quartz from the ore veins are composed of Na^+, K^+, Mg^{2+}, Cl^-, $SO_4{}^{2-}$, H_2O and CO_2, with an average sal of 5 wt% eq. NaCl.

The altered rock of ore veins has a K-Ar age of 147×10^5 a, suggesting that the Detiangou gold deposit was formed in Middle Yanshanian period. (From authors' abstract by E.R.)

CUNHA de SOUZA, L., VERKAEREN, J., LEGRAND, J.M., and **SONNET, Ph.,** 1996, Metamorphism and fluid involvement in micaschists around that gabbro-granite batholite of Acari, NE Brazil: heat transfer and transformation dynamics (abst.): 16th Earth Sciences Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 98 (in French). First author at UCL - Laboratoire de Géologie et Minéralogie, Place Louis Pasteur 3, B-1348 Louvain-la-Neuve, Belgium.

Micaschists from the Seridó Formation at the top of the Seridó Group have been transgressively deformed and metamorphosed at about 630°C. The behaviour of major and trace elements in the micaschists indicates important volume losses. A continuous series of metamorphic reactions of exchange and net-transfer is suggested. These mineralogical transformations are usually accompanied by quartz veins (µm to cm scale), elongated along the principal schistosity S_2. The FI in these quartz veins are of aq-carbonic nature. Aq I are dominant in the lowest-T metamorphic zones. In the other zones CO_2 is an important component. Eutectic T are -30°C in the biotite-chlorite-muscovite and in the biotite-garnet zones, and -50°C in the cordierite-sillimanite zone. This suggests that the system H_2O-CO_2 also contained NaCl, $MgCl_2$ and $CaCl_2$. I in the cordierite-sillimanite zone may contain halite crystals. (From authors' abstract translated by E.A.J. Burke.)

CUNNINGHAM, Betsy and **WILLIS, William,** 1996, The evolution of Lyon Mt. gneiss, associated quartz-sillimanite nodules, and fluid inclusions at Lyonsdale, NY (abst.): The Geological Society of American, 31st Annual Northeastern Section, 1996 Abstracts with Programs, v. 28, no. 3, p. 46, February 1996. Authors at Dept. of Geol., Colgate Univ., Oak Drive, Hamilton, NY 13346.

The pink leucogranitic Lyon Mountain gneiss at Lyonsdale, NY contains quartz/sillimanite veins and nodules, boudinaged pegmatites, quartz veins and dark early banding, and thus resembles the late- to post-tectonic Lyon Mountain gneiss of the Adirondack Highlands (Foose and McLelland 1995). The quartz/sillimanite nodules and associated magnetite, formed in response to high T hydrogen metasomatism involving acidic hydrothermal F that penetrated fractures at pluton margins (Vernon 1979). Strain near the margins of the partially molten pluton, associated with N50E magmatic flow, resulted in the disruption, folding and reorientation of quartz/sillimanite veins and thereby produced the N50E nodules. Continued strain produced N20E gash fractures in which hydrothermal F deposited a second generation of larger quartz/sillimanite nodules and veins. Fine-grained granite, similar to that in the rest of the outcrop, commonly crosscuts early nodule-bearing facies and is, in turn, crosscut by later quartz sillimanite veins which are, themselves, truncated by very late granite. These observations demonstrate the presence of magma throughout the tectonic process. These late granite pulses are in many cases associated with pegmatites and quartz veins that crosscut all other lithologies. The multiple intrusions have been constrained to between 1031-1025 Ma by single grain U-Pb zircon dating on both matrix granite and crosscutting pegmatite (Orrell and McLelland 1995). The quartz sillimanite veins are commonly zoned with sheaves of sillimanite ± garnet in the center. In many cases, the veins clearly crosscut individual grains of perthite demonstrating that they are not the residue of engulfed xenoliths, etc. At vein margins quartz can be seen to corrode and embay into feldspar, consistent with a hydrothermal origin.

Garnet-biotite geothermometry and FI studies indicate T of equilibration between 650-760°C and P between 4.5 and 5.0 kilobars, consistent with earlier phase equilibria determination of Florence et al. (1995). Aq I contain approximately 20-25 wt.% NaCl eq. Calculated densities of CO_2 I range from 0.80 to 0.96. These densities yield isochores which help to constrain maximum P following granite emplacement. (Authors' abstract)

CUNNINGHAM, C.G., RYE, R.O., BETHKE, P.M., and **LOGAN, M.A.V.,** 1996, Formation of coarse-grained, vein alunite by degassing of an epizonal stock (abst.): in Chapman Conference Abstracts, Crater Lakes, Terrestrial Degassing, and Hyper-Acid Fluids in the Environment, September 4-9, 1996, Crater Lake, Oregon, Johan C. Varekamp and Gary L. Rowe, convenors, p. 27. First author at U.S. Geological Survey, 954 National Center, Reston, VA 22092.

The world's largest, purest, coarse-grained, vein alunite deposits fill near-vertical fissures, up to 20 m wide, on Deer Trail Mountain-Alunite Ridge in the Marysvale volcanic field of west-central Utah. We interpret the alunite veins to have formed by the degassing of an underlying epizonal stock and each layer of alunite crystals to represent a degassing event. The vein alunite contains V-rich FIs that resulted from the entrapment of steam that transported the components of the alunite in the V-dominated geothermal system. Reconnaissance G studies indicate the presence of H_2 in the FI. (From authors' abstract by H.E.B.)

CZAMANSKE, G.K. and **LOFERSKI, P.J.,** Cryptic trace-element alteration of anorthosite, Stillwater

Complex, Montana: The Canadian Mineralogist, v. 34 (1996) p. 559-576. First author at U.S. Geol. Surv., M.S. 984, 345 Middlefield Rd., Melo Park, California 94025.

Evidence of cryptic alteration and correlations among K, Ba, and *LREE* concentrations indicate that a postcumulative low-density aq F phase significantly modified the trace-element contents of samples from Anorthosite zones I and [?] of the Stillwater Complex, Montana. (From authors' abstract by E.R.)

da SILVEIRA BELLO, R.M., FUZIKAWA, Kazuo, GANDINI, A.L., VALARELLI, J.V., and **SVISERO, D.P.,** 1996, FI Microthermometry of imperial topaz from Capão do Lana Deposit, Ouro Preto, Minas Gerais State, Brazil: Anais da Academia Brasileira de Ciências, v. 68, no. 1, (March, 1996) p. 91-102. First author at Dept. de Mineralogia e Petrologia, Inst. de Geociências/USP, C.P. 11348 - 05422-970 São Paulo, SP, Brazil.

The Capão do Lana deposit is one of many imperial topaz occurrences in the Ouro Preto region, Minas Gerais State, all associated with carbonatic metamorphic rocks. Topaz crystals of this deposit always contain abundant FI of saline aquo-carbonic composition. Microthermometric data indicated three groups with the following average CO_2 density and total F density (g/cc): (1) 0.8648, 0.9297-0.9747; (2) 0.8466, 0.9400-0.9866; and (3) 0.7559, 0.9620-1.0288. In the crystals of the same group, the total homogenization occurred either as H_2O or CO_2 phases indicating trapping of two originally immiscible F. The trapping T and P obtained for all groups (275 to 300°C and 1.75 to 3.2 kbar) and the equilibrium reaction curves involving solid I present in the crystals indicate a hydrothermal post-metamorphic origin for the imperial topaz in this deposit. (From authors' abstract by E.R.)

DADZE, T.P., ORLOV, R.Yu., and **SOROKIN, V.I.,** 1996, Solubility and Raman spectroscopy in the S-H_2O system (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 717. First author at Inst. of Experimental Mineral., RAS, Chernogolovka, Moscow district, Russia.

DAI, Chunsen, SONG, Yan, and **DAI, Jinxing,** 1996, Multi-stage degassing of the earth in extensional basins of eastern China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 838. Authors at RIPED, China.

In Cenozoic-Mesozoic extensional basins of eastern China, inorganic CO_2 pools (CO_2 content over 60%) and mantle helium abnormals all distribute along northeastern and north-northeastern trending extensional faults intersected by northwestern trending strike-slip deep faults where synextensional mantle-derived magmatism are developed.

$\delta^{13}C_{CO_2}$ values (-3 ~ -8‰), $^3He/^4He$ ratios (2.54~4.96Ra) and good correlation of CO_2 content with $^3He/^4He(R)$ ratios ($CO_2(\%)=61.3852+7.9745R/Ra$, r=0.9430) of these CO_2 G pools indicate that discharge of mantle-derived G is strong and CO_2 mainly is mantle-derived and magmatic origin. (From authors' abstract, by E.R.)

DALLA-TORRE, M., De CAPITANI, C., FREY, M., UNDERWOOD, M.B., MULLIS, J., and **COX, R.,** Very low-T meamorphism of shales from the Diablo Range, Franciscan Complex, California; new constraints on the exhumation path: Geol. Soc. of America Bull., v 108, no. 5 (1996) p. 578-601. First author at Basel Univ., Mineralogisch-Petrographisches Institut, Basel, Switzerland.

We have determined illite crystallinity, coal rank, percent $2M_1$ white K-mica polytype, and phase assemblages for shales and shale-matrix melange from various areas in the Diablo Range. Additional information concerning metamorphic conditions and F composition was derived from stable isotope work and FI measurements. This study presents new constraints on the P-T evolution of the Franciscan units from the Diablo Range. FI data from post-kinematic quartz veins from the Mount Hamilton area support the idea of a lower P, possibly higher T metamorphic event. P-T conditions of trapping early H_2O - and CH_4 -rich F were 4.5 kbars and nearly equal 230°C. Geothermal gradients for the transition from blueschist to greenschist facies and the formation of early FI are estimated to be nearly equal 14°C/km. Illite crystallinity for all areas indicates diagenetic to high-grade anchizonal conditions; coal ranks are between 1.6% and 2.5% mean Ro. These estimates are not consistent with metamorphic conditions deduced for two different shale assemblages, and imply that coal rank data from high-P terranes must be interpreted with caution if used as an absolute paleothermometer. (From authors' abstract by E.R.)

DAMMAN, A.H., KARS, S.M., TOURET, J.L.R., RIEFFE, E.C., KRAMER, J.A.L.M., VIS, R.D. and **PINTEA, Ioan,** 1996, PIXE and SEM analyses of fluid inclusions in quartz crystals from the K-alteration zone of the Rosia Poieni porphyry-Cu deposit, Apuseni Mountains, Rumania: Eur. J. Mineral., v. 8, p. 1081-1096. First author at Faculty of Earth Sci., Vrije Univ., de Boelelaan 1085, 1081 HV Amsterdam, The Netherlands.

The Rosia Poieni porphyry-Cu deposit is hosted by two Neogene shallow intrusions, an andesite and a slightly younger porphyritic microdiorite. The ore mineralization occurs in a central K-alteration zone, as a dense network of hydrothermal veins containing quartz and a great variety of ore minerals.

Numerous FI occur in quartz from the mineralized area. They belong to two synchronous types: V-rich F (V-type) and high-sal brines (B-type) (relative abundance of both types 100/1000 to 1). The stable coexistence of both types at the scale of the host mineral indicates that they result from unmixing of a homogeneous F phase, issued from the magma during its crystallization (incipient boiling of the magmatic F, observed in remnants of MI). Brine I (B-type) contain a number of solid phases (daughter or captured minerals): halite, sylvite, hydrated (K)-Fe-chloride, K-feldspar, hematite and undetermined ore minerals, anhydrite, rutile, etc. In most cases, V-type I are entirely gaseous, only in few of them a narrow rim of low-sal H_2O is visible under the microscope at room T.

Analysis by PIXE, supplemented by microscopic observation and SEM-EDS analysis on opened cavities, indicates the existence of 4 subtypes: B1, containing all observed elements (mainly Na, K, Cl, Fe, but also a number of other elements such as Cu, Pb, Zn, Rb, Sr) and B2, differing from B1 by the absence of Rb, Sr and, in general, elements heavier than Fe. Coexisting with B1 and B2, 2 subtypes of V-rich I (V-type) can be defined, which contain also metallic elements detectable by PIXE analysis: V1, containing Cu and Fe, and V2, in which other elements (e.g. Zn, Pb, Br, Rb, and Sr) occur. Metallic elements in the V-rich I do not correspond to accidental trapping of solid minerals from B-type I. They witness the possibility of metal transport in the gaseous phase during two successive episodes of incipient boiling. The first one (B1/V1) corresponds to the bulk of the formation of Cu mineralization, while the second one (B2/V2) leads to the transport of other metallic elements, notably Zn and Pb. (Authors' abstract)

DANILENKO, V.V., 1996, Physicochemical conditions of formation of zircon and fluorite in the Yastrebets Massif (according to impurities): Mineral. Zhurn., v. 16, no. 5-6, p. 53-58 (in Russian; Engl. abst).

FI in accessory zircon and fluorite from alkaline syenites of the Yastrebets massif (the Ukrainian Shield) are studied. A conclusion is made that zircon was apparently formed and transformed under hydrothermal conditions at the T of 300-460°C and above with participation of sodium chloride aq solutions. Fluorite crystallization starts at T not below 240°C. The fluorite formation medium was heterogenous and consisted of saturated aq NaCl solution, V, and halite crystals. Boiling of the hydrothermal solution was probably the main reason of fluorite formation in the Yastrebets massif. (From author's abstract by E.R.)

DANNENMANN, Stefanie, HANSON, Ben and **DELANO, J.W.**, 1996, Composition of magmas erupted explosively during the Taconic orogeny: Analysis of glasses preserved in quartz and apatite phenocrysts from bentonites (abst.): The Geological Society of American, 31st Annual Northeastern Section, 1996 Abstracts with Programs, v. 28, no. 3, p. 47, February 1996. Authors at Dept. of Geological Sci., Univ. at Albany, SUNY, Albany, NY 12222.

Pristine glass I in quartz and apatite phenocrysts occur in at least 40% of the bentonites from the sedimentary rocks of the Taconic Foreland Basin in New York State. While most bentonites within the Middle Ordovician section of the Mohawk Valley contain rhyolitic MI with 5-6 wt.% K_2O (high-K rhyolites), several bentonites contain rhyolitic MI with only 2-3 wt.% K_2O (low-K rhyolites). These low-K I also contain higher abundances of MgO, CaO, MnO, TiO_2, FeO and lower SiO_2 relative to the High-K I suggesting that these M are more primitive in nature. The bentonites that contain low-K rhyolitic MI are restricted to a 20 m thick stratigraphic interval in the upper *C americanus* graptolite zone of the Utica Formation (Mitchell et al, 1994). The dichotomy of low-K versus high-K magmas suggests the possibility of two different sources or source regions. perhaps the high-K rhyolites were erupted from portions of the Taconic arc built on continental crust (e.g., Samson et al, 1994), whereas the low-K rhyolites were erupted from subduction zone volcanoes built on oceanic crust.

Additional constraints on magmatic processes have been obtained by comparing the minor- and trace-element compositions of MI in both quartz and apatite phenocrysts from individual bentonites. Although MI in apatites compositionally overlap with MI in quartz phenocrysts from the same bentonite, MI in apatites often define a larger compositional range. Whereas the glasses in quartz are invariably high-silica rhyolite, the glasses in apatites range from rhyodacite to high-silica rhyolite. The compositional variation among I from individual bentonites may reflect either (a) M entrapped at different times during the evolution of a magma chamber or (b) M entrapped in different regions of a chemically zoned magma chamber. (Authors' abstract)

DANYUSHEVSKY, L.V., SOBOLEV, A.V., and **DMITRIEV, L.V.**, 1996, Estimation of the pressure of crystallization and H2O content of MORB and BABB glasses: calibration of an empirical technique: Mineral. and Petrol., v. 57 (1996) p. 185-204. First author at Dept. of Geol., Univ. of Tasmania, Hobart, Tasmania, Australia.

We present an empirical technique for estimating crystallization pressure and H_2O content of MORB and BABB glasses using glass major element compositions alone. This technique is based on models describing 1 atm mineral–basaltic M equilibria for olivine *(ol)*, plagioclase *(pl)*, and clinopyroxene *(cp)* which allow calculation of liquidus T for each mineral on the basis of M composition alone. A necessary requirement for using the proposed technique is cosaturation of glasses with *ol* and *pl* for estimation of H_2O contents, and with *ol* and *cp* for estimation of crystallization pressures. Mineralogical criteria can be used to assess cosaturation.

As the results of this technique are entirely dependent on the quality of glass major element analyses, we emphasize that application of this method to a single glass analysis can lead to erroneous results. (From authors' abstract by E.R.)

DARLING, R.S. and **IRELAND, J.S.**, 1996, Synthetic FI in quartz, (abstract): 22nd Rochester Mineral. Symposium: Rocks and Minerals, v. 71, no. 3 (1996) p. 193. First author at Geol. Dept., SUNY Cortland, Cortland, NY 13045.

A review of the method (E.R.)

DAVIDSON, G.J., 1989, Starra and Trough Tank: Iron-formation-hosted gold-copper deposits of Northwest Queensland, Australia: Doctor of Philosophy thesis, Univ. of Tasmania, xxx pp.

Starra and Trough Tank [now called "Osborne"] are stratabound Cu-Au deposits hosted by stratiform magnetite - hematite iron formation in the Mount Isa Eastern Succession, Australia. Starra, on the margin of a major greenschist facies shear zone, had ore metamorphism estimated at 500 - 550°C, 3.5 - 4.5 kbar. Both structural / metamorphic and syngenetic ore genesis models have been proposed for the ores. Trough Tank was metamorphosed to upper Amphibolite grade (680 - 720°C, ~ 4 kbar). Starra mineralisation consists of massive to banded quartz - magnetite - chalcopyrite - gold ironstone, grading laterally to magnetite - quartz - hematite - chalcopyrite- pyrite, and then to poorly mineralised hematite - pyrite ± magnetite ironstone over ~ 250 m. Trough Tank alteration is more focused around flattened, funnel-shaped, quartz-rich "pipes", characterised by Au - Cu enrichment and a ~ 66% volume increase compared to the least-altered eq. Carbonate-hosted FI homogenised between means of 114 and 200°C for individual samples, with sal of 4.0 to 23.1 wt.% eq. NaCl (Te = -8 to -40, Tm_{ice} = -15°C). Ironstone carbonate varied between $\delta^{13}C$ = -15.5 – -3.8‰, requiring a source component of oxidised organic carbon. Sediment matrix $\delta^{13}C$ varied between -5.3 and +0.0‰, overlapping with the vein range of -5.1 to 1.4‰. F-rock reactions are interpreted to have altered the sediment matrix $\delta^{13}C$ value towards the vein - F composition (reflecting mixing between deep metamorphic and shallow meteoric waters within the Starra Shear). In contrast, $\delta^{13}C$ in ironstone carbonates at Starra and Trough Tank do not converge with the vein - F compositions. Instead they form an older unusual trend of increasing $\delta^{18}O$ with decreasing $\delta^{13}C$, which suggests a $\delta^{18}O$ - enriched connate water contribution to the ore F. The $\delta^{34}S$ range of Starra and Trough Tank sulphides are very similar to one another, averaging ~ 0‰, ranging from -6 to +5‰. The most likely sulphur source is either H_2S formation by inorganic reduction of Mid-Proterozoic seawater (~ 20‰) at > 200°C, or leaching/expulsion from magmatic rocks. They preclude an origin from $\delta^{34}S$ - rich waters equilibbrated with marine sulphate evaporites. The many similarities between Starra and Trough Tank permit the formulation of a single genetic model. The features of the orebodies suggest syngenetic processes emplaced much of the mineralisation, whereas deformation produced minor remobilisation of sulphide.

In the syngenetic model, the critical features are the ascent of hot, oxidised, low aH_2S F to the seafloor, where ore deposition occurs mainly by cooling in a low aH_2S water column. Peak ore-formation conditions at Starra were: T, 260-380°C, log fO_2 = -27.5 – -30, pH = 3.9 - 6, $\Sigma S \sim 10^{-3}$ M, and sal ≥3 M NaCl. These conditions favour transport of Cu and Au as chloride complexes. The mineralogical effects of F-boiling are not apparent at Starra, but can readily explain the subsurface silica and gold enrichment of Trough Tank, which implies the latter was the shallower deposit. Small P I in the mineralised sub-surface breccias of Area 222 are the best evidence of P high sal F. Variation within this genetic model can explain the features of similar ores around the world, which are here termed the time-transgressive "Volcanogenic Copper-bearing Oxide" sub-class (VCO) of exhalative ores. This ore-type is favoured in (but not confined to) shallow continental rift-settings, because these can contain the requisite oxidised sediments or evolved oxidised magmas, which are capable of producing oxidised hydrothermal F. Cooling of a VCO F during its entry into a more H_2S - rich aq environment could produce Pb - Zn-rich BIFs, such as the Pegmont deposit of the Kuridala Formation, Mount Isa. (From author's abstract by E.R.)

DAVISSON, M.L. and **CRISS, R.E.,** 1996, Na-Ca-Cl relations in basinal F: Geoch. Cosm. Acta, v. 60 (1996) p. 2743-xxxx. First author at Isotope Sci. Div., Lawrence Livermore Natl. Lab., P.O. Box 808 L-231, Livermore, California 94550.

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 millieq. of Na and Ca cations. The transformation entails a simple millieq. comparison between the excess Ca and the Na deficit relative to seawater reference ratios.

Because the hydrosphere is dominated by seawater and the upper crust by feldspar minerals, this correlation arguably represents the overall product of cation exchange of high sal F in deep continental environments. (From authors' abstract by E.R.)

DeGROOT, P.A., ARVANITIDIS, N.D. and **BAKER, J.H.,** 1996, Regional carbon, oxygen and sulphur isotopic values in the Serbo-Macedonian and Rhodope massifs: Oryktos Ploutos = Mineral Wealth, v.98 (1996) p. 17-24 (in Engl.). First author at Univ. Utrecht, Inst. Earth Sci., Utrecht.

Indexed under FI (E.R.)

Del PAOLO, D.J. and **GETTY, S.R.,** 1996, Models of isotopic exchange in reactive F-rock systems: Implications for geochronology in metamorphic rocks: Geoch. Cosm. Acta, v. 60, no. 20 (1996) p. 3933-3947. First author at Berkeley Ctr. for Isotope Geoch., Dept. of Geol. and Geophy., Univ. of California, Berkeley, California 94720.

DELITSYN, L.M., 1995, Partition of strontium and the REE between phosphate and silicate liquid phases during liquation of an urtite magma: Dokl. Rossi. Akad. Nauk, 1995, v. 341, no. 4, p. 527-531 (in Russian, translated in Trans. (Doklady) Russian Acad. Sci., Earth Sci. Sect., v. 344, p. 218-224, 1996)

See FIR v. 28, p. 33. (E.R.)

DELLA-PASQUA, F.N., KAMENETSKY, V.S., GASPARON, M., CRAWFORD, A.J. and **VARNE, R.,** 1995, Al-spinels in primitive arc volcanics: Mineral. and Petrol., v. 53, p. 1-26. First author at Dept. of Geol., Univ. of Tasmania, Hobart, Tasmania, Australia.

In the rocks studied, Al-rich spinels also coexist with trapped silicate glasses and highly aluminous clinopyroxene in MI in olivine. This paragenesis suggests an origin involving contamination by localised Al-rich M pockets as opposed to a xenocrystic origin. Two mechanisms to produce this high-Al M in basaltic magma chambers are suggested: (1) localized high-Al M production by complete breakdown of assimilated lower crustal gabbroic rocks, and (2) incongruent breakdown of amphibole in amphibole-rich cumulates in sub-arc, or sub-OIB volcano magma chambers. (From authors' abstract by E.R.)

DEMARS, Christelle, PAGEL, Maurice, DELOULE, Etienne and **BLANC, Philippe,** 1996, Cathodoluminescence of quartz from sandstones: Interpretation of the UV range by determination of trace element distributions and fluid inclusion P-T-X properties in authigenic quartz: American Mineralogist, v. 81, p. 891-901. First author at CREGU & G.R. CNRS-CREGU, BP 23, 54501 Vandoeuvre-les-Nancy, Cedex, France.

Quartz overgrowths from Keuper sandstones of the Paris basin were examined using CL microscopy and spectroscopy coupled with a scanning electron microscope (SEM). With the use of standard cold CL equipment, it was observed that the emission of authigenic quartz is much less intense than that of detrital quartz grains, but a reversal of intensity was observed with scanned CL in the 200-800 nm range. The main CL emission band of diagenetic quartz is 330-340 nm in the UV range, with other bands in the visible range. The determination of trace element distributions in authigenic quartz by in situ analyses and by SIMS imagery reveals the correlation of the 330-340 nm emission band with the highest Al and Li contents. The Cl emission of diagenetic quartz in the UV range appears to be influenced by the coupled substitution of Al and Li into the crystal. Two explanations are suggested: (1) Al, Li, or both, serve as activators, and (2) the incorporation of Al and Li causes lattice defects that lead to an enhancement of the intrinsic luminescence. Trace element analyses and F-I studies revealed that quartz overgrowths precipitated from a F that partially originated from an Li-enriched P brine derived from eastern Triassic evaporites of the Paris basin. The specific Cl emission band in the UV range can be linked to the diagenetic environment. The chemistry of the F appears to be the essential parameter, whereas precipitation T do not influence the occurrence of such emissions. (Authors' abstract)

DEMÉNY, A. and **HARANGI, S.,** 1996, Stable isotope studies and processes of carbonate formation in Hungarian alkali basalts and lamprophyres: evolution of magmatic fluids and magma–sediment interactions: Lithos, v. 37 (1996) p. 335-349. First author at Laboratory for Geochemical Research., Hungarian Acad. of Sci., Budapest, Budaörsi út 45, H-1112, Hungary.

Processes of carbonate formation have been related to C and O isotopic compositions in the Mesozoic alkali basalt (Mecsek Mts.) and lamprophyre (Transdanubian Range) suites of Hungary. In the studied magmatic rocks, carbonates are present as ocelli, amygdales, xenoliths, veins and groundmass carbonate. C and O isotope studies of these types of carbonate have yielded information on the origin of the carbonates and indicated the following processes of formation that determined the $\delta^{13}C$ and $\delta^{18}O$ values of the carbonates: (1) *Crystallization of magmatic carbonate.* Textural characteristics and $\delta^{13}C$ values suggest formation of magmatic carbonate in alkali basalt and lamprophyre dikes, whereas the $\delta^{18}O$ compositions of these carbonates indicate low T oxygen isotope exchange with magmatic F. (2) *Assimilation of sedimentary carbonate by silicate magmas.* Even completely recrystallized amygdales and ocelli of basalts and lamprophyres have preserved their sedimentary $\delta^{13}C$ values. In contrast, variation in the extent of mobilization and isotope exchange with magmatic F are reflected in differences in the ranges of the $\delta^{18}O$ values of amygdales, ocelli and veins, and can be attributed to different amounts of F involved in the magmatic events. (3) *Low T alteration of magmatic rocks* caused only ^{18}O-enrichment in the carbonate amygdales of basalts and the groundmass carbonates of lamprophyres, indicating that no externally-derived CO_2 was present in the alteration F. (4) *Degassing of magma and magmatic F.* Correlations between $\delta^{13}C$ and $\delta^{18}O$ data, magma crystallization depths and amygdale sizes in the alkali basalts suggest that CO_2 degassing has been responsible for the negative $\delta^{13}C$ and positive $\delta^{18}O$ shifts observed. A similar trend was found in the lamprophyres, but the extent of the $\delta^{18}O$ shift indicates that in these rocks H_2O degassing also played an important role. (Authors' abstract)

DENWER, K.P., 1993, Geology and mineralisation of the Kerimenge-Lemenge prospect, Wau district, Papua New Guinea: Master of Economic Geology thesis, Univ. of Tasmania, 42 pp and appendices.

Mineralisation at the Kerimeng and Lemenge deposits, Wau, Papua New Guinea, is an example of a fault controlled, porphyry-related, gold - carbonate - base metal epithermal system. Repeated intrusion of Edie Porphyry (2.4 to 3.8 Ma) was accompanied by a local permeability-generating phreatomagmatic eruption to form a diatreme. Deposition of quartz-manganocarbonate-sulfide-telluride gold mineralisation was controlled by the Kerimenge Fault within the Kerimenge Sill Porphyry.

The gold mineralisation was deposited in two events. In the first event, gold was deposited in four [five] stages from convecting meteoric water. The four stages are: Stage I quartz - pyrite - minor gold; Stage II quartz - pyrite - gold, Stage III carbonate - quartz - arsenopyrite - gold and Stage IV (mangano) carbonate - minor gold. The mineral paragenetic sequence reflects cooling of the system with Stage I and II veins deposited from a boiling CO_2 - rich F with concomitant partitioning of volatiles including CO_2 and H_2S into the V phase. Condensation of the V phase higher and laterally within the system resulted in deposition of Stage IV veins. Stage III veins are regarded as transitional between Stages I, II and Stage IV. Quartz - sericite / (illite) - pyrite - rutile ± carbonate phyllic alteration within the Kerimenge Sill Porphyry forms a selvage to Stage I, II and III veins. Stage V consists of Au and Au tellurides. Gold occurs primarily within the lattice of Stage II pyrite and Stage III arsenopyrite, and is not amenable to conventional cyanide extraction, resulting in an uneconomic resource of 55 Mt @ 1 g/t Au.

The telluride mineralisation of Stage V was deposited from a relatively hot (T range of 190-258°C, average 220°C), low sal (1.0 - 2.7 wt.% NaCl eq.), F with log fS_2 = -11.39 and log fTe_2 increasing during telluride deposition from -13.5 to -12. The majority of the hessite and electrum deposition occurs when F conditions changed from deposition of silica to carbonate in response to one, or a combination of the following, a pulse of (magmatic?) F enriched in Te (i.e. increased fTe_2), Au, Ag, Cu and Sb, rapid cooling (by mixing with manganocarbonate depositing Stage IV F), or a pH increase. (From author's abstract by E.R.)

DESTRIGNEVILLE, C.M., BRODHOLT, J.P., and **WOOD, B.J.,** 1996, Monte Carlo simulation of H_2O–CO_2 mixtures to 1073.15 K and 30 kbar: Chemical Geol., v. 133 (1996) p. 53-65. First author at Institut de GÇologie, 1 rue Blessig, F-67084 Strasbourg Cedex, France.

The thermodynamic and structural properties of H_2O–CO_2 mixtures along two supercritical isotherms at 773.15 and 1073.15 K in the pressure range from 0.2 to 30 kbar have been investigated by the NVT and NPT Monte Carlo method using the TIP4P and MSM3 effective intermolecular potentials for H_2O and CO_2, respectively. (From authors' abstract by E.R.)

DIAMOND, L.W., 1996a, Isochoric paths in immiscible fluids and the interpretation of multicomponent fluid inclusions: Geoch. Cosmo. Acta, v. 60, no. 20, p. 3825-3834. Author at Mineralogisch-Petrographisches Inst., Univ. of Bern, CH-3012 Bern, Switzerland.

FI in minerals often follow isochoric-isoplethic paths through P-T space, both in nature and during microthermometry. The systematics which arise from this behaviour are the basis for interpreting FI analyses. Previous studies have claimed that isochoric-isoplethic paths may transect a given phase boundary only once, and natural FI have been interpreted accordingly. Herein it is demonstrated on theoretical and experimental grounds that such claims are false. Multicomponent FI may indeed show the disappearance then reappearance of L or V phases during microthermometeric heating, without violating the isochoric-isoplethic constraints. This result reinstates some formerly discredited observations of natural FI; it requires modification of the way in which FI are studied by microthermometry; and it opens new possibilities to understand the occurrence and geochemical effects of immiscibility at high T and P in the lithosphere.

The following sequences of phase transitions are deduced to be feasible upon heating multicomponent FI: (1) liq→ liq_1→ liq_2→ liq; (2) liq+vap (or liq_2)→ liq→ liq+vap (or liq_2); (3) liq+vap→ liq_1+liq_2+vap→ liq+vap; (4) liq+vap→ liq_1+liq_2+vap→ liq_1+liq_2; (5) sol+liq+vap→ sol+liq→ sol+liq+vap; (6) liq_1+liq_2→ liq→ liq_1+liq_2→ liq. Only some of these sequences have been reported so far from natural I. Presumably, the remaining sequences have not been found because, following conventional wisdom, systematic observations have never been made at T above the first Th transition. Investigators are therefore urged to conduct such measurements in the light of this new result and to make use of new technology to inhibit decrepitation.

FI which display the above sequences cannot be interpreted in the same way as I with only one intersection of an immiscibility boundary. If the assemblage of I shows petrographic evidence for homogeneous trapping, there is no way to deduce from the I measurements alone, on which segment of the isochore the I was trapped. Conversely, if petrography indicates heterogeneous trapping, microthermometry does not yield a unique formation T. Rather, there may be up to three possible P-T points of entrapment.

Based on the concept of global phase diagrams and on analogues with better known F, speculations are made on the topology of the CO_2-H_2O-NaCl and similar systems. It seems likely that the immiscibility field closes at high T, thereby allowing the region of high-P, low-T L to join the V field at low P and high T. Isochores in these systems may therefore exhibit type six behaviour listed above. (Author's abstract)

DIAMOND, L.W., 1996b, Isochoric paths in immiscible fluids and the interpretation of multicomponent fluid inclusions (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 36-37. Author at Mineralogisch-petrographisches Institut, Univ. of Bern, Baltzerstrasse 1, CH-3012 Bern, Switzerland; e-mail (larryn@mpi.unibe.ch)

See Diamond, FIR 28, p. 35 (E.R.)

DILL, H.G. and **HORN, E.E.,** 1996, The origin of a hypogene sarabauite–calcite mineralization at the Lucky Hill Au-Sb mine Sarawak, Malaysia: J. of Southeast Asian Earth Sci., v. 14, nos. 1/2 (1996) p. 29-35. First author at Bundesanstalt fÅr Geowissenschaften und Rohstoffe, D-30631 Hannover, P.O. Box 510153, Germany.

A gold-bearing hypogene mineralization from the Lucky Hill Mine in the Bau mining district, Sarawak, containing sarabauite and calcite as major constituents was investigated using a combination of optical microscopy, XRD and SEM + EDX. Sarabauite is the only Sb mineral of hypogene origin that is amenable to FI studies in thin section under normal light. The ore mineralization may be subdivided into two different stages. During stage I at temperatures somewhat higher than 400°C, wollastonite, diopside and epidote evolved in the Bau Limestone that forms the wall rocks of the Au-Sb mineralization under study. In stage II, sarabauite developed together with gold at T above 377°C, followed by calcite, stibnite and senarmontite, which formed in the T interval 377-194°C. The Au-Sb mineralization is of high T origin and characterized by Fe and S limitations. Both the T of formation and the chemical composition of the mineralizing F were responsible for the peculiar Sb - sulphide - oxides. (Author's abstract)

DING, Kang and **SEYFRIED, Jr., W.E.,** 1996, Direct pH measurement of NaCl-bearing fluid with an in situ sensor at 400°C and 40 megapascals: Science, v. 272 (1996) p. 1634-1636. Authors at Dept. of Geol. and Geophys., Univ. of Minnesota, Minneapolis, MN 55455.

The pH of concentrated NaCl-HCl F (0.57 mole of NaCl per kilogram of water) has been measured at supercritical conditions of water with a yttria-stabilized zirconia sensor in a titanium flow reactor. At 400°C and 40 megapascals, the in situ pH of the F, ranging from 3.3 to 6.2, differs greatly from its original value of 1.9 to 7.6 at ambient conditions. The measurements agree well with theoretical predictions, showing strong associations of HCl° and $NaOH^{\circ}$ complexes in high-T F. The pH sensor provides a powerful tool to investigate unambiguously the distribution of species in aq F at elevated T and P. (Authors' abstract)

DIX, G.R. and **EDWARDS, Caroline,** 1996, Carbonate-hosted, shallow-submarine and burial hydrothermal mineralization in the Upper Mississippian Big Cove formation, Port au Port Peninsula, Western Newfoundland: Economic Geol., v. 91 (1996) p. 180-203. Authors at Ottawa-Carleton Geoscience Centre and Dept. of Earth Sci., Carleton Univ., 1125 Colonel By Drive, Ottawa, Ontario, Canada K1SA 5B6.

Strata-bound sulfide (Zn-Pb-Fe) and sulfate (Ba-Sr) mineralization occurs in Upper Mississippian (Arundian-Holkerian) limestone. Stages of host-rock petrogenesis and mineralization are compared by integrating structure, stratigraphy, petrography, and geochemistry (FI, and C, O, S, Sr, and Pb isotopes). Strata-bound mineralization is linked to fault-controlled F flow through Ordovician (basement) carbonate and into porous Mississippian host rock, with subsequent F migration bounded by stratigraphic permeability barriers.

Prominent Zn-Pb sulfides (sphalerite, galena) and subsequent Ba-Sr sulfates (barite, celestite), with intergrown marcasite and calcite, have a shallow burial (30 + m) origin. F were variably hot (110° - 190°C). Mg-poor brines (20-25 wt % NaCl eq).

The mineralization is similar to Mississippian-hosted Irish Zn-Pb deposit. (From authors' abstract by E.R.)

DOBE, John, 1995, The alteration and geochemistry associated with a Proterozoic Cu-Au hydrothermal system (Lady Karen), near Cloncurry, Queensland: Bachelor of Science thesis, Univ. of Tasmania, xxx pp and appendices.

The Lady Karen Fe-oxide Cu-Au prospect is located in the Proterozoic Mt Isa Inlier. An epigenetic magnetite - hematite fault-fill breccia ≈ 1.5 km long and 2 - 5 m wide, in sediments, is host to anomalous surface Cu (395 ppm) and Au (1176 ppb). The ironstone forms a faulted contact between the Staveley Formation and the Marimo Slate. The Staveley Formation is locally reddened, brecciated and intensely metasomatised by K-spar ± biotite ± hematite. The Marimo Slate locally has several different styles of hydrothermal alteration, including sericite, albite, K-feldspar, and magnetite-dominated zones. In detail, a halo of sericite ± pyrite ± biotite ± magnetite alteration bleaches the Marimo Slate, which in turn is surrounded by a style of sericite ± chalcopyrite ± pyrite alteration, in which organic matter is preserved. Magnetite metasomatism was associated with potassic - biotite alteration. A second stage $SO_4^{=}$ bearing hematite-rich F infiltrated the fault zone resulting in hematite - calcite replacement of magnetite. Reduction of sulfate during this event resulted in the precipitation of sub-economic chalcopyrite and pyrite. The hematite-stable F was rich in Mo, Cu, Au, LREE, W, Co, P and U. Sulphur isotopes from mineralization associated with veins, altered dolerite, and magnetite - hematite ironstones range from -3‰ to -10.5‰ (mean -5.8‰; n = 6), highlighting the oxidised nature of the mineralizing F. Although FI analyses were not available, $\delta^{18}O_{(fluid)}$ values were constrained between +10‰ to +13.5‰ for magnetite, and +14.5‰ to +18.5‰ for magnetite - hematite for T varying between 100 to 500°C respectively. Oxygen isotopes from early stage magnetite have values of +2.2‰ to +2.7‰ (mean 2.5‰; n = 2), while later hematite - magnetite mixes range from +5.7‰ to +12‰ (mean +7.6‰; n = 6). The replacement of early high T magnetite by hematite stable F, associated with Cu-Au-REE-U mineralisation, is a typical feature of low sulphur Fe-oxide dominated hydrothermal systems worldwide. (From author's abstract by E.R.)

DOBROHOCZKI, J.C., FAYEK, Mostafa and **KYSER, T.K.,** 1996, Reactivated faults and fluid movement in the Athabasca Basin, northern Saskatchewan (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual Meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A23. First author at Dept. of Geol. Sci., Univ. of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0.

Unconformity-type uranium deposits of the Athabasca Basin in northern Saskatchewan are the highest grade uranium deposits in the world. Deposition of uranium was the result of mixing between saline uraniferous, oxidizing basinal F and reducing basement F along Hudsonian faults which crosscut the unconformity between Helikian Athabasca Group sediments and Aphebian basement rocks. F flow has been episodic as a result of reactivation of these faults throughout the history of the basin and has resulted in several stages of uranium mineralization. Four F events have been identified in the Athabasca Basin based on petrographic, F-I, paleomagnetism, and stable and radiogenic isotope systematics. (From authors' abstract by H.E.B.)

DOBROVOLSKAYA, M.G., DUNCHENKO, V.Y. and **BORNIKOV, N.W.**, 1996, Sulfide mineralization in the Kuril Islands: Mineral parageneses and geochemistry of the endogenic process: Geol. Ore Deposits, v. 38, p. 47-67. First author at Russian Acad. Sci., Inst. Geol. Ore Deposits, Petrog. Mineral. and Geochem. I Staromonetny, Moscow.

The Kuril Islands, an island arc, contain numerous young volcanoes, spatially associated with various ore occurrences and deposits of base and precious metals. The synthesis of the data on ore mineralogy and geochemistry for nine sites, situated on the island of Kunashir, Iturup, Urup, and Paramushir, revealed three types of sulfide mineralization: copper-zinc-massive sulfide, lead-zinc, and gold-silver-sulfide. Mineral parageneses, with a similar composition and formation succession, were identified for each type; locally occurring specific associations, which contain bornite and tellurides of silver and gold, were established for the gold-silver-sulfide type. Variations of the chemical composition of pyrite, sphalerite, and galena were used as indicators of definite mineralization types. The T-conditions (300-180°C) [Th data?] in the formation of early and late mineral parageneses do not differ much in various mineralization types. A change in mineral parageneses indicates a change in pH-$f(O_2)$ conditions. The gold-silver-sulfide type was formed in an oxidizing environment. Fractionation of sulfur (^{34}S from -12.7 to +9.9 ppt) and oxygen (^{18}O from +2.8 to +13.9 ppt) isotopes suggest that mineral-forming F of different origins were involved in ore magmatic systems. (Authors' abstract)

DOKUCHYAEV, A.Ya., NOSOVA, A.A., TARKHANOV, G.V., and **YAROSHEVICH, V.Z.**, 1996, Processes of ore-formation in the Imennovian complex of the Taguil Trough (the Ural superdeep well) (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 649. First author at Roskomnedra, GNPP"Nedra", Yaroslavl, Russia.

The Taguil Trough of the Middle Urals is a regional structure of meridian extension where the majority of payable pyrite deposits of the Urals is located. The Ural superdeep well (SG-4) was spudded in the Kabanian-Krasnouralsk area and by now it has reached a depth of 5350 m.

But the main part of mineralization is epigenetic relative to the host rocks and is connected with their hydrothermal-metasomatic transformation of a propylite type in zones of generation of picrite-basalt dykes and tectonic displacements. Associations of ore minerals are accompanied by quartz, carbonate, epidote, prenite, albite, chlorite, zeolite and antracsolite-type carbonaceous matter. By PT and geochemical data minimum T of crystallization of quartz, epigenetic quartz + calcite + phrenite + epidote veins are estimated by value of 230 ± 30°C, calcite - 200±40°C; in this case fluid are characterized by low sal and G saturation ($C_{total} < 260$g - equivalent NaCl, $C_{CO_2} <$ 5 wt%). (From authors' abstract by E.R.)

DOLGOV, Yu.A.* and **SHUGUROVA, N.A.**, 1996, Composition of gases in bottom oceanic sediments, based on fluid inclusions in authigenic minerals: Scientific Journal–Geologiya i Geofizika, v. 37, no. 5, p. 73-80 (in Russian; Engl. abst.).

I from various depths of some authigenic minerals from the pelagic region of ocean are analyzed and results of a great number of these analyses are reported. Analyses have been performed by absorption-volumetric method, which was proposed and developed by the authors.

Statistical and graphic processing of analytical data has been performed and alteration of the carbon dioxide content was found, depending on the depth of bottom sediments. At shallow depths (1480-4800 m), the content of carbon dioxide in G mixture grows negligibly. In the range of depths 4800-600 m, elevated CO_2 contents with considerable variations have been established. Starting from a depth of 9000 m, the content of CO_2 regularly grows. The CO_2 content in zeolite crystals and aggregates of palagonite for the 9000-m-depth sample is the highest and attains 81.7 to 88.6 vol%. This gives grounds to recommend using some authigenic minerals as natural bathometers. (Authors' abstract.)

* Deceased

DOMINY, S.C., CAMM, G.S. and **BUSSELL, M.A.**, 1996, Characteristics and development of carbona-style replacement tin mineralization in West Cornwall: Proceedings of the Ussher Soc., v. 9, part 1, p. 97-104.

Indexed under FI (E.R.)

DOMINY, S.C., BUSSELL, M.A. and **CAMM, G.S.**, 1996, Development of complex, granite-hosted, tin-bearing fracture systems in southwest England: applications of fluid inclusion microfracture studies: Trans. Instn Min. Metall. (Sect. B: Appl. earth sci.), v. 105 (1996) p. 139-144.

Reports a FI microfracture orientation study of granite-hosted Sn-lode zones in Cornwall, England, and a technique for structural interpretation and vein location. (From authors' abstract by E.R.)

DONG, G.Y. and **ZHOU, T.**, 1996, Zoning in the Carboniferous-Lower Permian Cracow epithermal vein system, central Queensland, Australia: Mineral. Deposita, v. 31 (1996) p. 210-224. Authors at National Key Centre in Economic Geol., Geol. Dept., James Cook Univ. of North Queensland, Q4811, Australia.

Four epithermal vein deposits (i.e. Dawn, Central Extended, Rose's Pride and Klondyke) in the Cracow gold field, central Queensland were investigated in terms of paragenesis, mineralogy, vein textures, FI and stable isotopes. All the deposits occur as open-space vein fillings, and have similar paragenesis. However, significant variations in mineralogy, textures of quartz and adularia, and F geochemistry were found for a main mineralisation stage (Stage II) of each individual deposits. At Rose's Pride and Klondyke, mineralisation T is less than 220°C and sal less than 0.2 wt%. The $\delta^{18}O$ values of quartz and calcite range from -2.65 to -2.06‰ and from -6.66 to -6.34‰ respectively, and calculated $\delta^{18}O_{H_2O}$ value is about -17‰ which represents a nearly unshifted palaeometeoric water.

Central Extended crustiform bands developed from both walls of a fissure, and T could drop sharply from 275°C to less than 220°C. The ore-forming F at Central Extended, compared with that at Rose's Pride and Klondyke, was isotopically shifted from meteoric water with $\delta^{18}O_{H_2O}$ value of -13.5‰ calculated in equilibrium with quartz ($\delta^{18}O$ values of -3.09 to -1.44‰).

At Dawn, quartz is the predominant gangue mineral, and commonly shows a coarse comb texture. The ore-forming F was 275 Ò 10°C and low sal (0.4 to 0.7 wt%). The $\delta^{18}O$ values of quartz range from -3.97 to -3.22‰, and calculated $\delta^{18}O_{H_2O}$ value is about -12‰, indicating large isotopic shifts from palaeo-meteoric water. A depth zoning in typical boiling epithermal systems, corresponding to different F compositions, wall rock permeability and boiling behaviors, was invoked to explain different characteristics of these selected epithermal veins. (From authors' abstract by E.R.)

DOUTHITT, C.B., JOHEMKO, J. and CHOW, Y., 1996, Isotope ratio monitoring mass spectrometry (IRM-MS): state of the art and prospectus for the future (abst): 30th Int'l Geog. Cong., Abstracts, v. 1, p. 482. Authors at Finnigan MAT, San Jose, California.

The new technique "isotope ratio monitoring" bypasses the dual inlet system completely. This field is being quietly revolutionized by a veritable explosion of novel and innovative irm-based sample preparation and inlet systems which allow measurements that were either extremely difficult or impossible with the dual inlet system. One of the principal limitations of the dual inlet system was a fundamental lower bound on sample size which, for high sensitivity systems, was on the order of 50 nanomoles of CO_2, with normal operation requiring samples in the μ-mole range. With IRM systems, a typical sample is 1-10 nanomoles of CO_2 and samples are routinely analyzed in the picomole range; femtograms of high enrichment samples have been detected. This represents, a real sample size reduction by 2 to 7 orders of magnitude. There are approximately 350 IRM-IRMS systems currently using either capillary GC or elemental analyzers as the primary sample inlet. (From authors' abstract by E.R.)

DRENNAN, G.R., ROBB, L.J., BOIRON, M.C., CATHELINEAU, M. and DUBESSY, J., 1996, The association between fluids and mineralisation in the Witwatersrand Basin, South Africa (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 724. First author at Dept. of Geol., Univ. of Witwatersrand, Johannesburg, South Africa.

The depositional and post-burial diagenetic/metamorphic history of the Witwatersrand sediments spans a time of c. 1000 Ma. Ore textures within the sediments indicate that certain minerals are both allogenic and authigenic in origin while other mineral associations represent a continua which range from allogenic to authigenic in character. Late metamorphic/hydrothermal F in quartz veins associated with Witwatersrand gold-bearing reefs are of four types, namely aq-rich, CO_2-H_2O-rich, CH_2-CO_2-rich, and CH_4-N_2-rich. Structurally related quartz veins, in particular, are characterised by abundant multiphase FI that exhibit complex trapping inter-relationships. A common feature of some of these I is the presence of abundant carbon nodules (migrated kerogen) as well as sulphide dxl.

FI microthermometry for aq- and hydrocarbon-rich F suggest entrapment T of between 200 and 450°C. These Ts are related to localised high P-T conditions experienced during faulting. Migrated kerogen nodules in fault-related quartz veins are characterised by enriched Au, U, Fe, Cu, As, Pb and Ni concentrations as well as other trace elements and rare earth elements. These nodules exhibit a close association with recrystallised sulphides and gold. This suggests that uranium, gold, kerogen and other metals were transported in the same solution. (From authors' abstract by E.R.)

DRURY, M.R. and FITZGERALD, J.D., 1996, Grain boundary melt films in an experimentally deformed olivine-orthopyroxene rock: implications for melt distribution in upper mantle rocks.: Geophysical Research Lett., v. 23, no. 7 (1996) p. 701-704. First author at Dept. of Geol., Geodynamics Research Inst., Utrecht Univ., Netherlands.

An unexpected microstructure, with important implications for M distribution in the upper mantle, has been found in a 70% olivine + 30% orthopyroxene rock experimentally deformed at 1500 k, 300 MPa, where incipient partial melting occurred. As found in previous studies of comparable systems, most M in the olivine-orthypyroxene sample resided in a network of grain-edge tubes and occasional thick (50-500 nm) layers. We infer, using electron microscopy at its highest resolution, that M also existed in another form as glass films 1.0-1.5 nm thick, along all grain boundaries, with total film fraction (F) of 0.0002. All of these M are unusually SiO_2-rich. Further work is needed to confirm that the thin films are not transient, although their coexistence with smoothly curved solid-M interfaces and flat crystal faces suggests they are stable. If thin high-silica M films are stable they might influence physical properties and M extraction processes in regions of incipient melting and metasomatism in the upper mantle. (Authors' abstract)

DU, Letian, 1996a, The relationship between crust fluids and mantle fluids: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 172-180. Author at Geol. Research Inst. of Nat'l. Nucler Cooperation, Beijing 100029.

This paper presents the tentative knowledge on the basis of the studies of U, Au ore deposits and mantle xenoliths. (1) magma-differentiated hydrothermal solutions are unreasonable; (2) alkaline metasomatism is the key to understanding mantle and crust metasomatism; (3) the detachment structure is the channel of the upwelling mantle F; (4) phosphorous is the characteristic tracer-component of mantle F; (5) the ocean anoxic events, El Nino and black shales have common causes (HACONS upwelling effects); (6) natural G, oil, oil shales, salts, hot brines, [and] hydrothermal ore formation constructed oregenesis systems are the derivatives of HACONS. The asthenospheric bodies and low velocity zones can be considered as the new prognostic targets. (Author's abstract)

DU, Letian, 1996b, The possible causes of the natural hazards from deep fluids of earth interior: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 298-305. Author at Geol. Research Inst. of Nat'l. Nuclear Cooperation, Beijing, 100029.

In this paper the author has emphasized views and concepts, by many examples, how a series of natural hazards have been controlled by the asthenospheric upwelling, the mantle F activities and degassing of the Earth. The author has made an attempt to show the close dependence of the earthquake, El Nino, forest fire, UFO and climate anomalies on the migration of mantle F (HACONS) from the Earth interior, that characterized by inner genesis, common sources, multiple phenomena and multiple issue [sic]. (Author's abstract by E.R.)

DUAN, Zhenhao, MOLLER, Nancy and WEARE, J.H., 1996a, A general equation of state for supercritical F mixtures and molecular dynamics simulation of mixture PVTX properties: Geoch. Cosm. Acta, v. 60, no. 6 (1996) p. 1209-1216. Authors at Dept. of Chem., Univ. of California, San Diego, La Jolla, California 92093.

A general Equation of State (EOS), which we previously developed for pure nonpolar systems, is extended to polar systems such as water and to mixtures in this study. This EOS contains only two parameters for each pure component and two additional parameters for each binary mixture (no higher order parameters are needed for more complicated mixture systems). The two mixing parameters can be eliminated for nonaq mixtures with a slight loss of accuracy in both total mole volume and in excess volume (or nonideal mixing). Comparison with a large amount of experimental *PVTX* data in pure systems (including H_2O) and in the mixtures, H_2O - CO_2, CO_2 - N_2, CH_4 - CO_2, and N_2 - CO_2 - CH_4 results in an average error of 1.6% in density. Comparison with commonly used EOS for supercritical F shows that the EOS of this study covers far more *T-P-X* space with higher accuracy. We believe that it is accurate from supercritical T to 2000 K and from 0 to 25,000 bar or higher with an average error in density of less than 2% for both pure members and mixtures in the system H_2O - CO_2 - CH_4 - N_2 - CO - H_2 - O_2 - H_2S - Ar and possibly with additional G. Comparison with the published simulated data suggests that this EOS is approximately correct up to 300,000 bar and 2800 K.

We also simulated the *PVTX* properties of a number of supercritical F mixtures using molecular dynamics (MD) simulation. These results and those of other authors are well predicted by the EOS of this study. (Authors' abstract)

DUAN, Zhenhao, MOLLER, N. and WEARE, J.H., 1996b, Prediction of the solubility of H_2S in NaCl aqueous solution: an equation of state approach: Chemical Geol., v. 130 (1996) p. 15-20. Authors at Dept. of Chemistry, 0340, Univ. of California, San Diego, La Jolla, California 92093-0340.

A model is developed for the prediction of H_2S solubility in NaCl-bearing aq solutions up to about 300 bar, 320°C and 6 *m* NaCl. Although many H_2S solubility measurements have been published, most of them are limited to low pressures (just above water saturation pressure). In order to predict solubilities to higher pressures, we have developed an equation of state (EOS) for the H_2S-H_2O binary, which allows us to calculate chemical potentials of both H_2S and H_2O in L or in V phase. Below 350°C NaCl has negligible effect on the V phase but has substantial effect on the activities of H_2S in the L phase. This salt effect is accounted for by specific ion interactions. Comparison of this model with all the available data indicates that predictions are within experimental uncertainty, even for P well above that covered by the data used for parameterization. (Authors' abstract)

DUAN, Zhenhao, MOPHIOLLER, Nancy, and WEARE, J.H., 1996, [Using molecular dynamics simulations] (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop / Shortcourse, Aug. 10-11, p. 2. (Note: this abstract was distributed at the I.G.C. Workshop/Shortcourse, but was not printed in the official 30th I.G.C. Abstracts volumes. E.R.) Authors at Univ. of California, San Diego, USA.

See same authors, FIR 1995a through 1995d. (E.R.)

DUBLYANSKY, Yuri, REUTSKY, Vadim and SHUGUROVA, Nina, 1996, Fluid inclusions in calcite from the Yucca Mountain exploratory tunnel (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 38-39. First author at Inst. of Mineral. and Petrol., Russian Acad. of Sci., Siberian Div., 3, University Ave., Novosibirsk, 630090, Russia; e-mail (dublyan@diamond.nsk.su)

The calcite filling the fractures within unsaturated zone of Yucca Mountain is often interpreted as being precipitated from rainwaters that have descended along interconnected fractures carrying dissolved carbonate from the overlying soil environment (e.g., Roedder et al., 1994). This interpretation, however, is at odds with a large body of the data: FI, ESR, ^{18}O in calcite-opal pairs, gradients $\Delta\delta^{18}O / \Delta z$ in calcites from drill holes (Hill et al., 1995) implying elevated T and geothermal gradients in the Yucca Mountain subsurface in the past. [sic]

The FI Th obtained in this study imply that calcites from exploratory tunnel were deposited from epithermal F. The new data are in good agreement with paleogeothermal gradient inferred from earlier FI results.

Large bubbles, occupying 40-80% of vacuoles have been interpreted earlier as the "air-water-CO_2 phase" (Roedder et al., 1994) trapped during the growth of calcite from films of percolating rain-water in vadose zone. Our results do not corroborate this interpretation. Instead, they imply heterogeneous entrapment of methane-rich water F in saturated zone. [sic]

The data obtained in this study are <u>not</u> compatible with the vadose-zone setting. Calcite encountered in association with zeolite, quartz, and opal in the Yucca Mountain exploration tunnel was formed within a low-T hydrothermal (epithermal) system. (From authors' abstract by E.R.)

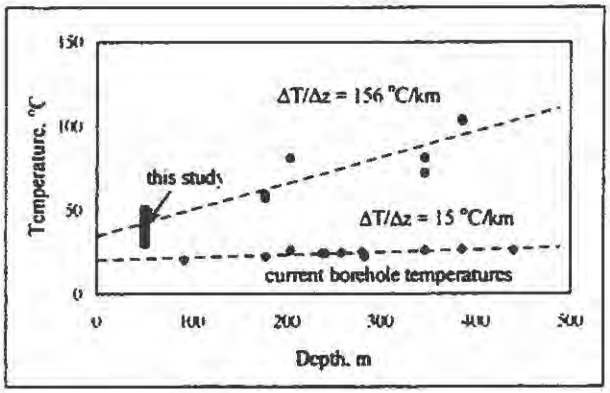


Fig. 2 Fluid inclusion and ambient temperatures in the Yucca Mountain subsurface. Circles - by YMP, 1993; diamonds - by Sass et al., 1987.

DUBLYANSKY, Y.V., SHUGUROVA, N.A. and REUTSKY, V.N., 1996, Preliminary data on gases trapped in fluid inclusions in calcite from the Yucca Mountain exploratory tunnel (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A522. First author at Inst. of Mineral and Petrogr., Russian Acad. of Sci., 3 Univ. Ave., Novosibirsk, 630090, Russia; e-mail (dublyan@uiggm.nsc.ru)

The calcite filling fractures within unsaturated zone of Yucca Mountain is often interpreted as being precipitated from rainwaters that have descended along fractures carrying dissolved carbonate from the overlying soils. However, elevated FI T (35-55°C) obtained by us argue against the "unsaturated zone" setting. Equally indicative are the compositions of G trapped in I.

On crushing, the bubbles of the seven G-rich I (G-L ratio 0.4-1.0) decreased in volume by factor of 20 to 120. The following G were determined by semiquantitative selective absorption volumetric analysis in individual bubbles: methane + heavy and light hydrocarbons (80-84 vol.%), nitrogen + noble G (16-18 vol.%) and carbon dioxide (traces to 10-15 vol.%).

Oxygen was not determined. Bubble from one I slightly increased (1.8) on crushing while maintaining similar G chemistry. Presence of methane (1-5 mg per kg of a mineral) and hydrocarbons (traces) was confirmed by bulk G chromatography.

G-rich I in the Yucca Mountain calcite were trapped from a F carrying both dissolved and gaseous methane. Upon cooling, I trapped as one-phase L formed "normal" shrinkage bubble. The P in such I is < 1 atm., its bubble decreases on crushing. An I trapped as two-phase F maintains entrapment P. Increase of the bubble on crushing indicates P•1 atm.

Large bubbles, occupying 40-80% of vacuoles have been interpreted as the "air-water-carbon dioxide phase" trapped during the growth of calcite from films of percolating rainwater. By contrast, our results imply formation from methane-rich thermal water in saturated zone. (Authors' abstract)

DUBOIS, M., AGUIRRE-DÍAZ, G., and **MARTINEZ-SERRANO, R.**, 1996, Thermobarometric estimations and nature of fluids in the crust below the Central Volcanic Chain (Mexico) based on fluid-inclusion studies in a granulitic xenolith (abst): 16th Earth Sci. Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 98 (in French). First author at Univ. Lille, UFR Sciences de la Terre, F-59650 Villeneuve d'Ascq, France.

A granulitic xenolith has been found in the ignimbritic breccias of the Amealco caldera. The granulite is a fragment of the lower crust brought up with the magma and ejected during the eruption of the caldera. It is a medium-grained equigranular rock consisting of plagioclase (An 60-70), quartz, orthopyroxene, clinopyroxene, ilmenite, apatite and zircon. The whole-rock composition corresponds to a dacite very rich in K_2O.

FI have been studied in quartz and feldspar grains of the xenolith. Two types have been described: (I) primary I showing signs of decrepitation, and (II) secondary I, mono or biphase at +25°C. The two types consist of practically pure CO_2 (-57.0 < TmCO_2 < 56.6°C, confirmed by Raman microprobe) and traces of CH_4 (< 5 mol%). Biphase I homogenize to the L between +22.3 and +29.1°C.

P in type-(II) inclusions have been estimated at 2.5 ± 0.2 kbar (at T = 800°C). These values, low compared to typical granulite-facies PT conditions, suggest a decompression phenomenon after passing through the granulite-facies conditions and after bringing the xenolith to the surface. The ascent of the xenolith caused the decrepitation of the P I and the partial melting of the xenolith. (From authors' abstract, translated by E.A.J. Burke.)

DUBOIS, Michel, AYT OUGOUDAL, M., MEERE, Patrick, ROYER, J.J., BOIRON, M.C. and **CATHELINEAU, Michel**, 1996, Temperature of paleo- to modern self-sealing within a continental rift basin; the fluid inclusion data (Soultz-sous-Forets, Rhine Graben, France).: European J. of Mineral., v. 8, no. 5, p. 1065-1080.

Full paper for previous abstract (E.R.)

Self-sealing of open microstructures and mesostructures characterizes evolving F flow in the sedimentary cover as well as in the granitic basement of the Rhine continental rift basin in the region of Soultz. This area currently experiences active F migration. A detailed petrographic and microthermometric study of paleofluids trapped as FI in the structures (veins filled by quartz or barite, healed microfissures) and authigenic minerals (quartz overgrowths in sandstones, and euhedral quartz in altered granite plagioclases) reveals a succession of contrasting P-T-X conditions for self-sealing of the rocks. The data have been obtained from rock cores sampled at different depths along the Hot Dry Rock Soultz-sous-Forêts drillhole EPS-1, extending from the Triassic sandstone cover down to the granitic basement. Several stages of paleofluid trapping are distinguished as a function of the type of host mineral or microstructure.

The earliest F stage (probably late Hercynian) is mostly recorded in healed fissures (FI planes) affecting the granite quartz grains, but also in some intragranitic early quartz-carbonate veinlets: i) rare CO_2 - (N_2) - H_2O F, ii) a succession of F of moderate sal (2-7 wt.% eq. NaCl) trapped under a large range of T (minimum T of 180 to 340°C)

The second main stage of mineral crystallization corresponds to a more recent crystallization of quartz cement in sandstones, and of quartz-barite veins hosted by granite or sandstone. This stage is probably related to post-Oligocene F flows. F trapped in these authigenic minerals display rather similar features to the modern brines (T in the range of 130 to 160°C, large range of sal) encountered in drillholes of the area. The T-depth profile obtained from recent vein infillings is close to the profile measured after drilling, indicating a recent to active self-sealing, or a rather monotonous thermal regime during the latest F migration period. The large variations of sal observed in some samples suggest a heterogeneous mixing process between low sal F (< 5 wt.% eq. NaCl) and brines. FI data indicate a deep penetration of F equilibrated with sediments, and large scale F movements between the sedimentary cover and the basement. (Authors' abstract)

DUGDALE, A.L., 1996, Multiple vein arrays and zoned alteration at Bronzewing gold deposit, W.A. (abst.): Geol. Soc. of Australia Abstracts, v. 41, p. 120.

Indexed under FI (E.R.)

DUNBAR, N.W., CAMPBELL, A.R. and **CANDELA, P.A.**, 1996, Physical, chemical, and miner-alogical evidence for magmatic fluid migration within the Capitan Pluton, southeastern New Mexico.: Geol. Soc. of America Bull., v 108, no. 3 (1996) p. 318-333. Authors at New Mexico Inst. of Mining and Tech., Dept. of Earth and Environmental Sci., Socorro, NM.

The nearly equal 300 km^3, 28.8 Ma granitic Capitan pluton, located in southeastern New Mexico, was the source of high-T (up to 600 degrees C), high-sal (up to 80 wt%) F that formed small REE-bearing zones of mineralization in the pluton carapace. Erosional dissection of the pluton reveals zones in the granite that are characterized by bubble-like void spaces and fissures. These could be interpreted, on one hand, as original magmatic porosity resulting from the interconnection and/or coalescence of bubbles of magmatic volatile phase, or on the other hand, as void spaces resulting from postcrystallization dissolution. These porous zones grade upward into the brecciated portions of the pluton carapace that hosts mineralization. The zones are planar features, traceable across valleys, and even between adjacent valleys on the pluton's flanks. The orientation of the zones is roughly concentric with the exposed shape of the pluton. Chemical analyses of samples collected across a porous zone reveal that some elements, including Fe, Al, Rb, and Sr are depleted in the entire area surrounding the porous zone, whereas Si, Na, Ba, and Ta are enriched. Other elements, including K, Sb, Zn, Zr, a number of rare earth elements (REE), Pb, and Th, exhibit a slight to strong depletion surrounding the porous zone and a strong enrichment roughly centered on the zone itself. Abundance of high-sal FI in igneous quartz is high within the entire 2.5-m-wide zone but is significantly higher in the central porous zone. The chemical and FI abundance patterns could be produced by a two-step process with the wide depletion caused first, by fractionation of elements from the M into a volatile phase at the time that volatile exsolution first occurred. This could be followed by the superimposed enrichment pattern for certain elements caused by deposition of these elements from trace-element-rich F, which evolved in a more central, deeper part of the pluton and were transported along the same zone (although now more crystallized) of F migration established earlier, depositing minerals as it cooled. Textural, petrographic, and geochemical evidence suggest that volatiles may have exsolved during crystallization, coalescing into bubble-rich zones that enhance the efficiency of volatile transport. (Authors' abstract)

DUNIN-BARKOVSKAYA, F.A., TSOY, L.A., and ZUYEV, Yu.N., 1996, The fluid regime within granitoids of the Muruntau gold field: studies of core of the D-10 superdeep hole (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 483. Authors at Inst. of Geol. and Geophysics, The Acad. of Sci. of Uzbekistan.

Gold mineralization within black shales (O-S) of Muruntau ore field in West Uzbekistan is of two kinds–a low-sulphide quartz rare metal-gold type in veined-stockwork bodies and a gold-sulphide type in subcomfortable lens-shaped bodies within massive and impregnated ores.

The genesis of this mineralization [is attributed to] sedimentary, sedimentary-metamorphic, volcanogenous-sedimentary, and hydrothermal [processes]. The D-10 hole has been drilled through a black shale series to granites at a depth of 4 km. A samples of the core obtained from 4167 m depth have been studied. Granite is leucocratic, biotite, macrocrystalline. It consists of microcline, albite, oligoclase, quartz, biotite and accessory minerals apatite, zircon, sphene and others. Postmagmatic alterations appear to be poorly shown. Sericite, muscovite are distributed over plagioclase, chlorite - over biotite, and albite - over microcline. FI of 0.004-0.01 mm size are distributed throughout all the rock-forming minerals, primarily in quartz. Vacuum decrepitation and G chromatography have been carried out for a granite sample. At a T of 600°C were released 0.19 weight per cent of H_2O. A gas phase is provided by CO_2 mainly. A total gas composition (mole/kg) of the I is as follows: CO_2-3.52, N_2-0.01, CH_2-0.005. For separated FI their shape, size, phase composition and Th have been determined.

As to granite minerals, the following genetic types of FI developed from postmagmatic solutions have been distinguished: 1- pseudo-secondary G I related to pneumatolytic event (G, G-water, CO_2-water) with G content 25-75%, and a Th 320°; 2- pseudo-S L I (G-30%, t=340°C); 3- S I caused by a hydrothermal process (gas-15%, t=220°-253°C). The authors came to the conclusions that pneumatolytic and hydrothermal L contributed into the postmagmatic transformation of deep-seated granites of the Muruntau ore field. (From authors' abstract, by E.R.)

DUNN, S.R. and VALLEY, J.W., 1996, Polymetamorphic fluid-rock interaction of the Tudor gabbro and adjacent marble, Ontario: American J. of Sci., v. 296 (1996) p. 244-295. First author at Dept. of Geol. and Geog., Mount Holyoke College, South Hadley, Massachusetts 01075.

Polymetamorphism of the Tudor gabbro and adjacent marble, Grenville Province, southern Ontario, has caused a complex history in terms of T, time, and F conditions in a mid-crustal environment.

The complexity of polymetamorphism is such that several P-T-time-X (F) paths may be hypothesized to arrive at the same final state. The data are best explained by the combined effects of a two-stage, polymetamorphic process. Volatilization reactions in the outer aureole proceeded in response to up-T F flow during contact metamorphism, and reactions in the inner aureole proceeded largely from thermal processes alone. Petrologic F fluxes for representative samples are from 60 to 530 moles/cm^2 for the contact metamorphism. Subsequent regional metamorphism involved the introduction of externally-derived, H_2O-rich F which locally infiltrated in a channelized manner resulting in F fluxes of 0 to ~10^5 moles/cm^2. This externally-derived F was focused along the gabbro-marble contacts resulting in infiltration-driven metamorphism of marble and hydration and carbonation of gabbro to metagabbro. Dehydration of lower crustal rocks at depth could provide more than sufficient quantities of water.

The Tudor aureole serves as an example of how profoundly model-dependent F flow calculations are, especially in areas of multiple metamorphic events. Metamorphic F flow processes can only be understood if the full thermal history of a region is known. (From authors' abstract by E.R.)

DUROC-DANNER, J.M., 1996, Euclase from Colombia showing three-phase inclusions: J. Gemm, v. 25, no. 3 (1996) p. 175-176. Author at Geneva, Switzerland.

The gemmological properties of a medium-dark greenish-blue euclase from Chivor, Colombia, are described and compared with the properties of other gemstones of similar colour with which it could be confused.

From the color plates shown the FI appear to be brine and V and halite. (HEB).

DUROCHER, K.E., KYSER, T.K., ANSDELL, K.M. and DELANEY, G.D., 1996, Tectonism, mesothermal gold, and fluid evolution in the paleo Proterozoic Glennie Domain of the Trans-Hudson Orogen, Saskatchewan, Canada (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 40-42. First author at Dept. of Geological Sci., 114 Science Place, Univ. of Saskatchewan, Saskatoon, Saskatchewan, Canada, S7N 5E6; e-mail (durocher@pangea.usask.ca)

This paper presents results of a multi-disciplinary study using FI microthermometry, stable and radiogenic isotope systematics and mineral compositions to constrain the P-T-t evolution of the Glennie domain (GD) of the Trans-Hudson Orogen (THO) and probable F associated with mesothermal gold mineralization.

Gold mineralization in the Santoy Lake area is spatially associated with shear-hosted quartz-diopside-calcite veins. Shear zones and associated veins are temporally related to the pre-peak metamorphic D2 event. Oxygen isotope equilibration T of vein mineral pairs and arsenopyrite geothermometry indicate T between ca. 440-620°C.

Gold mineralization in the Brownell Lake area is found within shear-hosted quartz-arsenopyrite microveinlets in volcanic rock and along arsenopyrite-bearing foliation surfaces within granite-hosted shear zones. These structures are related to a late stage of the peak metamorphic D3 event, and have not been affected by a later regional deformational episode. Vein minerals have oxygen isotope T between ca. 375-575°C.

The recognition of P vs. S I in variably-deformed quartz veins is problematic, especially since early I were likely affected by later deformation and associated F events, particularly in the Santoy Lake area. I can be divided into 2 principle types: (1) H_2O - NaCl and (2) H_2O - CO_2 - NaCl.

At Santoy Lake, both I types are present as isolated, possibly P I. Relative timing of these early inclusions is difficult to discern.

At Brownell Lake, two I types are present, with only Type (1) I being apparently P in origin. Type (1) P I homogenize between 183-232°C and have bulk densities of 0.83 - 0.93. I types (1) and (2) can be found as S I. Type (1) S I are three-phase, with degrees-of-fill between 90 and 97. Daughter mineral dissolution temperatures (Tm_{NaCl}) of 169-200°C correspond to sal of 30.4-31.8 wt% NaCl eq. These I homogenize to the L phase between 107-159°C. Two-phase S aq I are also found. These I have degrees-of-fill between 85 and 97. Their small size makes sal measurements difficult, with one value of 4.4 wt% NaCl eq. These I homogenize between 162-305°C, and have bulk densities between 0.67-0.94. Type (2) S I have CO_2 volume fractions of 0.6-1, Th_{CO_2} values of 13.7-14.7, and Tm_{Clath} values of 7.4-7.5, corresponding to sal of 4.8-5.0 wt% NaCl eq. and bulk densities of 0.83-0.91.

S and earlier-formed I at Santoy Lake are similar in their physiochemical characteristics. These are of similar densities and sal and suggest that either a similar F was trapped during multiple F events or earlier formed I were modified by later low sal F during peak and subsequent episodes of metamorphism and deformation. (From authors' abstract by E.R.)

EADINGTON, P.J., LISK, Mark and KRIEGER, F.W., 1996, Identifying oil well sites: United States Patent No. 5,543,616, Aug. 6, 1996.

Methods for determining maximum oil saturation and possible oil zone location use natural oil I in rock grains of granular rock samples. A first technique involves quantitatively determining the total number of grains in the sample and, of those grains, the number that include oil within them, thereby yielding a ratio (GOI); and correlating that ratio against standard rock samples to yield the maximum oil saturation. A second technique involves determining the location of oil containing and/or oil absent zones in geological sites by (a) sampling in the geological site from a first rock portion capable of granular retention of oil and subjecting the first rock portion sample to the technique of GOI; (b) sampling in the geological site from one or more further and distinct rock portions, each capable of granular oil retention, and subjecting [?] the or [?] each further rock portion sample to the technique of GOI; and (c) comparing the results of GOI between the first rock portion and one or more of each further rock portion to determine whether or not [?] the or [?] each further rock portion is located in a different zone within the geological site from that of the first rock portion. (Authors' abstract)

EADINGTON, Peter, PERSON, Mark, TOUPIN, Denah and HAMILTON, Joe, 1996, An outline of palaeoformation water compositions and flow patterns in the Eromanga and Cooper basins through Mesozoic time: Geol. Soc. Australia Extended Abstracts No. 43, p. 167-171. First author at CSIRO Div. of Petroleum, North Ryde, NSW, 2113.

Measurement of the sal of FI, the isotope composition of minerals, and two dimensional computer simulations of basin scale flow of formation water have been used to investigate the composition and flow patterns of palaeoformation waters in the Eromanga and Cooper Basins through Mesozoic time. Three main phases were identified.

FI in Jurassic aquifers trapped palaeoformation waters at this time with sal to 18,000 ppm which is higher than sal of current formation waters (<4,000 ppm.) Unlike current formation waters which retain a meteoric character, isotope compositions of palaeoformation waters are enriched in ^{18}O consistent with a long residence time in the basin. FI in the Cooper Basin trapped palaeoformation waters with sal commonly about 50,000 ppm which is consistent with alteration of formation water during burial diagenesis. Current formation waters have sal of 10,000 to 19,000 ppm.

Hydrodynamic flow at about 50 Ma and from Pliocene time was also recognized. (From authors' abstract by E.R.)

EBEL, D.S. and NALDRETT, A.J., 1996, Fractional crystallization of sulfide ore liquids at high temperature: Economic Geol., v. 91, p. 607-621. First author at Dept. of Geophys. Sci., Univ. of Chicago, 5734 South Ellis Ave., Chicago, Illinois 60637.

EDON, M., RAMBOZ, C., VOLFINGER, M., CHOI, Choon-Gi, and ISABELLE, D., 1996, Transport of metals by deep evaporitic fluids in the Oxfordian of the Southeastern Basin, France; PIXE microanalysis data: Comptes Rendus de l'Acad. des Sci., Ser. II, v. 322, no. 8, p. 633-640 (in French; Engl. abst. and summary)

Deep-seated F uplifted with Triassic diapirs in the SE basin, and minerals precipitated from evolved evaporitic F in the Oxfordian marls, have been characterized by Proton Induced X-ray Emission (PIXE) microanalysis. Trace amounts of Fe, Cu, ± Zn, ± Ti, ± As, ± Br have been measured in both cases, emphasizing the metallogenic potential of the diapiric F, and their influence during early diagenesis of the Oxfordian marls. The low Sr-content of evaporitic F (< 20 ppm) contrasts with the Sr-rich minerals deposited below the sea-floor surface. (Authors' abstract)

EICHHUBL, Peter and BOLES, J.R., 1996, Scale and timing of focused fluid flow along faults in the Miocene Monterey Formation, California: American Assoc. of Petroleum Geologists Annual Meeting Abstracts, v. 5, p. 41. First author at Univ. of California at Santa Barbara, Dept. of Geol. Sci., Santa Barbara, CA, US.

F flow along faults in the Miocene Monterey Formation is indicated by extensive carbonate and quartz cementation along fault surfaces and spatially related veins. Faults exposed at coastal outcrops along the uplifted margins of the Santa Barbara and Santa Maria basins have estimated total displacements in the order of 100 m. Large volumes of F are indicated by up to 6 m cumulative thickness of cement across individual faults and accompanying veins. Oxygen isotopic and FI data indicate T of vein fill of up to 130°C. Based on cross-cutting relations with folds, faulting and vein cementation occurs during uplift of the basin flanks. Abundant hydrocarbon I indicate that vein and fault cementation is concurrent with hydrocarbon migration. High rates of F flow in the order of centimeter to meter per second are inferred based on graded geopetal infill of breccia cavities indicative of fragment transport in suspension. Large volumes of F, high T, and high flow rates would be suggestive of a deep basinal source for the F. Yet, strontium isotopic ratios of fault-related carbonate cements are only slightly lower than the sea water value corresponding to the stratigraphic age of the exposed sections, with a difference equal to a cross-stratigraphic transport distance <100 m. Thus the strontium isotopic composition indicates a local source of the carbonate rather than a distant source within deeper parts of the basin. We interpret this apparent discrepancy as a result of extreme focusing of F flow along faults and interaction with the wall rock (Authors' abstract)

EL-SHAZLY, A.E.-D. and **SISSON, V.B.,** 1996, Fluid inclusion evidence for exhumation of eclogites and blueschists from northeast Oman (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 43. First author at Dept. of Earth Sci., Sultan Qaboos Univ., P.O. Box 36, Al-Khod, PC123, Sultanate of Oman; e-mail (jinnys@ruf.rice.edu)

Both FI and retrograde mineral reactions imply an isothermal decompression of eclogites and blueschists following peak metamorphism in the eastern part of the Saih Hatat window of northeastern Oman. In this region, blueschists, eclogites and epidote amphibolites are interlayered on a millimeter to decimeter scale in metabasalts. These were metamorphosed during the Cretaceous reaching peak metamorphic conditions of T of 500-580°C at P > 1000 - 1200 MPa. Geochemical and stable isotope data indicate that the eclogites and blueschists represent different protolith compositions whereas the epidote amphibolites represent S assemblages related to channelized fluid flow during exhumation. Fluid inclusions were observed in the mafic eclogites as well as in late quartz veins which cross cut the complex. They have a range in textural types from solitary I in clinopyroxene to S I in quartz. Solitary I in clinopyroxene are characterized by tubular of negative crystal shapes, with a few I surrounded by satellite I. This texture is probably indicative of overpressure during exhumation. Most of the FI are aq with final melting T between –2 to 0°C indicating low sal brines. Initial melting T suggest they probably belong to either the $MgCl_2$-$NaCl$-H_2O or $NaCl$-H_2O system. Some later FI in quartz veins contain minute quantities of CO_2. These probably have less than 5 vol. % CO_2 as only clathrate melting could be observed and there is not enough CO_2 to form a second immiscible phase at room conditions. Th cluster into three groups: > 380°C for FI in garnet or quartz in eclogites, 220-260°C in clinopyroxene and quartz segregations, and 170-180°C in vein quartz and rarely in eclogite. None of the isochores for these F intersect the metamorphic conditions. However, they do intersect retrograde reactions at P of 200-400 MPa at T slightly below peak metamorphic conditions. This combined with the textural evidence for overpressuring and stretching of FI supports an isothermal decompression path for the exhumation of the eastern Saih Hatat window. (Author's abstract)

ELLIS, P.D., 1996, The geology and mineralisation of the Waisoi porphyry copper deposits, Namosi Province, Republic of Fiji: Master of Economic Geol. thesis, Univ. of Tasmania, 219 pp.

The Waisoi porphyry copper / gold deposits at Namosi, in the Republic of Fiji, are hosted by several units of strongly faulted, fractured and altered andesitic-dacitic volcanic rocks. F associated with these intrusives caused extensive alteration in the Namosi area and led to formation of the 930 Mt Waisoi porphyry mineralisation, averaging 0.43% copper and 0.14 ppm gold. Petrological, mineralogical, alteration and FI investigations, combined with field observations of temporal relationships between geological features, demonstrated that the paragenetic sequence consists of early, regional, greenschist facies, burial metamorphism and albitisation followed by porphyry-related alteration. The latter (porphyry-related alteration) consists of early sericitisation, followed by silicification, before the main mineralising F were introduced. These resulted in a potassic alteration event, during which most of the copper and gold was deposited, followed by a chloritisation event, also with significant copper mineralisation. The variable phase mineralising event was followed by several carbonate-rich alteration events.

Minor copper mineralisation was deposited as chalcopyrite during the silicification event, but most of the copper and gold was introduced and deposited as chalcopyrite and bornite during the subsequent main mineralisation episode. This involved a series of events, from those with highly saline F at T > 500°C, to high sal (+45 wt.% NaCl eq.) F at T > 380°C, to F with lower sal (10 wt.% NaCl eq.) and T around 300°C. Minor copper was also deposited as chalcopyrite during the early stages of the carbonate alteration event. Mineralisation distribution is controlled by lithology and structure. Regional structure controlled the location of the mineralising porphyries, the F pathways and the porosity / permeability of the host rocks, whereas the lithologies controlled the degree of chemical reaction and the style of mineralisation. The high erosion rate of the Waisoi area has resulted in the exposure of the Waisoi mineralisation, but lower erosion at nearby Waivaka has only exposed the top of a similarly mineralised system. (From author's abstract by E.R.)

ELYAS, Y.K., 1996, Fluid inclusions study, another key to the history of tourmalinization in the Cheviot Granite, north east England (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 482. Author at Geol. Dept., College of Science, Mosul Univ., Mosul, Iraq.

FI are present in the minerals of the tourmalinized rocks of the Cheviot Granite. Quartz seems to be the dominant host for these I, and to a less extent tourmaline. These FI were heated and frozen to find out their Th and the sal which will be the T and sal of the hydrothermal F responsible for tourmalinization. The order of tourmalinization occurrence is deduced from the thermometric data. According to these data, disseminated type of tourmalinization comes first followed by vein associated and lastly tourmaline quartz rock. (Author's abstract.)

ERDMAN, C.P. and **BARABAS A.H.,** 1995, Precious metal mineralization at Gold Mountain, Tonopah Divide District, Esmeralda County, Nevada (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A27-A28. First author at Boyajian and Ross, Inc., 1320 E. Shaw Ave., Suite 144, Fresno, California 93710.

Gold mineralization correlates closely with low-T potassic alteration, defined by adularia replacing both plagioclase and earlier hydrothermal albite, and by some associated white mica. Potassic alteration overprinted pervasive propylitic alteration (albite replacing plagioclase, adularia replacing only sanidine; ± white mica, smectite, chlorite, rutile, calcite, and pyrite). District-scale propylitic alteration occurs nearly everywhere on Gold Mountain. In contrast, potassic alteration is generally limited to selvages around gold-bearing veins. Within narrow zones of potassic alteration, replacement of plagioclase and albite by adularia is rarely complete. Potassic alteration was generally not discernible in the field; petrographic examination was necessary to determine its distribution. Latest stage silicic alteration, defined by quartz replacing plagioclase and white mica in wallrocks, occurs at high structural and topographic levels.

The mean Th for FI in both vein quartz and wall rock adularia which replaced sanidine (i.e. propylitic alteration) is 245°C (N = 444). Sal range from 0.0 to 2.4 eq. wt.%NaCl. T-sal relationships suggest that the hydrothermal F upwelled, and possibly boiled in the central and eastern portions of the flow-dome complex, and flowed laterally westward while cooling with little change in sal. Gold-bearing propylitizing F as depth were channeled upward into late-stage fractures where Gold Zone mineralization formed concurrently with potassic alteration of adjacent wallrocks. (From authors' abstract by H.E.B.)

ERDMAN, C.P. and **BARABAS, A.H.,** 1996, Precious metal mineralization at Gold Mountain, Tonopah Divide District, Esmeralda County, Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 329-351. First author at Boyajian and Ross, Inc., 1320 E. Shaw Ave., Suite 155, Fresno, CA 93710.

In the Tonopah Divide district are volcanic-hosted, adularia and sericite-bearing epithermal precious metal deposits of middle Miocene age. Detailed mapping revealed five types of silicified hydrothermal veins and breccias. Oldest are Stage 1, gold-poor, chalcedonic-drusy quartz microbreccias. These were followed by three types of Stage II structures that contain sulfide oxidation products and the main gold concentrations. Post-mineral Stage III structures include faults and gold-poor stony chalcedony veins; gold is restricted to vein filling and microbreccia; wallrocks contain little mineralization.

Gold mineralization correlates closely with fracture-controlled low-T potassic alteration, defined by adularia replacing both plagioclase and earlier hydrothermal albite, and by some associated white mica. Potassic alteration overprinted pervasive, district-scale propylitic alteration.

The propylitizing F, contained in abundant PFI in adularia replacing sanidine, were trapped in the L phase, mainly between 235°C and 250°C. Subsequently, F producing both gold mineralization and potassic alteration apparently upwelled into the Gold Zone fractures and were trapped in vein quartz, locally at T at least 10°C greater than those at which propylitic alteration had formed in the immediately surrounding wall rocks. Some boiling appears to have occurred at this stage. Similar, low apparent sal ranges (0.0 to 2.4 wt.% eq. NaCl) were determined for the propylitizing F; the F that produced mineralization and potassic alteration; and slightly cooler, late-stage F trapped in SI in vein quartz. FI were also used to infer a minimum depth of formation of approximately 550 m (1,800 ft.). (From authors' abstract by E.R.)

ERTAN, I.E. and **LEEMAN, W.P.,** 1996a, Fluid inclusion studies in xenoliths of the Cascades subarc mantle (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 44. Keith Wiess Geological Laboratory, MS 126 Rice Univ., Houston, Texas 77005-1892; e-mail (evren@owlnet.rice.edu)

Pure CO_2 I with or without V bubbles, up to 50 microns in length occur as S or pseudosecondary I mostly in ortho- and clinopyroxene in websterite- and orthopyroxenite-, and rarely in olivine in dunite xenoliths in basaltic lavas of the Simcoe volcanic field. These xenoliths are invaded by alkali- and silica-rich glasses (phonolithic-trachytic) that are not related to the host lavas. Almost all of the S I can be traced back to glass veins which percolated along the grain boundaries. Necked-down and vermicular M I (some vitrified glass) in websterites are also common features. In some very coarse grained websterites dark, negative crystal-shaped S CO_2 I lie parallel to exsolution planes of Opx-Cpx lamellae, blades of spinels, melt inclusions, [and] along with trains of sulfide blebs. CO_2 I are particularly abundant and diverse in a rare phlogopite-bearing olivine orthopyroxenite and usually occur in the healed fractures or cleavage planes of orthopyroxenes along with metasomatizing M and newly formed phlogopites.

The entrapment P and T of these FI are calculated by using the MacFlincor program (Brown, 1992). Calculated representative isochores for the lowest and highest density CO_2 I suggest the existence of several generations of densities between ρ = 1.07-0.58 g/cc in phlogopite-bearing olivine orthopyroxenite and websterite xenoliths. Assuming equilibration T of 1000-1060°C, entrapment P of the highest density I are estimated to be ~9-9.5 kb. The lowest density S CO_2 I suggest a P of ~2 kb. This range in P may simply reflect progressive F entrapment during ascent; low density S I may be either retrapped, decrepitated P I or CO_2 exsolved from the host lava. Because high P FI are rarely preserved due to deformation or decrepitation during ascent in hot lava we consider 9-9.5 kb to be a minimal depth of entrainment for these xenoliths and thus olivine orthopyroxenite and websterite were probably derived from a subarc mantle domain corresponding to at least ~30 km depth. (From authors' abstract by E.R.)

See also next item (E.R.)

ERTAN, I.E., and **LEEMAN, W.P.,** 1996b, Metasomatism of Cascades subarc mantle; evidence from a rare phlogopite orthopyroxenite xenolith: Geology. (Boulder), v. 24, no. 5, p. 451-454.

Ultramafic xenoliths in the southern Washington Cascades lavas provide a rare view of the upper mantle beneath a convergent margin volcanic arc. An unusual olivine orthopyroxenite from this xenolith suite shows evidence of extreme multistage metasomatism involving infiltration of high K_2O silicic M and CO_2 F, replacement of olivine by orthopyroxene, and entrapment of F, M, and phlogopite inclusions within orthopyroxene--all prior to its entrainment in the host basaltic magma. Analyses of minerals, glass, and FI show that the mantle source of this rock was ≥ 30 km below the surface and reached a T of at least 1000°C–possibly in response to basaltic underplating. This region of the mantle was previously enriched in silica and potassium, but not necessarily due to subduction processes. The metasomatic M may be derived from an accreted slab of oceanic lithosphere, as opposed to a subducting oceanic plate. (Authors' abstract)

ESPINOLA, M.R., SOLER, A., and **ARCOS, D.,** 1996, Tungsten-bearing ores related to the Santa Coloma granodiorite (Andorra) (in Spanish; Engl. abst.): IV Spanish Geological Congress, Universidad de Alcalá, 1-5 July, 1996, published in Geogaceta, V. 20, p. 1586-1589. Authors at Departamento de Cristal Iografia, Mineralogia i Diposits Minerals, Univ. Barcelona, C/Marts i Franques s/n, 08028 Barcelona.

The late Hercynian Santa Coloma granodiorite intruded Paleozoic metasediments of upper Ordovician to Devonian age. Several forms of tungsten-bearing ores are found associated to the Santa Coloma granodiorite in the Central Pyrenees: veins, filled joints and skarns. FI study in quartz crystals from veins suggests that the mineralising fluid was a polysaline brine (22 wt% NaCl eq.) which was trapped at 360 ± 30°C and 2.5 ± 0.3 kbar, even the first mineralizing stage could be formed at higher T (up to 500°C). Preliminary data of $\delta^{34}S$ of sulphides from skarn and vein mineralizations show values near 5 ± 1‰ suggesting a sulphur of magmatic origin. (Authors' abstract.)

ESSARRAI, S., BOIRON, M.C., CATHELINEAU, M., PIRONON, J.,

CHOUHAIDI, M.Y., MELLAL, A., and EL BOUKHARI, A., 1996, Fluids associated with silver-bearing mineralizations in the Zgounder deposit, Anti-Atlas, Morocco (abst.): 16th Earth Sciences Meeting, [Abstracts}, pub. by Soc. Géol. Fr., Paris, p. 154 (in French). First author at Faculté des Sciences et Techniques, B.P. 618, Marrakech, Morocco.

The silver-bearing deposit of Zgounder occurs in metamorphosed Precambrian schist and sandstone intruded by a dolerite sill. Two important polyphase hydrothermal mineralization stages have been identified: (i) a stage with sulfides (Fe, Fe-As, Co-Ni, Zn) ± quartz, without associated silver-bearing mineralization; (ii) a later stage with sulfides and sulfosalts of silver, Ag-Hg amalgam, native silver, chalcopyrite and galena.

Two types of F exist: 1) Early aqueo-carbonic F of the system C - H - O - N - (NaCl), in association with quartz Q_1, tourmaline and biotite. The F have a high Th: 300-520°C (mode: 380-440°C), and medium sal: 4-10 % eq. NaCl. The composition of the gaseous phase (Raman) is: CO_2 68-97 mole%, CH_4 1-28 mole%, N_2 0-16 mole%, and 2) Later high-sal aq F of the system H_2O - LiCl - NaCl in two generations: (i) a first F supersaturated with halite, contemporaneous and slightly later than quartz generation Q_2, associated with an important deposit of chlorite and sphalerite; this F has relatively low Th (120-180°C) and a sal of about 32% eq. NaCl; (ii) a colder F (Th = 50-180°C) of medium sal. It was identified in F-I planes cutting through all quartz and through the host rocks. It is probably responsible for the deposit of the economic hydrothermal silver-bearing mineralization. (From authors' abstract, translated by E.A.J. Burke.)

ETOH, Jiroh, TAGUCHI, Sachihiro, IZAWA, Eiji and GOKOU, Kazunori, 1996a, The distribution of homogenization temperatures of fluid inclusions from KE1-4 drillhole in the Ogiri geothermal field, West-Kirishima, Japan: Geothermal Research Report of Kyushu Univ., 1996, no. 5, p. 79-90 (in Japanese; Engl. abst.).

The Th of FI in hydrothermal minerals from KE1-4 drillhole in the Ogiri geothermal field have been measured. The measured T of geothermal F is about 220°C in the depth from 1420 to 1760 m. In broad distribution of Th of FI, the minimum values will correspond to the present T. In the past, the T of geothermal F was about 250°C below 1800 m. Boiling of geothermal F was revealed by observation of FI. (Authors' abstract)

ETOH, J., TAGUCHI, S., IZAWA, E. and GOKOU, K., 1996b, The distribution of homogenization temperatures of fluid inclusions from KE1-4 drillhole in the Ogiri geothermal field, west-Kirishima, Japan: Geothermal Reserach Report of Kyushu Univ., no. 5, p. 79-90 (in Japanese; Engl. abst.).

ETTNER, D.C., LINDBLOM, Sten, and KARLSEN, Dag, 1996, Identification and implications of light hydrocarbon fluid inclusions from the Proterozoic Bidjovagge gold-copper deposit, Finnmark, Norway: Applied Geochem., v. 11, p. 745-755.

Carbonic FI were observed in quartz-bearing veins at the Proterozoic-Bidjovagge Au-Cu deposit within the Kautokeino greenstone belt in Norway, where mineralization occurred in oxidation zones of graphitic schists. A primary FI zonation was observed with CO_2-rich FI in the structural footwall of the deposit, and CH_4-rich I within the ore zone in the oxidation zone. Microthermometry of the P hydrocarbon I revealed 2 groups; (1) a group which homogenized between -125°C and the critical temperature of CH_4 (-82.1°C), which indicated the presence of pure CH_4, and (2) a group which homogenized between the critical T of CH_4 and -42°C, which indicated the presence of CH_4 and higher hydrocarbons (HHC). Raman microprobe analyses of the first group confirmed the presence of CH_4. The second I group was fluorescent, and Raman spectra clearly displayed CH_4, C_2H_6, and rarer C_3H_8 peaks. A typical feature of the Raman spectra were elevated baselines at the hydrocarbon peaks. Carbon peaks were usually detected in each I by Raman analysis. Bulk G chromatography analyses of samples containing the first group (CH_4) indicated the presence of CH_4 and low concentrations of C_2H_6 and C_3H_8. G chromatography analyses of samples containing the second group (CH_4 and higher hydrocarbons) confirmed the presence of CH_4, and higher hydrocarbons such as C_2H_6 and C_3H_8 and also butanes. Based on the spacial zonation of hydrocarbons and the estimated P-T conditions of 300 to 375°C and 2 to 4 kbars, the authors suggest an abiotic origin for the hydrocarbons. It is suggested that the hydrothermal F oxidized the graphitic schist, precipitated Cu and Au and formed light G hydrocarbons. (Authors' abstract)

EVANS, M.A. and BATTLES, D.A., 1996, Characterization of a late Alleghanian fluid migration event in the central Appalachians: The Geological Society of American, 31st Annual Northeastern Section, 1996 Abstracts with Programs, v. 28, no. 3, p. 52, February 1996. First author at Dept. of Geol. and Planetary Sci., Univ. of Pittsburgh, Pittsburgh, PA 15260.

FI microthermometric data and stable isotope data from vein minerals confirm a Late Alleghanian F migration event in the central Appalachian Valley and Ridge province. The migrating F was a CH_4-saturated NaCl/$CaCl_2$ brine that is stratigraphically zoned into two distinct intervals based on sal. The low sal F (9 to 14 wt.% NaCl eq.) is generally restricted to the stratigraphic interval above the Devonian Marcellus Fm., while the higher sal F (up to 22 wt.% NaCl eq.) is restricted to the Marcellus and Oriskany Formations, and locally stratigraphically lower units. The Marcellus acted as a barrier to F communication between the two intervals. The F also contains minor CO_2.

Minimum T of the F ranged from 230 to 250°C in the eastern Valley and Ridge province to 160 to 200°C near the Alleghany structural front in the west. These T values are above 'background' T of approximately 180°C in the east to 120°C in the west as determined from CAI values and FI not associated with the F migration event. This suggests a cooling of the F as it migrated 30 to 45 km across the province. F sal shows a general trend of lower sal in the east and higher sal in the west.

The passage of the migrating F is interpreted to be synfolding. The FI recording the event are found in bed-parallel veins, bed-normal/strike-parallel beins, and bed-normal cross-fold veins that are mineralized with late quartz and chlorite. In some veins, early calcite is partially dissolved with the quartz embayed into it, and calcite fragments occur as I within the quartz.

The migration event may be directly related to 1) late Paleozoic remagnetization of Devonian clastic and carbonate rocks; 2) 'flushing' of hydrocarbons from the Upper Paleozoic of the Valley and Ridge into the Plateau province; 3) elevated vitrinite reflectance values in the Plateau province near the structural front, and 4) widespread chloritization of upper Devonian rocks, particularly in the hinterland portions of the province. (Authors' abstract)

EVANS, W.C., 1996, A gold mine of methane: Nature, v. 381, p. 114-115.

A review of the various possible mechanisms of origins of the CH_4 found in deep sea vent fluids and in fluid inclusions in dredge samples.

See also Kelley, this volume. (E.R.)

EYRE, S.L., WILKINSON, J.J., STANLEY, C.J. and BOYCE, A.J., 1996, Geochemistry of dolomitization and zinc-lead mineralization in the Rathdowney Trend, Ireland (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A210–A211. First author at Dept. Of Geol., Imperial College of Sci., Tech. And Medicine, London SW7 2BP, U.K.; e-mail (s.eyre@ic.ac.uk)

The Rathdowney Trend, a 40 km long NE-SW trending belt of carbonate rocks in the Irish Midlands, contains the Mississippian (Waulsotian) mudbank-hosted zinc-lead deposits of Lisheen and Galmoy. A complex paragenetic sequence of dolomitization and sulphide precipitation is observed in the Lisheen area. Five dolomitization events are recognized: (1) regional fine replacive; (2) regional coarse white; (3) hydrothermal white matrix breccia (WMB); (4) ?hydrothermal black matrix breccia (BMB); and (5) late vein and vug-filling ferroan dolomite, pink dolomite and calcite. Each has been characterized by its CL properties. Major and minor trace elements (Ca, Fe, Mg, Ba, Sr, Ce, Mn) generally correlate with luminescent properties. FI data show that the WMB dolomite was precipitated from a moderate T (170-230°C), moderate sal (5-17 wt.% NaCl eq.) F precipitated the late pink dolomite. Pyrite, marcasite, galena and sphalerite, and minor chalcopyrite, aresenopyrite and tennantite are common to all sampled localities. Widespread replacement textures support dominantly post-depositional mineralization. Epigenetic open-space textures and crosscutting veins are volumetrically minor. A few layered ores with soft-sediment features are suggestive of some early diagenetic mineralization. Lisheen sulphides show a broad range of $\delta^{34}S$. Early pyrites ($\delta^{34}S$ -24 to –40 per mil) are interpreted as resulting from bacteriogenic reduction of Lower Carboniferous seawater sulphate. Later sphalerite and galena (–10 to –15 per mil) are consistent with a bacteriogenic sulphide source, but may indicate mixing with a deeper hydrothermal sulphur source, a characteristic seen in some of the other Irish deposits. Sulphides from sub-economic deposits and prospects have considerably higher d34S than Lisheen (–10 to +10 per mil), suggestive of a purer deep hydrothermal component. (Authors' abstract)

FAINGHERSH, Lidia, 1996, Geochemical conditions of accumulation of non-hydrocarbon compounds in hydrocarbon pools: nitrogen, helium, and carbon dioxide in gas fields of central Europe (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 891. Author at VZG, Russia.

We hypothesize that concentrations of non-hydrocarbon G in pools of natural G are controlled by solubilities of these G in underlying formational water. This hypothesis is valid if a phase equilibrium between free non-hydrocarbon G dissolved in water exists in all or, at least, in the majority of G fields. The existence of the phase equilibrium results in the approximate equality of partial P of each non-hydrocarbon component in free and water/dissolved phases. The solubility of each non-hydrocarbon G is affected by T, P, and water sal. (From author's abstract, by E.R.)

FAN, Qicheng, LIU, Ruoxin, LIN, Zhuoran, CHU, Xuelei, ZHAO, Rui and HUO, Weiguo, 1996, Preliminary study of carbon isotope in mantle CO_2 fluid inclusion from eastern China: Geochimica, v. 25, no. 3, p. 265-269 (in Chinese, Engl. abst.).

CO_2 in xenoliths containing CO_2-rich FI (including twelve peridotites and one granulite) in Cenozoic basalt from eleven regions of eastern China has been extracted using method of decrepitation through step heating, and its carbon isotopes have been determined. The results show that $\delta^{13}C$ at 800°C mainly ranges from –16.0‰ to –22.0‰, while that at 100°C from –21.0‰ to –29.0‰. There exist low $\delta^{13}C$ and inhomogeneity of carbon isotopic composition in mantle F from eastern China, and high T carbon has an even lower $\delta^{13}C$. No significant correlation has been shown between carbon and oxygen isotopes. (Authors' abstract)

FARAJ, B.S.M., FIELDING, C.R., and MACKINNON, I.D.R., 1996, Cleat mineralization of Upper Permian Baralaba/Rangal Coal Measures, Bowen Basin, Australia: *in* Gayer, R. and Harris, I., eds., Coalbed Methane and Coal Geology, Geological Society Special Publication No 109, p. 151-164.

Coals from the Permo-Triassic Bowen Basin have been investigated using a variety of complementary analytical techniques [including FI?]. Face cleat minerals in the studies samples are dominated by authigenic clays, notably pure illite or illite-chlorite mixtures. Butt cleats and joints are dominated by carbonates, mostly calcite with less abundant ferroan calcite, ankerite and siderite. (From authors' abstract by H.E.B.)

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: Noble Gas Geochem. and Cosmochem., Matsuda, J. (ed.), Terra Scientific Publishing Company, Tokyo, 1994, p. 159-178. First author at Div. of Geol. and Planetary Sci., MS 170-25, Caltech, Pasadena, CA 91125, USA; e-mail (farley@legs.gps.caltech.edu)

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 crushng 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 ^{4}He-^{21}Ne*-^{40}Ar* systematics close to long-term closed-system behavior, the comparatively G-poor samples have lost *up to* 90% of their helium without concomitant loss of neon and argon. This likely represents diffusive loss of helium after FI entrapment. (Authors' abstract)

FARROW, C.E.G. and WATKINSON, D.H., 1996, Geochemical evolution of the epidote zone, Fraser mine, Sudbury, Ontario: Ni- Cu - PGE remobilization by saline fluids: Exploration and Mining Geol., v. 5, no. 1, p. xx - xx.

FAUZI, H., SOLOVOVA, I.P., BABANSKII. A.D., and RYABCHIKOV, I.D., 1996, Formation conditions of veined fluorite Khomrat Akarem, Egypt (inferred from inclusion study): Geokhimiya, 1996, no. 1, p. 36-40 (in Russian, Engl. abst., translated in Geoch. Int'l., v. 34, p. 32-xy.)

FI in veined fluorite were studied. The Khomrat Akarem fluorite deposit is shown to have been formed in the T range of 320-95°C, under a P of 500-800 bar, with the involvement of high- and low-mineralized F (0.1-4.3 and 13.5-19.0 eq. wt % NaCl, respectively). Low-mineralized solutions could arise from the cooling of F-bearing essentially chloride F, which were derived from a residual granitic M at a T of about 550°C. Carbon dioxide F did not take part in the ore deposition and was present only during the late stage of fluorite vein carbonatization. (Authors' abstract)

FENG, Jianzhong, 1996, The geologic features and metallogenesis of the Maotang and Putang gold deposits hosted in breccia pipe in Henan Province (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 774. Author at Beijing Inst. for Geol. for Mineral Resources, China.

The Maotang and Putang gold deposits are hosted in breccia pipe related to a granite. [Alteration includes] silicification, pyritization, sericitization, carbonatization and kaolinization. The differences in T, F and ore-forming condition cause the Maotang and Putang gold deposits [to] have different fineness. The fineness of the former is 917.8~969.16 with T 200~600°C, sal 20~45 wt% NaCl and complex FI. The fineness of the latter is 620.49~906.81 with T 175~350°C, sal 5~15 wt% NaCl and simple FI. The ore deposits were formed under the conditions P = 180 x 10^5 ~ 560 x 10^5Pa, pH = 6.77~8.31, Eh = -0.67 ~ -0.89 ev. The deep derived sulfur is convinced by the δ^{34}S 0.12~3.9%. The much more meteoric water involved in the ore-forming process is supported by $\delta^{18}O_{water}$ 2-.95 ~ -8.6% and δD -35.9 ~ -97.8%. The deposition of gold is related to the dilution of F caused by the mix of meteoric water after boiling. (From author's abstract by E.R.)

FENG, Youli and ZHANG, Dongnan, 1996, Researching on the characteristics of geochemistry and metasomatite of Caijiaying Pb-Zn-Ag deposit (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 651. Authors at Inst. of Geol. Sci. of Henan Prov., China.

The Caijiaying Pb-Zn-Ag polymetal deposit is in volcanic rock series of Jurassic system. The H, O, C isotopes indicate that ore-forming solution belongs to the ordinary magmatic hydrothermal and may be effected [affected?] by groundwater. The analyses of FI shows the property of ore-forming solution was from weak acid to weak basic; mineralizing T between 150-300°C. Comprehensive study shows the genesis of the deposit belongs to stratabound volcanic hydrothermal. (From authors' abstract by E.R.)

FENG, Zhongyan and CHANG, Zhaoshan, 1996, Mineralization and rock alteration associated with igneous intrusion in the southern eastern Shanxi province, China (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 620. Authors at Dept. of Geol., Peking Univ.

There are more than fifty igneous intrusions in southern eastern Shanxi province, China. Most of the intrusions are large composite sills, formed by separate injections of gabbro, gabbro-diorite and diorite magmas. Four successive stages of skarnization and iron mineralization have been noted:

1. Diopsite-andradite stage: magmatic hydrothermal F which rose along the intrusive contact and other structures interacted with limestone and yielded skarn characterized by diopsite and andradite. The average Th and average sal of diopsite is 580°C and 65 wt.% NaCl; of andradite is 499°C and 26 wt.% NaCl.
2. Epidote-iron oxides stage: the chief minerals of this stage include magnetite, hematite, epidote, actinolite, quartz and fluorine. The average Th of epidote is 422°C, average sal 41 wt.% NaCl.
3. Chlorite-metal sulfides stage: chlorite, serpentine, calcite, pyrrhotite, chalcopyrite, galena and sphalerite.
4. Carbonates stage: calcite with few dolomite deposited, often as veinlets. The average Th of calcite is 246°C, average sal 30 wt.% NaCl. (From authors' abstract by E.R.)

FERKOUS, K., MONIÉ, P., RAMBOZ, C., CABY, R., LEBLANC, M., and BÉNY, C., 1996, The Amesmessa-Tirek gold-bearing district in the Pan-African lithospheric shear zone in East Ouzzal (Hoggar, Algeria): geodynamic evolution and gold deposition (abst.): 16th Earth Sci. Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 154 (in French). First author at ORGM, C.P. 102, Boumerdès, Algeria.

A shear zone (SZ) is cut by N-S quartz veins which developed in the greenschist facies a peripheric alteration mineralized with gold. E-W quartz veins, undeformed and without mineralization, also cut the SZ. Fluid inclusions (FI) have been studied in quartz from the cores of the SZ (N-S veins) and on both sides of the SZ (leptynites on the west, E-W veins on the east). The primary FI in the N-S veins contain compressible F, carbonic with low water contents, probably mixtures of two extremes, aq and carbonic. These FI represent the early circulation of abnormally hot (550-400°C) and reduced (fO_2=QFM) F under variable P (P = 2.5-1.5 kbar). Then synkinematic fractures were opened and trapped several F phases, aqueo-carbonic and high-sal aq (21-13 eq NaCl). These F are responsible for the hydrothermal alteration around the veins. Each hydrothermal stage accompanied the uplift and cooling of the structure (420<T<170°C, 0.7<P<1.5 kbar). More diluted F were trapped during a late N-S fracturing, limited in time and possibly very diachronous, contemporary with the deposition of visible gold and of galena and pyrite in dissolution cavities in quartz. On both sides of the SZ F events are recorded (aq and/or carbonic) which accompany the uplift of the structure. Minimum Th in the leptynites, however, are 65°C and 30°C lower than those measured in the oblique planes in quartz of the SZ and of the E-W veins. This suggests that a thermal asymmetry was present near the SZ for the greater part of the uplift period. (From authors' abstract translated by E.A.J. Burke.)

FERNANDES, P.C.A., GIULIANI, Gaston and McREATH, Ian, 1996, Uranium and molybdenum mineralizations of early Proterozoic charnockites and granites of Itaberaba (Bahia, Brazil) (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual Meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A29. First author at CPRM, UFBA, Salvador, Brazil; e-mail (pcda@pppg.ufba.br)

Transamazonian (~2.15 Gy., Rb-Sr) molybdenum and uranium rich peraluminous high-silica hypersthene granites and biotite-granites have been intruded in a transitional interface between the Archean granulitic Jequié Nucleous and the early Proterozoic amphibolitic/granulitic Salvador-Curaçá mobile belt.

Molybdenite mineralization is present in the Itaberaba and Pedra d'Água massifs, but also in smaller dyke-like bodies. The Itaberaba massif is a sheet-like N-S 30 km long body of mostly biotite-porphyroid granites besides differentiated lenses of garnet-biotite and garnet-allanite leucogranites and pegmatites. Molybdenite is present as small specks in the latter.

The Pedra d'Água massif is composed of hypersthene ± garnet leucogranites with accessory uraninite. Uranium enrichment goes up to twenty times the granitic average, and these rocks host the most important molybdenite mineralizations in the area. Molybdenite is present as: (i) disseminations in granites and in biotite-cordierite-garnet-zincian spinel-plagioclase enclaves; (ii) specks in diffuse quartz-rich pegmatites and aplites which grade into quartz veins; (iii) late quartz veins.

Mineralization is believed to have taken place from the early magmatic stage through high T pegmatitic/hydrothermal stage and low T hydrothermal stage. Carbonic connate FI in quartz from the early veins indicate T = 720°C; P = 3.5 kb. The composition of lower T FI, as well as enrichment in SiO_2, P_2O_5, HREE, F, Cl, Li, W, U, Nb, Zr, and Th in mineralized granites indicates the presence of a CO_2 and Cl rich V phase. Mo and U enrichment occurred in response to small degrees of crustal melting under high pCO_2, producing peraluminous silicic magma in a granulite facies setting. Molybdenite grades (0.42%) are high, but the mineralized area is small and access is difficult. (Authors' abstract)

FERNANDEZ, J.C., CASQUET, Cesar and **GALAN, Emilio,** 1996, Complex multiphase fluid inclusions in wollastonite from the Merida contact-metamorphic deposit, Spain; evidence for rock/HCl-rich fluid interaction: European J. of Mineral., v. 8, no. 5, p. 1015-1026.

Full paper for previous abstract (E.R.)

Primary multiphase FI are abundant in skarn wollastonite from a contact-metamorphic aureole near Mérida, Spain. Wollastonite is found along the boundaries between marble and interbedded metachert layers and nodules. At room T, FI consist of an aq L, a bubble and several solids (wollastonite, calcite, apatite, quartz, halite and sylvite have been identified). Wollastonite and calcite are always present and show a fairly uniform phase ratio suggesting that they are dm. The solid assemblage, except the chlorides, does not dissolve appreciably, even at 550°C. Two types of FI are found: Type 1, which contains no visible halite and sylvite, and Type II, which contains halite (± sylvite). The first type seems to be ubiquitous within the aureole, whereas the second is restricted to the proximity to the granite contact.

An estimation of the composition of the trapped F has been made for two cases of Types 1 and II FI. They were highly saline brines, especially the Type II F. Total sal is 52 wt.% in the case of Type I F, and rises to ca. 69 wt.% in Type II F. The $CaCl_2$ content is remarkably high (ca. 39 and 45 wt.% respectively); silica content (as SiO_2^0) is also high in both cases (11.2 and 7.4 wt.% respectively) and CO_2 molar fraction is close to 0.05 in both F. These F are interpreted as exhaust F resulting from the wollastonite-forming reaction.

Taking into account the inability of H_2O - NaCl F to incorporate significant amounts of Ca into solution, we suggest that HCl of granitic origin was an important component in the P F entering the marble-metachert sequence, thus explaining the high solubility of wollastonite and calcite (and probably also quartz) at the expected Tt of the FI. This P F was a moderately saline brine with H_2O - NaCl - (KCl $MgCl_2$) - HCl and aq SiO_2, as major components, and minor amounts of CO_2 and P. The range of F compositions recorded by FI can be explained as a result of mixing of either the P F, or the exhaust F, with a low-sal brine. Precipitation of wollastone (and probably also in part, calcite and quartz) inside FI was probably favoured by outward diffusion of hydrogen through the wollastonite host. (Authors' abstract)

FISHER, D.M., 1996, Fabrics and veins in the forearc: a record of cyclic fluid flow at depths of <15km: *in* Geophysical Monograph 96, p. 75-89.

Quotes from data from FI studies (E.R.)

FOMIN, Yu.A., DEMIKHOV, Yu.N., SHIBETSKY, Yu.A., LASARENKO, E.E., and **BLAZHKO, N.I.,** 1996, Gold-polymetallic mineralization of Balka Shyroka (Mid Dneiper Area): Mineralog. Zhurn., v.18, no. 1, p. 74-87. (In Russian; Engl. abstract)

On the strength of mineralogic-geochemical, isotopic and thermobarogeochemical data we propose [a] many-staged ore-system evolution, including P ore mineralization of volcanogenous nature, areal metamorphism followed by diaphthoresis, [and] epithermal substance redistribution in the berezite zone. During the final period of the process, gold-polymetallic mineralization was precipitated from near neutral or slightly alkaline F (pH 6-7), at reduced situation (lgf_{O_2} -39 ... -38), under high sulphur activity conditions (lga_{S_2} -15.7 ... -13.4), at T range 260-175°C. (Authors' abstract)

FORSBERG, P., STURKELL, E.F.F., BROMAN, C., and **TORSSANDER, P.,** 1996, Stable isotopes and fluid inclusions in cavity grown minerals from the Lockne impact breccia, Jämtland, Sweden (abst.): Short Papers and Abstracts for the Jubilee Meeting–"Current Problems, Ideas, and Results in Geology"–Stockholm 16-18 October 1996 at the celebration of the 125th anniversary of The Geological Society of Sweden; edited by Björn Sundquist; GFF, V. 118, Jubilee Issue, 1996, p. A-99. Authors at Dept. of Geol. and Geochem., Stockholm Univ., SE-106 91 Stockholm, Sweden.

The Lockne impact structure was formed c. 455 Ma ago during the Middle Ordovician. The impact took place in a marine environment, with a water depth exceeding 100 m. The Proterozoic basement, dominated by the Revsund granite, is overlain by c. 20-25 m of Cambrian alum shale and 50-55 m of Lower Ordovician orthoceratite limestone. The impact structure is a nested crater with an inner crater (7.5 km diameter) in crystalline basement. The surrounding outer crater is floored by the crushed top surface to the basement and marine sedimentary rocks. The diameter of the entire structure is 13.5 km. The crater is filled with brecciated and fractured rocks. The clasts in the lowermost part, the impact breccia, are composed of local basement rocks. This breccia grades outwards and downwards into a zone of shattered rocks. The resurge material forming the upper part of the breccia is largely composed of clasts of Lower and Middle Ordovician orthoceratitic limestone and subordinate Cambrian shales and Proterozoic basement rock. The Lockne area has been affected by Caldonian overthrusting and associated low thermal metamorphism. The maximum metamorphic T did not exceed 300°C as shown by conodont alteration color, the presence of laumontite and degree of crystallinity of the alum shale graphite.

Drilling and geophysical measurments have shown that fractured basement occur to a depth of at least 2 km. The breccia and the shattered basement were initially rich in open cavities that became partly or totally filled with calcite. Many of the cavities are still not completely filled. Other cavity grown minerals are quartz, chalcopyrite, pyrite and minor galena.

Stable isotope analysis of sulphides (S) and calcite (C, O) and FI studies were performed on minerals from cavities in the breccia using drillcore material and on five reference samples from the area.

Microthermometry and Raman microspectrometry on hydrocarbon FI in quartz crystals grown in cavities reveal the presence of methane (XCH_4=0.95), ethane and possibly aromatic hydrocarbons. Calcite-filled interstices between the breccia fragments contain two-phase aq I with sal in the range 17-29 eq.wt.% $CaCl_2$ which display homogenization to L at T from 100 to 180°C. Similar aq I, that in addition contain a hydrocarbon phase, occur below the 140 m level in the drillcore; these have Th between 180 and 220°C. The higher T are due to heterogeneous trapping of water and hydrocarbons which gives too high values. Late calcite crystals in open vugs carry aq I of low T and sal (<1 eq.wt.% $CaCl_2$).

The $\delta^{12}C$ range for calcite is between -2 and -14‰ (PDB), which suggests mixing with carbon from a marine and an organic source. The presence of hydrocarbon-bearing I supports the involvement of an organic component. The variation in $\delta^{18}O$ values for calcite is small, varying from +10 to +14‰ (SMOW). This is consistent with the uniform Th of the aq I. Using the T obtained for the aq I and assuming that water was in equilibrium with calcite during deposition, the oxygen composition may indicate a meteoric or seawater source.

Our study shows that the impact structure acted as a trap for the hydrocarbons and aq solution precipitating calcite and sulphides. The heat produced as a result of the impact only generated a low hydrothermal system. There is no indication of a heat source such as a M as a result of the impact, which is remarkable for a structure of this size. (From authors' abstract by E.R.)

FORTES, P.de T. F.de O. and **GIULIANI, Gaston,** 1996, Fluid inclusion studies associated with massive and disseminated sulphide and quartz vein ore bodies from the Mina III, Mina Nova and Mina Inglesa gold deposits, Crixás greenstone belt, Brazil (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 45-47. First author at Instituto de Geociências/Universidade de Brasília (Brasília, DF, Brazil-70910-900)

The Mina III gold deposit has two main mineralized zones. The Upper Ore Zone (UOZ) is represented by massive sulphide within a sequence of marbles and schists. The Lower Ore Zone (LOZ) is represented by a concordant quartz vein within carbonaceous schist. The Mina Nova gold deposit occurs in carbonaceous schist and sericite-carbonate schist. The ore body of Mina Inglesa is a concordant quartz vein within talc schists.

Mineral paragenesis indicates metamorphism under epidote-amphibolite facies consistent with geothermobarometric data of silicates (450 to 550°C and 1.5 to 4.5 kb), followed by greenschist hydrothermal alteration consisting of silicification, sulfidization, sericitization, carbonatization and talcification, closely related to the mineralization.

Early FI consist of:

- H_2O-NaCl-KCl-CO_2-CH_4-N_2 (type S): saturated aq-carbonic F;
- CO_2-CH_4-N_2 (type C): carbonic F;
- H_2O-NaCl-CO_2-CH_4-N_2 (type LC): aq-carbonic F;
- H_2O-NaCl (types L and L'): aq F;
- (H_2O)-CH_4-N_2-(H_2S-C_2H_6) (types C' and CL', very rare).

Microthermometric data (halite dissolution, ice melting and clathrate melting T) indicate sal (in wt.% NaCl eq.) in the range of 30.7 to 52.7 (type S), 0.2 to 21.8 (type LC), and 0.4 to 13.8 (type L). Type S FI homogenize to the L in the range of 265 to 461°C (more commonly around 330°C) after halite dissolution. The other EFI types decrepitate or leak at T close to their total Th, in the same range as that of type S FI. At Mina Inglesa, ice melting T of type L indicate sal in the range of 1.7 to 20.9 and total homogenization occurs in the L phase from 170 to 317°C (more commonly around 240°C).

At Mina III and Mina Nova, the simultaneous trapping of C, LC and L EFI types, in the absence of recognizable leakage or necking down features, the presence of a wide range of degree of filling and of global compositions, and the fact that all of them decrepitate in the same range of T, allow us to propose a mechanism of heterogeneous trapping (immiscibility) for these FI. They may represent unmixed aquo-carbonic F (H_2O-NaCl-CO_2-CH_4-N_2 system), probably of metamorphic origin.

Type S EFI (H_2O-NaCl-KCl-CO_2-CH_4-N_2 system) may be related to metamorphic devolatilization reactions of the marbles, retrometamorphic processes and reactions of micas and amphiboles, as there are no geological evidences for magmatic or late circulation of basinal formation water processes. As they are much more common in the UOZ than in the LOZ or OB I, a lithological control in their generation is proposed, considering the presence of a thick sequence of marbles and of intercalated metabasic rocks associated with the UOZ.

Methane and nitrogen rich fluids (C' and CL' EFI types, (H_2O)-CH_4-N_2-(H_2S-C_2H_6) system) may have originated from metamorphic reactions involving carbon present in the carbonaceous schist, for which carbon stable isotopic data indicate an organic origin. The presence of C_2H_6 (detected by Raman microprobe) strengthens this possibility.

The type L EFI at Mina Inglesa probably reflect a lithological control on the generation and/or an evolution of the mineralizing F. The lower total Th and moderate to high sal are compatible with the association of gold and galena. (From authors' abstract by E.R.)

FOURCADE, S., KIENAST, J.R. and **OUZEGANE, K.,** 1996, Metasomatic effects related to channelled fluid streaming through deep crust: fenites and associated carbonatites (In Ouzzal Proterozoic granulites, Hoggar, Algeria): J. Metamorphic Geol., v. 14, p. 763-781. First author at Géosci. Rennes, Univ. of Rennes 1, Campus de Beaulieu, 35042 Rennes Cedex, France; e-mail (Fourcade@univ-rennes1.fr)

The In Ouzzal granulitic unit (IOGU) consists predominantly of felsic orthogneisses most of which correspond to granitoids emplaced during the Archaean, plus metasediments, including olivine-spinel marbles, of late Archaean age. All units were metamorphosed at granulite facies.

The stable isotope signature of the marbles does not record a massive streaming of C-bearing F during metamorphism. Most of the isotopic variation in the marbles is explained in terms of pregranulitic features. On the basis of the C isotope ratios ($\delta^{13}C$= -3.5 to -9.7‰), the F responsible for the crystallization of carbonates and metasomatic alteration is thought to be derived from the mantle, presumably through degassing of mantle-derived magmas at depth. Intense interaction with the crust during the upward flow of the F may explain its chemical and isotopic signatures. The zones of metasomatic alteration in the In Ouzzal granulites may be the deep-seated equivalents of the zones of channelled circulation of carbonated F described at shallower levels in the crust. (From authors' abstract by E.R.)

FOURNIER, R.O., 1996, Chemical and physical consequences in fluid movement from plastic into brittle rock in the magmatic-epithermal environment (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A333–A334. First author at U.S. Geological Survey, MS-910, 345 Middlefield Rd., Menlo Park, CA 94025; e-mail (rfourn@mojave.wr.usgs)

Deep drilling into presently active hydrothermal systems generally shows a brittle-plastic transition and increase in F P (Pf) to > hydrostatic at about 370-400°C. Rapid rates of alternating uplift and subsidence occur at some calderas, such as at Yellowstone National Park, Wyoming. Some or all of the uplift may result from accumulation of magmatic F in blister-like lenses at lithostatic P in plastic rock surrounding crystallizing magma. The subsidence can result from episodic release of F from the plastic region into the brittle epithermal region where Pf is about hydrostatic. Evolved magmatic F 2-5 km deep would be hypersaline brine and G. At high T and P this G is a potent solvent for silicates and salts. Solubilities of minerals in the G decrease markedly as P declines. Rupturing of lithostatically-pressured fluid-filled blisters, with release (injection) of G into cooler and brittle rock, results in deposition of various minerals, including quartz and gold. At the same time, non-reactive HCl° is generated by hydrolysis of salt (particularly $CaCl_2$). The HCl° moves with the G phase, and where steam condenses at the cooler reaches of the epithermal hydrothermal system the HCl° dissociates and attacks the surrounding rock. Hydrothermal brecciation occurs in the source region by expansion of F accompanying depressurization. It also occurs in the cooler, brittle rock as a result of rapid heating of F in cracks adjacent to new or reactivated channels of flow, much as poorly cemented casing collapses inward when hot F is first produced from a geothermal well. (Author's abstract)

FOWLER, A.D., and **L'HEUREUX, Ivan**, 1996, Self-organized banded sphalerite and branching galena in the Pine Point ore deposit, Northwest Territories: Canadian Mineralogist, v. 34, p. 1211-1222.

Pertinent to FI studies in sphalerite. (E.R.)

FRANZ, Gerhard, ANDREHS, Gerhard and **RHEDE, D.**, 1996, Crystal chemistry of monazite and xenotime from Saxothuringian-Moldanubian metapelites, NE Bavaria, Germany: European J. of Mineral., v. 8, no. 5, p. 1097-1118.

Full paper for previous abstract (E.R.)

FRANZ, Gerhard, GILG, H.A., GRUNDMANN, Günter, and **MORTEANI, Giulio**, 1996, Metasomatism at a granitic pegmatite-dunite contact in Galicia: The Franqueira occurrence of chrysoberyl (alexandrite), emeralds, and phenakite: Discussion: Canadian Mineralogist, v. 34, p. 1329-1331.

The authors disagree with both the data and the interpretation of FI studies by Martin-Izard et. al. (1995, FIR v. 28, p. 94).

See also rebuttal, Martin-Izard et. al., this volume (E.R.)

FRASER, S.C., 1996, Geology and geochemistry of the Prairie Creek Zn, Pb, Ag deposits, southern MacKenzie Mountains, N.W.T.: Master's thesis at Univ. of Alberta, Edmonton, AB, Canada, 146 pp.

The Prairie Creek dolomite-hosted Zn, Pb, Ag deposits located in the southern MacKenzie Mountains, N.W.T., consist of three distinct types of mineralization. These include 1) Type I stratiform mineralization which is characterized by banded, fine-grained pyrite and sphalerite in a mottled, chert-rich, dolostone unit of late Ordovician, early Silurian Whittaker Formation, 2) Type II, MVT-style mineralization, within middle Silurian, Root River Formation, and 3) a final phase of mineralization consists of cross-cutting, quartz-sulfide veins characterized by a more complex mineralogy consisting of pyrite, sphalerite, galena plus or minus tetrahedrite. Saddle dolomite gangue, associated with both types I and II mineralization, have distinctly different geochemistry. Gangue dolomite associated with Type I mineralization possess highly radiogenic $^{87}Sr/^{86}Sr$ isotopic ratios (up to 0.723), as Th 130°C) and heavy ^{18}O values (+23 per mil SMOW) support relatively low T of formation. Type I mineralization is interpreted as syndiagenetic with Zn-Pb mineralization forming within the Prairie Creek Embayment, interpreted by Morrow and Cook (1987), as an extensional tectonic structure associated with rifting. Dolomitic cement associated with Type II mineralization shows geochemical signatures characteristic of MVT mineralization. These include $^{87}Sr/^{86}Sr$ isotopic values of 0.710, ^{18}O values to +14 per mil SMOW, and ^{13}C values suggesting oxidation of organic matter. FI results from I in gangue dolomite and sphalerite indicate sal. >20 eq. wt.% NaCl and Th of 150-200°C. Type III mineralization is characterized by a broad spread in sal, Th, and ^{18}O values suggesting that meteoric F were subjected to extensive water-rock interaction through MacKenzie shelf carbonate rocks. Measured delta D values versus calculated ^{18}O values suggests that Type III mineralization is indicative of syn- to post-orogenic Laramide F, consistent with the findings of Nesbitt and Muehlenbachs (1994). While Pb/Pb isotopic values statistically all fall along a single isochron suggesting that all mineralization types have similar source and age, geological and geochemical variation for mineralization types suggests an alternative interpretation. This study suggests that mineralization types I and II are of Devono-Mississippian age, while Type III (silver-rich) mineralization falls along a lead line supporting a Laramide age for mineralization. (Author's abstract)

FREI, Robert, 1996, The extent of inter-mineral isotope equilibrium; a systematic bulk U-Pb and Pb step leaching (PbSL) isotope study of individual minerals from the Tertiary granite of Jerissos (northern Greece): European J. of Mineral., v. 8, no. 5, p. 1175-1189.

Full paper for previous abstract (E.R.)

FREZZOTTI, Maria-Luce, GHEZZO, Claudio, and **GIORGETTI, Giovanna**, 1996, Fluid regime in North Victoria Land (Antarctica) during Ross orogeny: evidence from fluid inclusions (abst.): 30th Int'l Geol.

Cong., Abstracts, v. 2, p. 484. Authors at Dip. Scienze Terra, Siena, Italy.

FI have been studied in selected metamorphic (Wilson Terrane HT-LP metamorphic sequence) and intrusive rocks (Cambro-Ordovician Granite Harbour Intrusives) from North Victoria Land in order to address the role of F phases during Ross orogeny.

Based on textural criteria, microthermometric measurements and Raman microspectroscopy analyses, four [three?] main types of FI represent the earliest F phases circulating in the different rock types:

1) mixed aqueo-carbonic (pure CO_2) FI (CO_2 ~ 50 mole%); 2) carbonic (CO_2 99 - 90 mole%, CH_4 1 - 10 mole% in the carbonic fraction) + water (< 10 to 50 mole% of the total I volume) I; 3) water I.

There is a clear relationship between dominant I type and host rock: Type 1 mixed aqueo-carbonic F have been recognised as magmatic stage F in intrusive rocks (both in mafic and acid rocks), and as F related to "in situ metling" in leucosomes of stromatic migmatites. The other I types are related to metamorphic processes and show differences according to the metamorphic grade: Type 2 carbonic I dominate in the medium to high metamorphics (mesosomes in migmatites, migmatitic gneiss and the biotite schiest): with increasing grade, the amount of methane and water decreases progressively. Type 3 are late aq F present in all investigated rocks and dominant in low grade metamorphics.

P-T evolution derived from the FI point substantially to an isobaric cooling at high T, followed by decompression below 400-450°C.

The tectono-thermal evolution of the Ross Orogeny in the Deep Freeze Range of Northern Victoria Land indicates for this area a typical example of high T-low P metamorphism during Cambro-Ordovician time. We propose that F phases played a fundamental role during the magmatic and metamorphic processes in Terra Victoria. In particular, we have evidence from FI studies that CO_2-H_2O rich F participated to and possibly triggered the metamorphic reactions. The ultimate origin of these CO_2-H_2O F is believed to be magmatic.

The F regime well fit in the proposed underplating and magmatic accretion model and give us evidence of a complex multistep evolution:

a) A first stage, with emplacement of mafic intrusives in the lower crust, release of $CO_2 \pm H_2O$ in the middle crust and possibly melting of pure crustal components.

b) A second stage with continuous emplacement of mafic intrusives and the remobilisation of the middle crust with formation of granitic melts which are the carrier of heat and $CO_2 + H_2O$. Emplacement in the upper crust of intrusives and release of $CO_2 \pm H_2O$ continued during the exhumation of the orogenic chain. (Authors' abstract.)

FREZZOTTI, Maria-Luce, NEUMANN, Else-Raghnild, TOURET, Jacques L.R., and VITI Cecilia, 1996, Carbonate melt-silicate melt-CO_2 immiscibility in the upper mantle, fluid and melt inclusion studies in composite xenoliths from La Gomera (Canary Islands) (abst.): 30th Int'l Geol. Cong., Abstracts, V. 2, p. 484. First author at Dip. Scienze Terra, Siena, Italy.

FREZZOTTI, Maria-Luce, TOURET, J.L.R., NEUMANN, Else-Raghnild and VITI, Cecilia, 1996, Carbonate melt-silicate melt-CO_2 immiscibility in the upper mantle, fluid and melt inclusion studies in composite xenoliths from La Gomera (Canary Islands) (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 484. First author at Dip. Scienze Terra, Siena, Italy.

Composite xenoliths in alkali-basaltic lavas on La Gomera (Canary Islands) consist of clinopyroxene-spinel-dunites cut by 3 mm up to 2 cm wide clinopyroxenite veins. The xenoliths are crosscut by a complex system of mainly intracrystalline veinlets, filled by microcrystalline aggregates and glass remnants.

Two different types of F and MI occur.

Type 1: P glass I + CO_2 FI; these contain Cr-spinel and diopside dm, compositionally similar to those in dunite. CO_2 I (L+V at room T) have glass rims (10-30% of the volume), and are always re-equilibrated. Type I inclusions are remnants of the magma from which the dunites were formed.

Type 2: S silicate glass I and mixed silicate glass + carbonate I occur together with re-equilibrated CO_2 I along fractures originating from the complex network of late veinlets.

MI consist of glass and may include a carbonate drop. The glass has an ultramafic composition (Mg) (24-38 wt.%), FeO (5-18 wt.%) and SiO_2 (33-46 wt.%). A high volatile content ($H_2O + CO_2$) is suggested by very low oxide totals (≈85 wt.%) and by high Cl contents (up to 3900 ppm). Late veins have similar compositions, but higher FeO/MgO ratios. The carbonates are high-Mg calcite or dolomite, in some cases poorly crystalline: they represent a quenched M. Associated CO_2 I always contain magnetite grains and have low densities (0.56-0.19 g/cm^3).

TEM observations indicate that late veins are largely constituted by amorphous and partly heterogeneous material. In some zones, prismatic pyroxene (enstatite) crystallites are observed. These have maximum dimensions of 600-700 è. electron diffraction patterns collected are typically ring-shaped and diffuse, as it is expected for microcrystalline and amorphous material (i.e. glass).

We propose that the fracture-bound ultramafic glass + carbonate I and the associated CO_2 I represent a single trapping episode of a volatile-rich, CO_2-oversaturated ultramafic M which was present in the upper mantle during Canary Islands volcanism. This M corresponds to a discrete episode of mantle metasomatism, but is apparently distinct from the erupted lava. The best estimate of the composition of this metasomatic system is a carbonate-rich M containing about 80% carbonate, 20% ultramafic glass, with a few % volatiles (H_2O and CO_2). This evolved through repeated episodes of magmatic immiscibility in distinct ultramafic and carbonate M. CO_2 was present as immiscible oxidising F phase, whereas H_2O remained dissolved in the ultramafic, Mg-Fe-rich M. (Authors' abstract)

FU Bin, REN Qijiang, and HU Wenxuan, 1996, Evolution and distribution of hydrothermal fluids in the Shaxi porphyry copper deposit, Anhui Province: Kuangchuang Dizhi [Mineral Deposits], v. 15, no. 1, p. 23-33. (In Chinese; Engl. abst.)

Investigations of fluid inclusions and stable isotopes were carried out for the Shaxi porphyry copper deposit, Anhui province, and the results reveal a complicated variation in T and composition with respect to time and space.

Microthermometry shows the T to be 450~340°C for the potassic zone, 340~250°C for the transitional zone, and 250~170°C for the propylitic zone. Compositions and Th of FI indicate that F P varies from 25 to 113 MPa, and sal vary bimodally from 2 wt% to 20 wt% and from 40 wt% to 60 wt% respectively. In the saline halo diagram, there are two major high-sal F-rich centers in concordance with mineralizing intrusives.

Chemical compositions of FI were determined by G and ion chromatographic analysis. Components such as CO_2, HCO_3^-, $Na^+/(Ca^{2+}+Mg^{2-})$, Ca^{2+}, and SO_4^{2-} vary systematically not only with mineralization phases but also with distance from disseminated mineralization.

The coexistence of V- and L-rich or dm-bearing multiphase I in vein quartz suggests that chalcopyrite-bearing anhydrite and quartz veins were formed in boiling low-sal brines at 360 to 420°C. Coexistence of L-rich and V-rich I which are homogenized at similar T to L phase and V phase respectively indicates that boiling existed from the potassic core outward to the potassic-propylitic transitional zone. The F immiscibility in the Shaxi porphyry copper deposit may have played an important role in the mineralizing process. The chlorine- and alkali-rich F would have boiled due to a sudden decrease in pressure, resulting in the deposition of ore-forming substances and hence the formation of orebodies.

Oxygen, hydrogen and carbon isotope studies on vein quartz and its FI show that the ore-forming F have $\delta^{18}O$ of 3.51‰ to 5.52‰, δD of -60‰ to -82‰ and $\delta^{13}C$ of -3.6‰ to -6.53‰. These data suggest a magmatic origin for the ore-forming fluids. However, the introduction of meteoric water must have also occurred at the last stage or ore deposition (δ^{18}=-4.71‰). (Authors' abstract)

FUXI, Jin, 1996, Mode of occurrence of ore minerals and mineralization of the Dalingkou silver deposits, Tiantai County, Zhejiang Province, eastern China: J. of Mineral., Petrol. and Economic Geol., v. 91, no. 4, p. 133-144 (in Japanese; Engl. abst.). Author at Dept. of Earth Sci., Kanazawa Univ., Kanazawa 920-11, Japan.

A Pb-Zn orebody with high Ag concentration is situated in the Cretaceous rhyolites in Dalingkou, Tiantai County, Zhejiang Province, eastern China. The orebody occurs in brecciated and fissured zones. Unlike many other shallow-seated hydrothermal gold-silver ore deposits in North American and Japan, the Ag/Au ratio of the ore is very high and ranges from 97 to 60,000 (average: 970). Main silver minerals are polybasite, tetrahedrite, argentite, and pyrargyrite. The gangue mineral assemblage is characterized by abundant rhodochrosite and the absence of adularia. Chemistry of FI suggests ore-forming conditions, such as sal 0.2-4.1 wt.%, pH = 3.4-5.6 and P 98.3-186.8 bars, which are not much different from those of the other Ag-Au deposits. The ore body is an epithermal fracture-filling, Ag-Au-bearing, base metal ore deposits. (Author's abstract)

GAMMONS, C.H., 1996, Experimental investigations of the hydrothermal geochemistry of platinum and palladium: V. Equilibria between platinum metal, Pt(II), and Pt(IV) chloride complexes at 25 to 300°C: Geoch. Cosmo. Acta, v. 60, no. 10, p. 1683-1694. Author at Dept. of Earth Sci., Monash Univ., Clayton, Victoria 3168, Australia.

GAMMONS, C.H., WOOD, S.A. and **WILLIAMS-JONES, A.E.,** 1996, The aqueous geochemistry of the rare earth elements and yttrium: VI. Stability of neodymium chloride complexes from 25 to 300°C: Geoch. Cosm. Acta, v. 60, no. 23, p. 4615-4630. First author at McGill Univ., Dept. of Earth and Planetary Sci., MontrÇal, Quebec, H3A 2A7, Canada.

GAMO, Toshitaka, CHIBA, Hitoshi, MASUDA, Harue, EDMONDS, H.N., FUJIOKA, Kantaro, KODAMA, Yukio, NANBA, Hiromi and **SANO, Yuji,** 1996, Chemical characteristics of hydrothermal fluids from the TAG mound of the mid-Atlantic Ridge in August 1994: implications for spatial and temporal variability of hydrothermal activity: Geophysical Research Lett., v. 23, no. 23, p. 3483-3486. First author at Ocean Research Inst., Univ. of Tokyo, Tokyo, Japan.

We report the first Br/Cl ratios for the TAG hydrothermal F, showing no fractionation between Br and Cl during the F-rock interaction. (From authors' abstract by E.R.)

GAMYANIN, G.N., 1996, The polyform tin-silver deposit of Yakutia (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 623. Author at Yakut Inst. of Geol. Sci., Siberian Dept., Russian Acad. of Sci., 39, Lenin Ave., Yakutsk, 677891, Russia.

The Kupolnoye Sn-Ag deposit, one of the largest, is located at a granitoid massif formed in three stages.

The rare-metal stage is represented by a quartz-muscovite association of the near-vein greisenization, quartz-tourmaline and cassiterite-wolframite-arsenopyrite associations of the vein filling. Ores started to form under high-acidity conditions (pH 5) at T higher than 400°C and completed their formation in near-neutral ones at 200°C. The composition of G-phase is I in quartz is substantially hydrous, carbon dioxide-methanoic. Sn, W, and Bi are the chief minerals.

The II-stage Sn-Ag ores were formed with the development of ore-bearing beresites of the sericite-carbonate facies. Vein-filling associations (siderite-ankerite, ankerite-galena-sphalerite, galena-freibergite, pyrargjrite-okartite [sic]) were successively formed when alkalinity being progressively increased (pH 6.6-7.7) and T decreased (350-200°C). Composition of the G phase in moderate-hydrous methane-carbon dioxide added with heavy gases. Sn, Pb, Z, and Ag are the leading elements.

The Ag-Sb- stage of mineralization started from the formation of wallrock argillite followed by a deposition of arsenopyrite-marcasite-quartz, galena-freibergite-pyrargyrite, and antimonite-valentinite-bethierite-calcite associations from near-surface solutions high-concentrated in silica in conditions of their severe oversaturation. T interval of ore formation ranges between 300 and 100°C. G composition is carbon dioxide, high hydrous, heavy G concentrated. Sb and Ag are the leading elements. (From author's abstract by E.R.)

GANOR, Jiwchar, MATTHEWS, Alan, SCHLIESTEDT, Manfred and **GARFUNKEL, Zvi,** 1996, Oxygen isotopic heterogeneities of metamorphic rocks: an original tectonostratigraphic signature, or an imprint of exotic fluids? A case study of Sifnos and Tinos islands (Greece): Eur. J. Mineral., v. 8, p. 719-732. First author at Dept. of Geol. and Mineral., Ben-Gurion Univ. of the Negev, P.O. Box 653, Beer-Sheva 84105, Israel.

Oxygen isotope compositional heterogeneities among Eocene high P/T rocks and retrograde overprinting assemblages on the Cycladic islands of Sifnos and Tinos are studied with the aim of determining the extent to which they reflect an original tectonostratigraphic signature or the effects of F infiltration. The isotopic data support the view that outcrop- and layer-scale variations in the degree of retrograde metamorphic transformation were controlled by selective infiltration (possibly involving local deformation-enhanced permeability creation) of small amounts of F. Simple mass-balance calculations suggest that these amounts of F were of the order of several weight percent.

The isotopic compositional heterogeneity of regional metamorphic sequences must be taken into account when applying models of F infiltration. (From authors' abstract by E.R.)

GAO, Taizhong, YANG, Minzhi, and ZHANG, Jimin, 1996, Study on gold mineralization controlled by ore fluid-tectonic dynamic evolution in Muping-Rushan gold metallogenic belt in eastern Shandong Province of China (abst): 30th Int'l Geog. Cong., Abstracts, v. 1, p. 425. First author at Northeastern Univ., China.

Muping-Rushan gold metallogenic belt consists of mainly auriferous sulfide quartz vein type ones, and occur[s] in granite bodies. The wall-rock alteration is potassic alteration, pyritization, silication, sericitolitization and carbonation, etc. Ore minerals are mainly native gold, electrum, pyrite, chalcopyrite, sphalerite, galena and arsenopyrite. Vein minerals are chiefly quartz, calcite and siderite. Gold hydrothermal mineralization period can be divided into four stages: (1) pyrite-quartz stage, (2) quartz-pyrite-pyrrhotite stage, (3) quartz-multimetal sulfide stage and (4) carbonate-quartz stage. The second and third stages are main metallogenic ones.

Studying on physicochemical conditions show that the ore-forming T varies from 110 to 310°C, that the pressure varies from 29.8 to 85.5 MPa, that the sal of mineralizing F is mainly from 0.8 to 7.7 wt% NaCl eq, that the pH is from 6.1 to 7.5, that the ore-forming hydrothermal F is a slightly acid system enriched in G, CO_2, and S, and that the migrating form of Au is $[Au(HS)_2]$ in F. (From authors' abstract by E.R.)

GARRETT, S.J.M., 1992, The geology and geochemistry of the Mount Elliott copper-gold deposit, northwest Queensland: Masters of Economic Geology thesis, Univ. of Tasmania, 139 pp and appendices.

A new resource of approximately two million tonnes at 4.2% Cu eq. has been discovered beneath old workings of the Mount Elliott mine in northwest Queensland. Potentially economic copper and gold mineralization occurs as massive chalcopyrite with pyrite and pyrrhotite hosted in breccia matrix and shallow-dipping calc-silicate + calcite veins which cross-cut the local stratigraphy. The deposit occurs within brecciated and pervasively skarn-altered shales. Bleaching of the shales was followed by Ca-F metasomatism and albite-hematite (red-rock) alteration. Brecciation was accompanied by pervasive, prograde skarn alteration consisting of coarse-grained diopside-hedenbergite, scapolite, sphene, apatite and calcite.

The prograde skarn assemblage formed from a hot (450-650°C) saline (> 10 wt.% NaCl), weakly acidic and relatively oxidised magmatic F that was rich in CO_2 and depleted in total sulphur. At depth the granitic F homogenously mixed with a downward convecting, low T, reduced and sulphur-rich F that had leached metals and sulphur from biogenic sulphides ($\delta^{34}S \approx -12‰$) in the black shale. The resulting hot (250 - 350°C) sulphur and metal-rich hydrothermal F transported iron, copper and gold in solution as chloride complexes and, upon interaction with the calc - silicate + calcite gangue, precipitated sulphides ($\delta^{34}S = -5.7$ to $-3.6‰$) in response to decreasing fO^2 and increasing pH conditions. (From author's abstract by E.R.)

GAS'KOVA, O.L. and SHVEDENKOV, G. Yu., 1996, Experimental study of gold solubility in complex fluids with carbon dioxide (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 717. Authors at United Inst. of Geol., Geophys. and Mineral., Novosibirsk, Russia.

Experiments were carried out at 500°C and 100 MPa in KCl or KCl-HCl solutions in sealed gold tubes or in titanium autoclaves (~3 ml) which were placed into the high P reactor.

Data on solubility of gold at 500°C in KCl+HCl solutions did not recognize any differences in its solubility in systems with and without CO_2 (effect of CO_2 presence is within the limits of experimental error). One can suppose that ~3 m of CO_2 is too low concentration for these T-P parameters. (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., v. 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 Mountains (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 table listing Th, $\delta^{18}O$, $\delta^{13}C$, and $\delta^{18}O$ for seven samples omitted (E.R.)

GEDDES, D., 1993, Carbonate cement in sandstone as an indicator of accretionary complex hydrogeology, M.S. thesis, Univ. California Santa Cruz.

Veins in melange zones are typically composed of carbonate or quartz. H_2O-rich F trapped within veins are low in Cl^-. (E.R.)

GENE Yuansheng, SHEN Qihan, and LI Yinqing, 1996, Characteristics of fluid inclusions from granitic gneisses in northwestern Hebei Province and their geological significance: Acta Petrologica Sinica, v. 12, no. 2, p. 277-286. (In Chinese; Engl. abst.)

According to the morphology and attitude of I and in consideration of the density evolution of CO_2, four types of the FI in granitic gneisses metamorphosed to granulite facies could be divided, 1) single-phase CO_2-rich I, 2) CO_2-rich I with G-F binary phases, 3) three phase I with F CO_2, and 4) polyphase I with halite. The morphology, Th and densities of the different types of the I indicate that the granitic gneisses in the area underwent metamorphism in three stages. In the first stage, single-phase CO_2-rich I with high density were trapped after the peak of granulite facies metamorphism. The Th and density of the I formed in this stage exhibit isotemperature depressional evolution. In the second stage, binary phase CO_2-rich I with lower density were formed during amphibolite facies retrometamorphism. In the third phase, three-phase I with F CO_2 and the lowest density were trapped. The lowest density of I in granitic gneisses reflects the T and P conditions during shear deformation and retrometamorphism. (Authors' abstract)

GENG, Aiqin, ZEEH, Stefan, and BECHSTÄDT, Thilo, 1996, Diagenesis and pore-fluid evolution in Upper Rhine Graben and its flanks: the Muschelkalk Group, southwest Germany (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 21. Authors at Geologisch-Paläontologisches Institut, Im Neuenheimer Feld 234, 69120 Heidelberg, Germany.

Based on a combined petrographic and geochemical approach of cementation within a well-studied stratigraphy and geologic history, we aim to estimate the timing, T, and geochemistry of diagenetic F that affected the Muschelkalk Group. Diagenetic processes of the Muschelkalk, beginning sedimentation, continuing through progressive burial, and followed by uplift and local deep reburial, include calcite cementation (six generations), saddle dolomite and siderite precipitation, dolomitization (four stages), dissolution and dedolomitization.

The marine calcite cements (generation A and B) include acicular and other fringing cements that infill in P porosity within shelly grainstones. Early burial sparry calcite cements (generation C and D) include both prismatic and equant cements. The stable-isotope composition of early calcite cements (generation A, B, C, D) is less variable, with $\delta^{18}O$ values ranging from -6.94 to -4.63‰ PDB and $\delta^{13}C$ of -0.12 to +1.35‰ PDB. The slight depletion in $\delta^{18}O$ of early cements compared to brachiopod shells of the Muschelkalk can be attributed to isotopic re-equilibrium with shallow-burial marine pore waters. Both CL and isotope composition suggest that meteoric pore waters were not involved in early diagenesis. Saddle dolomite cements have a relatively light oxygen isotope compositions ($\delta^{18}O$ = -10.09 to -7.93‰ PDB) and variable C-isotope composition ($\delta^{13}C$ = +0.33 to +2.53‰). FI studies show that saddle dolomite cement has a Th between 150°C and 164°C, reflecting burial hydrothermal origin.

Fracture-filling late calcite cements (generation E) were formed in post-Cretaceous time. They can be subdivided into two types, (a) zoned-luminescent calcite in uplifted areas (generation E1) and (b) dull luminescent calcite (generation E2). The latter contain secondary bitumen I and coexist with siderite cement in the Rhine Graben. There is strong geological significance that zoned-luminescent calcite was precipitated from meteoric waters near the surface, which is further supported by the carbon and oxygen isotope data. Cement E1 has a wide range of $\delta^{18}O$-values from -11.38 to -7.80‰, and $\delta^{13}C$-values from -2.01 to +2.44‰. The calculated palaeofluid composition from which this cement formed shows that cement E1 is not in isotopic equilibrium with Tertiary/Quaternary meteoric water. Interactions 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 a 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-waters (Pliocene-Pleistocene oil-field brines) and an origin from subsurface brines during Oligocene/Miocene time is suggested. (Authors' abstract.)

GENG Wenhui, 1996, Fluid inclusion geochemistry of the volcanic rock-hosted silver deposits, Eastern Zhejiang: Acta Mineralogica Sinica, v. 16, no. 1, p. 66-71.

Volcanic rock-hosted Ag deposits are closely related with such alteration as silicification, illitization, adularization, sericitization, rhodochrositization, pyritization and prophylitization. FI geochemistry of the volcanic-hosted Ag deposits is discussed at this paper. The ore-forming components include Na^+, K^+, Ca^{2+}, F^- and Cl^-. The hydrothermal solution might be the mixture of P volcanic magmatic hydrothermal solution and meteoric water. The ore-forming T and P were estimated at 205~236°C and (380~500) x 10^5Pa, respectively. The Ag deposits could be assigned to the epithermal precious metal deposits. (Author's abstract)

GERMAN, J.M., 1993, Geology of the McDuffie County gold belt: Dept. of Natural Resources Bulletin 125, Atlanta, 1993, 59 pp.

The types of alteration that the host rocks have undergone and the mineralogy of the ore bodies suggest the ore-forming F were rich in CO_2 and reduced sulfur. To confirm this hypothesis, FI studies were conducted on ore samples from the Columbia, Parks, Landers and Tathum Mines. All data were collected with a modified USGS-type G flow heating and freezing stage manufactured by Fluid, Inc. P and S (or pseudo-secondary) I were observed. The P I vary in size (2-20 μ) and shape and generally contain 5-15% V phase. Some P I are elongated by roughly 5 to 10 times in one direction. Some equant P I occur in chevron patterns. The S or PS I are generally smaller and more equant than the P I and range in size from 0.5 to 15 μ. They are oriented in certain planes assumed to be fractures that have been annealed to various degrees. Approximately 40 FI from samples of the Parks mine were observed during heating and freezing. Many I contain three phases at room T: aq L, V (generally 5-15%), and a L carbonic phase (generally 30 volume %). Melting T for the carbonic phase ranged from -58.4° to -56.4°C with the majority falling between -57.2° to -57.0°C, indicating that the carbonic phase is almost pure CO_2 (CO_2 melting T = -56.6°C). Ice melting was not observed, however, a slight expansion of the V phase of some I occurred upon heating at around -1.1°C. Assuming that this expansion indicates the Tm ice in the I, the sal of the water is at least 2 to 4 wt.% NaCl.

One clathrate melting point of 7.7°C was obtained. The value of 7.7°C corresponds to 4.5 wt.% NaCl in the aq phase and is consistent with the inferred Tm ice.

Recorded Th for CO_2 ranged from 18 to 30°C with two maxima at 18 to 19° and 28 to 29°. The range of total Th was from 153 to 301° with the majority falling between 180 and 240°. Using the preliminary data for the carbonic phase melting point of -57°C, the clathrate melting point of 7.7°C, and the CO_2 Th of 28°C and comprising 30 vol% of the I, a typical F can be postulated. Using the program FLINCOR, this F is calculated to have 10 molecular % CO_2 and a bulk density of 0.91 (assuming a CO_2 - H_2O - NaCl F). The F P is 2.0 kb at 200°C, 3.2 kb at 300°C, and 4.3 kb at 400°C. If the T of ore formation can be constrained by an independent geothermometer, the ore F P may be estimated. Assuming ore formation took place under greenschist grade conditions (i.e., around 250°C), the F P was 2.5 kb. Depending on whether F were under hydrostatic or lithostatic P, this implies a crustal depth of 25 km or 8.3 km, respectively. The values obtained by Newton and Pyle (1991) are consistent with Tt and P obtained from auriferous veins in the Slate Belt of North Carolina, and also are consistent with greenschist facies metamorphic conditions. (From author's text by H.E.B.)

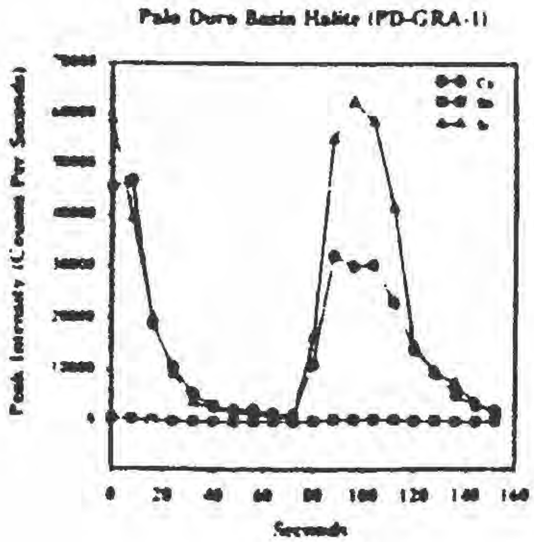
GERVILLA, Fernando, LEBLANC, Marc, TORRES-RUIZ, José and FENOLL HACH-ALÍ, Purificación, 1996, Immiscibility between arsenide and sulfide melts: A mechanism for the concentration of noble metals: Canadian Mineralogist, v. 34, p. 485-502.

Evidence of immiscibility between arsenide and sulfide M can be observed locally in the magmatic ores associated with the Carratraca (Serranía de Ronda, southern Spain) and Beni Bousera (northern Morocco) lherzolite massifs. They occur in the form of Fe-Ni-Cu sulfide ores containing arsenide globules. The globules are interpreted as droplets of an immiscible arsenide M with a composition close to that of maucherite-nickeline, suspended in the sulfide melt. The data suggest that PGE and Au have a higher affinity for arsenide M than for sulfide M, remarking their importance as collectors of noble metals in nature. (From authors' abstract by E.R.)

GHAZI, A.M., McCANDLESS, T. and **RUIZ, J.**, 1996, New elemental analyses of single fluid inclusions in halites from the Paradox and Palo Duro basins: applications of LA-ICPMS and artificial fluid inclusions standards (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F775, November 12, 1996. First author at Dept. of Geol., Georgia State Univ., Atlanta, GA 30303.

Halite samples from the Permian Paradox Basin, Utah, and the Palo Duro Basin, TX, USA, were analyzed for Ca, Rb and Sr concentrations. Data were obtained with a Finnigan MAT SOLA and the system 266 Nd:YAG laser which operates in UV region. Quantification was performed by using calibration curves created by using a set of artificial FI standards consisting of standard solutions of known composition of Ca, Rb and Sr in microcapillary tubes. The laser was operated in Q-switched mode at ~4 mJ and a repetition rate of 4 pulses per second. After "drilling" through wall of the tube, the F was reached and the content was entrained in the flow of argon, which transported the material through a Y-shaped elbow connector to the ICP torch where ionization takes place. This type of connector allows introduction of L-S mixture to give better sensitivity. The average volume of F released per pulse of laser is ca. 100 picoliter. The quadrupole mass spectrometer and a S electron multiplier were used to acquire data for all microcapillary and natural FI.

Halite samples were selected for analysis because they contained FI in similar volumes to the microcapillary tube FI. Thus it was possible to analyze the natural I under analytical conditions identical to those for the microcapillary tube I. The figure is a time-resolved mass spectrum showing signals (counts per seconds) for Ca, Rb and Sr for two single FI that were located at two different depths. The peak at zero seconds represents a very shallow I whereas the second peak represents signals from a deeper I located at ca. 75 seconds below the surface.



Calibration curves were created by plotting signal intensity versus concentration. The results show that in all the FI Rb concentration is relatively small (<5 ppm). Also, results show systematic variation among Ca and Sr concentrations in all the samples. The concentrations of Ca and Sr for the Palo Duro Basin range from 90 to 1060 ppm and 27 to 886 ppm, respectively, whereas those for the Paradox Basin range from 122 to 178 ppm and 38 to 158 ppm, respectively. (Authors' abstract)

GHAZI, A.M., McCANDLESS, T.E., VANKO, D.A., and **RUIZ, Joaquin,** 1996, New quantitative approach in trace elemental analysis of single fluid inclusions: Applications of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS): J. of Analytical Atomic Spectrometry, v. 11, p. 667-674.

Laser ablation inductively coupled plasma mass spectrometry has been used for the *in situ* elemental analysis of individual FI with artificially prepared FI as external standards. Artificial FI standards are prepared by drawing a standard solution of known composition into microcapillary tubes. An ICP-MS equipped with a Nd:YAG laser operating in the UV region (266 nm) was used for data acquisition. The laser was focused and fired on 25-30 µm spots on the microcapillary tubes until the F was reached. The content of the microcapillary tube then emptied and was transported with argon to the torch. The average volume of F released, per pulse of laser, was approximately 100 pl. Calibration curves were created by plotting signal intensity *versus* concentration. The long-term precision (RSD%) of measurements for Sr were 1.1-3.1% for a 1000ppm solution, 2.7-4.9% for a 500 ppm solution and 3.1% for a 250 ppm solution. Similar measurements on the same solutions for Rb gave values of 1.9%-2.3% for a 1000 ppm solution, 5.1-6.3% for a 500 ppm solution and 1.7% for a 250 ppm solution. The technique was tested on FI in halite from the Palo Duro Basin, Texas, USA. The results show that concentrations for Sr range from 90 to 153 ppm, and for Rb from 98 to 100 ppm. The precision of analysis for individual natural FI ranges from 5 to 31% for both Sr and Rb. The concentration of Sr calculated by this method is in agreement with earlier work. (Authors' abstract)

GIGGENBACH, W.F., 1996, Control of CO_2 and CH_4 contents in high-heat flow sedimentary basins: American Assoc. of Petroleum Geologists Annual Meeting Abstracts, v. 5, p. 52-53. Author at Inst. of Geol. and Nuclear Sci., Lower Hutt, NZ.

Extensive exploration of a wide range of geothermal systems for power production has led to the development of a large array of comparatively simple and adaptable techniques for the interpretation of the chemical and isotopic compositions of high T water and G discharges. By applying these techniques to natural G deposits in areas of comparatively high heat flow, in SE Asia and New Zealand, they were found to resemble closely lower T geothermal systems. In both cases, relative CH_4/CO_2 contents approach those expected for a redox environment governed by equilibration with crustal host rock. In this case, CO_2 becomes the predominant C-bearing G at T >170°C. Variations in the isotopic compositions of coexisting CH_4 and CO_2, in higher T G deposits (>160°C), correspond to mixing of two end member source F: one containing predominantly CO_2, the other predominantly CH_4. At 170°C, CO_2 is some seven times more soluble in water as compared to CH_4 thus favoring partitioning of CO_2 into any coexisting aq L phase and that of CH_4 into the V phase. Entrainment of these two F phases in varying proportions is likely to be the major cause of rapid and short-distance variations in relative CO_2 and CO_4 contents of well discharges. In addition to lower T (<120°C) decarboxylation processes, the other major process giving rise to high CO_2 contents in natural gas, is equilibration with host rock at T >160°C. Generally speaking, with increasing T, kinetic processes increasingly give way to thermodynamic processes controlling G compositions. (Author's abstract)

GIL, P.P. and **VELASCO, F.**, 1996, The Bilbao stratabound iron deposits in the Lower Cretaceous of the Basque-Cantabrian Basin, Northern Spain (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 788. Authors at Dpt. Mineralogía-Petrología, Universidad del País Vasco, Bilbao, Spain.

Ores occur as massive or stratiform lenses, hosted within shallow-water carbonate platform. The late-stage of mineralization has FI which homogenize at 180-230°C (siderite) 160-200°C (quartz) and 110-160°C (calcite) and moderate sal (9-18 eq. wt% NaCl). These geologic and geochemical data support an epigenetic model. Both stratabound mineralization types were formed by replacement and open space fill carbonates in relation to synsedimentary faults. F were expelled upward during subsidence, from deepest sediments of the basin toward the highest zones of the carbonate platform. Ore precipitation was possible caused by mixture of metalliferous brines with sea water, at intermediate to relatively high T, during the late diagenetic stage. The proposed model is quite similar to the so-called Mississippi Valley type.

GILES, A.D. and **MARSHALL, Brian**, 1996, Establishing the fluid history of the Woodcutter's Pb-Zn-Ag massive sulphide deposit by the use of inclusion petrography, cathodoluminescence, and sulphur isotope and laser Raman microprobe studies: Geol. Soc. of Australia Abstracts, v. 41, p. 158. First author at Univ. of Tech., Sydney, Dept. of Applied Geol., Broadway, NSW, Australia.

GILINSKAYA, L.G. and **ZANIN, Yu.N.**, 1996, CO_2^-, CO_3^- and CO_3^{3-} paramagnetic centers in natural carbonate apatites and their genetic significance (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 498. Authors at Unit. Inst. Geol., Geophys., Mineral., Siberian Branch of Russian Acad. Sci., Novosibirsk, Russia.

GIONCADA, Anna, BOTTAZZI, Piero, CLOCCHIATTI, Robert, OTTOLINI, Luisa, and **SBRANA, Alessandro,** 1996, Petrogenetic evolution of the lavas on Vulcano (Aeolian Islands, Italy): contraints from studies on glass inclusions (abst.): 16th Earth Sciences Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 89 (in French). First author at Dipartimento di Scienze della Terra, Universitá de Pisa, I-56100 Pisa, Italy.

To avoid, or at least the minimize the extent of the effects of mixing, assimiliation and alteration on lava evolution, our study was based on glass I in olivine and pyroxene of the most representative members of the volcanic series. The chemical compositions of major elements (electron microprobe at Paris VI) and trace elements (ion microprobe at Pavia) show that the dominant process is fractional crystallization: through it the lavas evolve from P basalts (Sommata) to rhyolites (Commenda, Pietre Cotte, 1888-90) with intermediate products as latites (Tufi Bruni, Spiaggia Lunga . . .) and trachytes (Palizzi). This process is accompanied by the assimilation of acid material of crustal origin. The fractionation provokes the formation of small quantities of evolved magma confined in superficial reservoirs. Magma mingling processes are extremely frequent, and render any separation technique useless. The evolution of the Vulcano lavas takes place in a T interval between 1180 and 1000± 20°C. Results of analyses of major and trace elements in glass I allow to discern better the different processes in the reservoirs which lead to the formation of more or less potassium-rich magmas starting from a homogeneous mantle source. (From authors' abstract, translated by E.A.J. Burke.)

GIORGETTI, G., FREZZOTTI, M.-L.E., PALMERI, R., and **BURKE, E.A.J.,** 1996, Role of fluids in migmatites: CO_2-H_2O fluid inclusions in leucosomes from the Deep Freeze Range migmatites (Terra Nova Bay, Antarctica): J. Metamorphic Geol., v. 14, p. 307-317.

The metasedimentary sequence of the Deep Freeze Range (northern Victoria Land, Antarctica) experienced high-*T* /low-*P* metamorphism during the Cambro-Ordovician Ross orogeny. The reaction Bt+Sil+Qtz = Grt+Crd+Kfs+melt was responsible for the formation of migmatites. Peak conditions were *c.* 700-750°C, *c.* 3.5-5 kbar and x_{H_2O} *c.* 0.5).

Distribution of FI is controlled by host rock type: (1) CO_2-H_2O FI occur only in graphite-free leucosomes; (2) CO_2-CH_4±H_2O FI are the most common type in leucosomes, and in graphite-bearing mesosomes and gneiss; and (3) CO_2-N_2-CH_4 FI are observed only in the gneiss, and subordinately in mesosomes.

CO_2-H_2O mixtures (41% CO_2, 58% H_2O, 1% NaCl mol. %) are interpreted as remnants of a synmigmatization F; their composition and density are compatible P-T-a_{H_2O} conditions of migmatization (*c.* 750°C, *c.* 4 kbar, x_{H_2O} *c.* 0.5). CO_2-H_2O F in graphite-free leucosomes cannot originate via partial melting of graphite-bearing mesosomes in a closed system; this would have produced a mixed CO_2-CH_4 F in the leucosomes by a reaction such as Bt+Sil+Qtz+C±H_2O=Grt+Crd+Kfs+L+CO_2+CH_4. We conclude that an externally derived oxidizing CO_2-H_2O F was present in the middle crust and initiated anatexis.

High-density CO_2-rich F with traces of CH_4 characterizes the retrograde evolution of these rocks at high F and support isobaric cooling (*P-T* anticlockwise path). In unmigmatized gneiss, mixed CO_2-N_2-CH_4 F yields isochores compatible with peak metamorphic conditions (*c.* 700-750°C, *c.* 4-4.5 kbar); they may represent a peak metamorphic F that pre-dated the migmatization. (Authors' abstract)

GIRARD, Jean-Pierre, SANJUAN, Bernard, CZERNICHOWSKI-LAURIOL, Isabelle, and **FOUILLAC, Christian,** 1996a, Geochemical modelling of diagenetic processes in reservoir sandstones: An example from the Oseberg Formation (BRENT) of the northern North Sea (abst.): 30th Int'l Geol. Cong., Abstracts, v. 21, p. 855. Authors at BRGM, Research Div., 45060 Orléans, France.

A detailed multidisciplinary integrated study was carried out with the objectives 1) to reconstruct the timing, T conditions and spatial variation of diagenetic transformations as precisely as possible, 2) to characterize the nature, origin and quantity of the endmember diagenetic F, and 3) to develop a quantitative geochemical model of the observed diagenesis by use of the numerical code Allan™/Neptunix.

The 20-60 m thick Oseberg Formation occurs at depths of 2.5 to 3.2 km, and at present T of 100 to 125°C. The detrital assemblage is mainly composed of quartz, K-feldspar, albite, muscovite and lithic clay casts, and is very homogeneous throughout the field. The diagenetic sequence includes: minor siderite and pyrite, K-feldspar rims, ankerite, pervasive feldspar dissolution, abundant kaolinite, quartz overgrowths, ferroan calcite, and dickite. Diagenetic T were derived from FI in ankerite, quartz and calcite, and combined with the modelled burial/thermal history to constrain approximate ages and duration of diagenetic events. Isotopic compositions of carbonates and kaolinite indicate that meteoric water and seawater were two major constituents of diagenetic F. The results indicate that the general evolution of diagenetic transformation can be adequately reproduced from a qualitative standpoint, by introducing reconstructed endmember waters at appropriate times (T) in the system. Also, the chemical composition of the final interstitial F is consistent with the measured composition of present day formation F. From a quantitative standpoint, however, the results of box-type stimulations were unsatisfactory. Reaction kinetics may have been significantly enhanced if the modeled diagenetic reaction took place at higher T (80-100°C) in the presence of organic acids during late diagenesis, a scenario supported by petrographic and FI data. This possibility and others are being further investigated. (From authors' abstract by E.R.)

See also adjacent item (E.R.)

GIRARD, J.P., SANJUAN, Bernard, CZERNICHOWSKI, L.I. and FOUILLAC, Christian, 1996b, Diagenesis of the Oseberg Sandstone reservoir (North Sea); an example of integration of core, formation fluid and geochemical modelling studies: American Assoc. of Petroleum Geologists Annual Meeting Abstracts, v. 5, p. 53.

See previous item (E.R.)

GIULIANI, G., ZIMMERMANN, J.-L., FRANCE-LANORD, Chr., CHEILLETZ, A., and **RUEDA, F.,** 1996, Contributions of $^{18}O/^{16}O$ and D/H isotope geochemistry and of the study of permanent gases to the characterization of the sources of emerald deposits in Brazil and Colombia (abst.): 16th Earth Sciences Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 154 (in French). First author at ORSTOM and CRPG-CNRS, B.P. 20, F-54520 Vandœuvre-lés-Nancy, France.

The $^{18}O/^{16}O$ and D/H isotope compositions have been measured in emeralds from 10 Brazilian deposits (8 deposits of the pegmatite type and 2 of the shear-zone type) and 16 Colombian deposits (7 deposits from the eastern zone and 9 from the western zone of the eastern Cordilleras). The obtained values show the existence of separate sources for each of the three types of deposits. Emeralds of the pegmatite type have isotopic signatures of magmatic and/or metamorphic sources. Emeralds of the shear-zone type have a metamorphic origin of the F. The emeralds from Colombia reveal a strong enrichment in $\delta^{18}O$ indicating that the water has been mixed (for the oxygen) with minerals from the sedimentary host rocks; on the other hand the values show a contribution from basin waters.

The study of permanent G with quadrupole spectrometry shows that the global composition of the F of each type of deposit is very different (Colombia: $80<H_2O<92\%$, $3<N_2<10\%$, $2.5<CO_2<5\%$, $H_2<5\%$, $CO<1.5\%$; Brazil, pegmatite type, Carnaiba deposit: $90<H_2O<95\%$, $N_2=1.3\%$, $CO_2=2\%$, $H_2=4.7\%$, $CO=1.75\%$, $CH_4=0.1\%$; shear-zone type, Santa Terezinha deposit: $80<H_2)<85\%$, $N_2=1.3\%$, $CO_2=12.5\%$, $H_2=4\%$, $CO=1.85\%$, $CH_4=0.1\%$). The water content in the emerald channels is also different for the three types of deposits (Colombia, eastern zone: $1.34 <H_2O<1.41\%$; western zone: $1.69<H_2O<2.12$; Brazil, pegmatite type: $1.23<H_2O<3.01\%$; shear-zone type: $2.90<H_2O<3.16\%$). The water content of these channels is clearly correlated with the alkaline contents. (From authors' abstract, translated by E.A.J. Burke.)

GOFF, F.E. and **STIMAC, J.A.,** 1996, Recent gold degassing and deposition, Galeras Volcano, Columbia (abst.): 126th Annual Meeting Prog., p. 43. First author at Los Alamos National Laboratory, Los Alamos, NM.

Galeras is a composite, andesitic stratovolcano that has formed during the last 0.7 Myr and has erupted frequently in the last few years. Magmatic fluids (≤360°C in early 1993) contained significant CO_2, SO_2, H_2S, and HCl, plus ~0.04 ppm Au. Altered andesite breccia on the cone contains alunite, anhydrite, quartz, pyrite and ~2 ppm Au. Older veins within the edifice contain ores with visible electrum and sulfosalts. The hydrothermal environment surrounding the magma conduit is "high sulfidation". Assuming constant SO_2 flux of 500 t/d, Galeras can emit ~0.5 kg/d Au during short-lived eruptive events. (Authors' abstract.)

GOLDFARB, R.J., 1996, Ore fluids associated with mesothermal gold deposits in the North American Cordillera (abst.), in Mesothermal Gold Deposits : A Global Overview. Volume of extended abstracts to accompany short course, Perth, 11-12 July, 1996. Pub. No. 27, p. 88-93, Geol. Dept. (Key Centre) & UWA Extension, Univ. Western Australia, 135p. ISSN 0156-9287.

GOLDSTEIN, R.H., 1996, Dolomite from reflux of moderate salinity brine, Enewetak Atoll: American Assoc. of Petroleum Geologists Annual Meeting Abstracts, v. 5, p. 54. Author at Univ. of Kansas, Lawrence, KS, US.

See next item (E.R.)

GOLDSTEIN, R.H. and **BENISON, K.C.,** 1996, Cation, anion and $^{87}Sr/^{86}Sr$ analyses of inclusion fluids elucidate processes of reflux dolomitization, Enewetak Atoll (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 48-50. First author at Univ. of Kansas, Dept. of Geol., 120 Lindley Hall, Lawrence, KS 66045; e-mail (gold@kuhub.cc.ukans.edu)

Extensively dolomitized intervals of deep-slope deposits from the Eocene section of Enewetak Atoll provide a natural laboratory for using FI to elucidate conditions of dolomitization and for evaluating other methods commonly used in diagenetic studies. Specimens have had simple tectonic and burial histories, are geologically very young, and have never been heated. Therefore, interpretations about diagenetic conditions from FI are unambiguous. The distribution of dolomite, its position in the paragenesis, new Sr isotope data, new stable isotope data, FI freezing point depressions, and composition of FI extracts strongly indicate that dolomite precipitated from deeply refluxing brines of moderate sal [but > seawater]. Further, FI microthermometry combined with major-ion chemistry and $^{87}Sr/^{86}Sr$ of FI extracts provide data that are more reliable than mineral-based geochemical techniques. (From authors' abstract by E.R.)

See also previous item (E.R.)

Int'l Geol. Cong., Abstracts, V. 2, p. 889. First author at VNIIGeosystem, Russia.

In petroleum basin one can commonly find the effects of reducing F on formation complexes nearly within a 10 km arc section including AR-PR crystalline associations disclosed at a depth down to 4 km. The evidences of upgoing migration of these F can be traced by I preserved inside fine cracks in rock-forming minerals, by dispersed inclusions of hydrocarbon material of various classes and associated vein mineralization, mostly calcites. The F relicts are represented by HC, HC-H_2O components, and, also, by bitumen I consisting of oil to tar-asphaltene components. Varying relation between immiscible L and G in the vacuoles, thermodynamic characteristics of F with T ranging from 320 to 60°C and P from 2 kbar to a hydrostatic value at certain levels of the section are indicative of the heterogeneity of systems being laminated. (From authors' abstract, by E.R.)

GRAHAM, Rod, HOWE, Spencer, O'LEARY, John, PULHAM, A.J., PIGGOTT, Neil, VEAR, Alwyn and **WARREN, E.A.,** 1996, The evolution of the Piedemonte Llanero petroleum system, Cordillera Oriental, Colombia; 1, Structural evolution and play definition (abst.): American Assoc. Petro. Geol. Bulletin, v. 80, no. 8, p. 1297. First author at BP Exploration, Bogota, Colombia.

A wide variety of geological and geochemical analytical techniques including biostratigraphy, reservoir petrology, petroleum geochemistry, thermal maturity data, basin modeling and FI studies were undertaken. These were iteratively integrated into the seismo-structural model to develop a constrained interpretation for the evolution of the Piedemonte Llanero petroleum system. This paper summarises the current understanding of the structural evolution of the trend, and the development of a major petroleum system. A companion paper details the reservoir petrography and petroleum geochemistry studies. (From authors' abstract by E.R.)

GRANEY, J.R. and **KESLER, S.E.,** 1996, Role of magmatic gas in adularia-sericite epithermal vein deposits (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A402. First author at Dept. of Environmental and Industrial Health, Univ. of Michigan, Ann Arbor, MI 48109; e-mail (graney@sph.umich.edu)

Magmas probably underlie most active adularia-sericite-type epithermal systems. The most likely contributions from these magmas are heat and G, largely CO_2. Analysis of FI from porphyry copper deposits shows that CO_2 is the dominant G in V-rich I. Evidence that this CO_2 probably migrates upward into overlying hydrothermal systems is seen in the high levels of CO_2 in geothermal systems (versus natural water-rock experiments) and in high levels of CO_2 in soil G over volcanic centers including Etna and Mammoth Mountain. These emissions are episodic, suggesting that G flux through overlying hydrothermal systems should also vary. It is reasonable to ask whether these G affect ore-forming processes in epithermal systems.

We have tested this possibility by quadrupole mass spectrometric analysis of G in IF from successive paragenetic bands in epithermal vein deposits at Fresnillo, Guanajuato, Hishikari, McLaughlin, Mogollon, Pachuca and Tonopah. These G compositions could reflect internal (boiling, cooling, mixing, mineral deposition/dissolution) or external (magmatic G flux) processes. Results show that IF in growth bands with similar mineralogy have similar G compositions regardless of paragenetic sequence. IF in growth bands with precious metals have low CO_2 / H_2S and high H_2O/CO_2 and H_2S / N_2 ratios that reflect L remaining after boiling, according to CHILLER-based reaction progress calculations. IF from quartz have lower H_2O/CO_2 and higher CO_2 H_2S ratios, show little change from layer to layer, and reflect deposition by cooling or F mixing. IF in calcite have more variable G concentrations with higher CO_2/H_2S and lower H_2O/CO_2, and also reflect boiling with V entrapment. I in growth bands containing sericite have higher CO_2 H_2S and lower H_2O/CO_2 that cannot be accounted for by reaction progress calculations involving internal processes and probably reflect introduction of G from subjacent magma. (Authors' abstract)

GRAUPNER, T., KEMPE, U., DOMBON, E., PAETZOLD, O. and **LEEDER, O.,** 1996, The fluid regime in the tungsten (-yttrium) deposits of Kyzyltau (Mongolian Altai); Comparison with fluid zonation in tungsten-tin ore systems (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 51-52. First author at Earth Sci. Centre, Dept. of Geol., Univ. of Toronto, 22 Russell Street, Toronto, Ontario M5S 3B1, Canada; e-mail (graupner@zircon.geology.utoronto.ca)

The Kyzyltau ore field contains W(-Y-Be-Mo) mineralization in veins and stockworks within granites, felsic volcanics and gabbro-diorite intrusions, as well as in conglomerates.

Melt- and G-L I in magmatic quartz, apatite and zircon in different types of granites and in hydrothermal quartz, fluorite and beryl from veins of the Ulaan uul, Buraat uul and Tsunkheg deposits were investigated by microthermometry and Raman spectroscopy. The homogenization Th of crystalline silicate M I range from 735 to 1030°C. Two generations of F are distinguishable in the ore veins according to Th, sal and the gross compositions of FI at room T. The Th values of aq I in veins are between 180 and 433°C (first generation) and 55 and 225°C (second generation). Using FI in vein fluorites I and II (core and rim of the same fluorite crystal) a T increase during crystallization of fluorite II in Ulaan uul is indicated.

FI data indicate that there are different trends in the F circulation of Ulaan uul and Buraat uul. These trends are correlated with phase separation in the F. In Ulaan uul a repeated opening of the system resulted in losses of considerable amounts of CO_2 and significant mineral deposition. In Buraat uul there is no evidence for an intensive opening of the system, leading to the formation of low-grade ores.

FI gases (first phase I) in veins are CO_2-dominated. The amounts of N_2 and CH_4 are notably lower with N_2 / CH_4 ratios >1. I of the second phase contain no or only traces of G (only indicated by clathrate melting) in most samples.

From high-T, Fe-rich, K-dominated brines cassiterite ores can precipitate in quartz veins together with Fe-chlorite and Fe-tourmaline (Bolivian type). If phase separation of a G-rich (CO_2, F_2, N_2), low-sal and high-T F occurs, cassiterite-wolframite or wolframite ores are deposited during repeated boiling of the system with escaping CO_2 (Cornwall/Devon and Kyzyltau type).

According to this interpretation, tin mineralization may be found in a more favourable setting in the vicinity of the Kyzyltau deposits. (From authors' abstract by E.R.)

GRAY, G.G., POTTORF, R.J., SUMMA, L.L., MAY, S.R. and **HOLL, J.E.,** 1996, Fluid flow and the Cashin Fault, Paradox Basin, Colorado (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A254. First author at EXXON Production Research Co., P.O. Box 2189, Houston, TX 77252-2189.

The Cashin Fault is a small, planar feature on the south-ern flank of the Paradox Valley salt anticline that serves as a good analog for subsurface fault-related flow processes. The fault has been the focus for flow of basinal brines and buoyant hydrocarbons, with flow from bottom to top. Evidence for F flow includes reduction of hematite and deposition of a variety of sulfides, gangue minerals, and native metals. Mineralization is concentrated in vertical patches within the fault zone, suggesting enhanced vertical flow related to faulting, in spite of already high matrix permeabilities in the Wingate, near 0.5 Darcy. The vertical patches of mineralization are also concentrated near the tip of the reactivated segment, suggesting greater dilation of the host rocks in this portion of the fault. Tt from aq FI are as high as 105-110°C. Apatite fission track data indicate similar T in the host rocks at the base of the mineralized section, suggesting nearly isothermal conditions for the mineralizing F. Paleomagnetic dating of chemical remagnetization associated with the F flow event is consistent with a Paleocene to Eocene age, which coincides with maximum burial and maturation of the shales within the Paradox Fm. Faulting is either synchronous with or predated this Early Tertiary F flow event, and is therefore interpreted to be Laramide in age, formed in response to compressional uplift of the Uncompagre Plateau. (From authors' abstract by E.R.)

GRAYBEAL, F.T., 1996, Sunnyside: A vertically-preserved porphyry copper system, Patagonia Mountains, Arizona: SEG Newsletter, no. 26, p. 1 & 10-14.

A petrographic study of FI in quartz reveals that G-rich I (V bubble exceeds 50% of I volume), generally thought to indicate boiling, are common throughout the Sunnyside area with two exceptions; they are absent from both the quartz feldspar porphyry and the lapilli tuff within roughly 600 m of the present surface. Broken quartz crystals in the lapilli tuff are juvenile and the lack of FI in these crystals, as well as in quartz phenocrysts within the upper portions of the quartz feldspar porphyry, permits the inference that boiling had not evolved significantly within the porphyry at the rime the lapilli tuff unit formed. Boiling appears to have been superimposed on the quartz feldspar porphyry following its emplacement and eruption and was never a significant hydrothermal process within the lapilli tuff.

Initial evolution of a hydrous phase in the porphyry appears to have resulted from decompression following eruption and exsolution of water in the interstitial magma. If the quartz feldspar porphyry ascent had been rapid, it is possible that second boiling may have contributed energy for the explosive eruption (Burnham, 1985).

G-rich FI in quartz are largest and most abundant in the advanced argillic zone. Both the advanced argillic zone and the zone of abundant G-rich FI wrap partly around the west side of the lapilli tuff unit and quartz feldspar porphyry outcrops, suggesting that boiling had begun prior to emplacement of the porphyry, perhaps following intrusion of the quartz monzonite porphyry dike system. G-poor, halite-bearing FI are rare or absent within roughly 600 m of the surface. (From author's text, by E.R.)

GREBENSHCHIKOVA, V.I., PROKOF'YEV, V.Y. and **TROSHIN, Y.P.**, 1995, New data on the genesis of gold-ore veins in the Kommunar deposit, Kuznetskiy Alatau: (in Russian, translated in Trans. (Doklady) Russian Acad. Sci., Earth Sci. Sect., v. 343A, no. 6, p. 131-136, 1996) Authors at Vinogradov Inst. of Geoch., Siberian Dept., Russian Acad. of Sci., Irkutsk.

GREEN, T.H., 1996, Experimental versus natural two-mineral partition coefficients; a "high-tech" controversy: Geol. Soc. of Australia Abstracts, v. 41, p. 166.

Indexed under FI (E.R.)

GU, Chifeng, and **VANKO, D.A.**, 1996, Nature of fluid inclusions in samples of the deep sheeted dikes cored during Leg 148 (Hole 504B): Proceedings of the Ocean Drilling Program, Scientific Results, v. 148, p. 87-95.

Hole 504B of the Ocean Drilling Program (ODP) provides the only available in situ samples of oceanic sheeted dikes. The rocks cored during Legs 137, 140, and 148 consist of altered diabase characterized by greenschist-facies secondary minerals. FI are abundant in plagioclase within highly altered vein halos, formed as apparently isolated I or along healed planes of S I. All FI are two phase (L plus V) and L dominated (the volume of vapor is commonly less than 10%).

Microthermic results from plagioclase-hosted I in the lower sheeted dikes reveal fluids with ice-melting T ranging from -0.1°C to -4.9°C. The corresponding F sal range from 0.2 to 7.7 wt.% NaCl eq., similar to the sal of F exiting submarine hydrothermal vents at mid-ocean ridges (about 0.4-7.0 wt.% NaCl eq.). The mean sal for individual samples are between 1.8 and 3.8 wt.% NaCl eq., close to that of seawater (3.2 wt.% NaCl eq.). The FI in some S planes display much lower sal (less than 1.0 wt.% NaCl eq.).

The measured Th of FI range from 124° to 211°C. The *mean* Th for individual samples increase systematically with depth, from 135°C at 1500 mbsf to 165°C at 2100 mbsf. This T range is much lower than that of hydrothermal alteration in the Hole 504B dike complex (250°-350°C), that of predicted greenschist-facies alteration (250°-450°C), and that of F in modern black smoker vents (250°-400°C). Assuming a gas-free F, hydrostatic-pressure-corrected "trapping temperatures" for the sheeted dike section from Legs 111, 137, 140, and 148 range from 150° to 201°C, which is consistent with the present-day borehole T. Lithostatic-pressure-corrected Tt are 15°-25°C higher than the present-day borehole T. Crushing experiments show that I contain in the order of 0.1 mol% compressible G. If the presence of G is considered, the lithostatic-pressure-corrected Tt correspond closely to the present borehole T.

The sheeted dike complex at Hole 504B was altered at the ridge axis 5.9 m.y. ago at high T (>350°C). The FI, however, record T appropriate for present-day conditions. Thus, FI in hydrothermal plagioclase have been open systems, continually reequilibrating to the ambient conditions. I must be interpreted in terms of the history of T and P changes undergone by the young ocean crust as it formed at the mid-ocean-ridge axis and was then transported from the rift environment. (Authors' abstract)

GUILHAUMOU, Nicole, DUMAS, Paul and **WILLIAMS, G.P.**, 1996, Synchrotron infrared microspectrometry of single fluid inclusions beyond the diffraction limit (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 53-55. First author at Ecole Normale Supérieure, Laboratoire de Géologie, URA 1316 du CNRS, Paris (France)

The microanalysis of individual FI by infrared microsspectrometry is currently limited by the brightness of the conventional black body thermal emission source. The spatial resolution and signal is limited and allows only the analysis of elements with significantly high absorption in I greater than 15 µm. The use of the infrared Beam line of the National Synchroton Light Source (U2B, Brook-haven National laboratory) overcomes these problems. We have performed infrared microscopy measurements using a confocal system and a SpectraTech IRuS microspectrometer on hydrocarbon and aq FI in fluorite and quartz matrix. A 3x3 μm^2 aperture was used in this study as optimal conditions. The system is completely purged by dry nitrogen allowing a significant detection of CO_2 in V and L phase of both types of I. The bending and stretching CH vibrations of aliphatics are easily detected in 5 to 10 µm hydrocarbon FI in a fluorite matrix. Such measurements will allow the rapid characterization of very small sized FI representative of diagenetic events at the limit of detrital quartz and overgrowth in reservoir sandstones. Joint analyses by Raman spectrometry in aq I aim to completely define the F in the reservoir when diagenesis started.

Semiquantitative measurements of the integrated intensities of each vibrator allow one to establish a chemical image of each component inside the FI. We have mapped the oil and the CO_2 chemical images of FI in fluorite and in quartz. This opens up the possibility of quantitative analysis of hydrocarbon FI.

The spatial resolution is not strictly limited to 3 microns, but can be further improved using brightest synchrotron source; spatial resolution of 1 µm can be achieved. (From authors' abstract by E.R.)

GUILHAUMOU, N., TOURAY, J.C., PERTHUISOT, V. and ROURE, F., 1996, Palaeocirculation in the basin of southeastern France sub-Alpine range; a synthesis from fluid inclusions studies: Marine and Petrol. Geol., v. 13, no. 6, p. 695-706. First author at Ecole Normale Superieure, Laboratoire de Geologie, Paris, France.

GUO, Xinsheng and **DU, Jun'eng,** 1996, Fluid inclusions and isotopic geochemistry in the Changken gold-silver deposit: Mineral Resources and Geol., (Kuangchan Yu Dizhi), v. 10, no. 3, p. 187-193 (in Chinese, authors' abstract translated courtesy Dr. Xu Jiuhua). First author at the Inst. of Minerals and Geol. of China, Nat'l. Nonferrous Metal Industry Corp., Guilin 541004, China.

FI and isotope geochemistry study on Changkeng Au-Ag deposit indicated that both the ore materials and the hydrothermal F were from the same source, though there exists a zoning between gold ore bodies and silver bodies. During the formation of Au-Ag deposit, the ore-forming T was 250°C, with -38 ~ -37 of log fO_2, 4.0 ~ 5.6 of pH. The $\delta^{34}S$ values of sulfides are -6.6 ~ 8.8 per mil, the $\delta^{18}O$ values of hydrothermal F are -7.8 ~ 9.0 per mil, and δD -80 ~ -43 per mil. The K-Ar age of gold-silver ore is 133 Ma ~ 137 Ma. Hence, the activity of Yanshanian magma provided the heat source for ore-forming of Au-Ag deposit, driving meteoric water to leach ore materials from country rocks, and to precipitate ores in ore-forming structures. (Authors' abstract)

GURENKO, A.A., HANSTEEN, T.H. and **SCHMINCKE, Hans-Ulrich,** 1996, Evolution of parental magmas of Miocene shield basalts of Gran Canaria (Canary Islands): constraints from crystal, melt and fluid inclusions in minerals: Contrib. Mineral. Petrol., v. 124, p. 422-435. First author at GEOMAR Research Center, Dept. of Volcanol. and Petrol., Wischhofstrasse 1-3, D-24148 Kiel, Germany.

Picritic units of the Miocene shield volcanics on Gran Canaria, Canary Islands, contain olivine and clinopyroxene phenocrysts with abundant PM, crystal and FI. Composition and crystallization conditions of P magmas in equilibrium with olivine fO_{90-92} were inferred from high-T microthermometry of FI and simulation of the reverse path of olivine fractional crystallization based on major element composition of MI. The P magmas crystallized in the presence of an essentially pure CO_2 F. The P magmas originated at P>30 kbar and T of 1500-1600°C, assuming equilibrium with mantle peridotite. This implies melting of the mantle source at a depth of ≈100 km within the garnet stability field followed by migration of M into magma reservoirs located at the boundary between the upper mantle and lower crust. The T and pressures of P magma generation suggest that the Canarian plume originated in the lower mantle at depth ≈900 km that supports the plume concept of origin of the Canary Islands. (From authors' abstract by E.R.)

GYANI, K.C. and **OMER, I.E.M.,** 1996, Origin and evolution of Archaean granulites from Rajasthan, northwestern India (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 552. Authors at P.G. Dept. Geology, MLS Univ., Udaipur, Rajasthan, India.

The presence of CO_2 rich high density (1.03 g/cm^3) (also aq) FI in granulites indicate role of carbonic metamorphism. The source of CO_2 production is most likely deep seated (hot spots) rather than overplating or intrusion of magmas or local stratigraphic sources.

From the evidences it is concluded that Bhinai granulites represent early Archaean counter clockwise path and the Sandmata granulites represent the late Archaean clockwise PT paths and tectonic emplacement of granulites to present level. (From authors' abstract by E.R.)

HABERMEHL, M.A., 1996, Groundwater movement and hydrochemistry of the Great Artesian Basin, Australia: Geol. Soc. Australia Extended Abstracts, no. 43, p. 228-236. Author at Australian Geol. Survey Org., Canberra, A.C.T.

Groundwater in the Lower Cretaceous-Jurassic confined aquifers of the Great Artesian Basin, Australia, flows from the recharge areas in the eastern margins to the western, southwestern, southern, and northern margins where artesian groundwater discharges from springs. The chemistry of the artesian groundwater in the Basin is dominated by $Na\text{-}HCO_3\text{-}Cl$ and these ions contribute more than 90% of the total ionic strength of solutes in the eastern, central and northern Basin areas. In the western parts of the Basin, groundwater is chemically characterised by $Na\text{-}SO_4\text{-}Cl$ type water, and the groundwater flow direction is from the recharge areas in the western margin towards the southwestern discharge margins. (Author's abstract)

HAGEMANN, S.G., BRAY, C., BROWN, P.E. and **SPOONER, E.T.C.,** 1996, Combined gas and ion chromatography of fluid inclusions and sulfides from the Archean Epizonal Wiluna lode-gold deposits, western Australia (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 56-58. First author at Univ. of Wisconsin-Madison, Dept. of Geol. and Geophys., Madison-WI 53706, USA; e-mail (hagemann@geology.wisc.edu)

Combined Microthermometric (MT) and laser-Raman (LR) G and ion chromatography (GC/IC) studies were carried out on FI, pyrite and stibnite in 28 samples of representative drill core and surface (open pit) locations. Two samples (quartz and epidote) of unmineralized pillow lava are interpreted to contain early, possibly seafloor metamorphic F. The aim of this preliminary study was to characterize and contrast the G species, mono- and divalent cations and anions of FI and sulfides associated with early quartz-graphite alteration, gold-pyrite-arsenopyrite and gold-stibnite mineralization, and identify possible processes that resulted in the observed type and occurrence of FI.

Microthermometry and Laser-Raman Spectroscopy

Three co-existing P FI types in quartz veins and breccia matrices that are associated with Stage I mineralization: (1) aq I of low sal (mean 2.9 ± 2.1 eq. wt% NaCl), (2) $H_2O-CO_2 \pm CH_4$-salt I of low sal (mean 2.9 ± 2.1 eq. wt% NaCl) containing approximately 17 ± 14 mol% CO_2), and (3) $CO_2 \pm CH_4$ I ($X_{CO2+CH4} > 0.9$) with rare, thin rims of water. These three types of FI are interpreted to have been produced by phase separation at 300° ± 50°C at < 0.5 to 1.5 kbars. FI related to gold-stibnite mineralization and trapped in quartz veins and breccia matrices consist of two coexisting P types: (1) aq I of medium sal (mean 5.0 ± 1.8 eq. wt% NaCl), and (2) $H_2O-CO_2 \pm CH_4$-salt I of low sal (mean 3.8 ± 2.2 eq. wt% NaCl) containing approximately 16 ± 8 mole% CO_2. The total Th of both I types is 280 ± 50°C at pressures of <0.5 to 1.5 kbars. FI trapped in early graphite-quartz veins are rare but where observed contain medium density (mean 0.82 g/cc) $CO_2 \pm CH_4$ inclusions ($X_{CO2+CH4} > 0.9$) with rare, thin rims of water.

For the GC/IC analyses quartz and epidote samples were crushed to 1 to 2 mm, handpicked and cleaned in diluted HNO_3, DIW and H_2O_2 at 60°C, before the final electrolytical cleaning (Channer and Spooner, 1992). Sulfides were cleaned in an ultrasonic bath using ethanol and DIW. About 1.7 g of material was loaded into a stainless steel crusher linked to the inlet of a HEWLETT PACKARD 5890 GC. The sample was precleaned overnight in He gas with the crusher at 105° C. The sample was crushed once at a P of 3500-4500 psi and the volatiles such as N_2^+, CH_4, CO_2, H_2O, COS, and various hydrocarbons analyzed using an isothermal (80° C) run according to procedure given in Bray et al. (1991). The crushed sample was then removed into a teflon beaker where it was leached with DIW. The leachate was filtered, made up to 10 ml, and then analyzed for strong anions (Cl^-, NO_2^-, Br^-, NO_3^-, HPO_4^{2-} SO_4^{2-}), and weak cations (Li^+, Na^+, NH_4^+, K^+, Rb^+, and Cs^+) cations on a DIONEX 2000i-SP IC. A separate hand crush/leachate was conducted using the procedure described in Channer and Spooner (1992). The purpose of this was to analyze for divalent cations such as Mg^{2+}, Ca^{2+}, Sr^{2+} and repeat analyses of other cations. System blanks and standards were used according to Channer and Spooner (1992). Precision of <0.2 mol% for all species are obtained.

Volatiles: The bulk volatile composition of Stages I and II FI are broadly similar and consist of about 60-99 mol% H_2O, 0.1-33 mol% CO_2, 0.01-5 mol% CH_4, 0.02-1.8 mol% N_2, and trace species (<1 mol%) of hydrocarbons. Quartz and epidote from an unmineralized pillow basalt consist of 99.4 % H_2O, 0.6% N_2 and 0.1% CO_2. The CO_2 / CH_4 and CO_2 / N_2 ratios of FI trapped in early quartz-graphite veins, and in quartz related to gold-pyrite-arsenopyrite and gold-stibnite mineralization differ widely from 140 ± 232 (n=10) to 2540 ± 2654 (n=3), and 54 ± 93 (n=10) to 470 ± 393 (n=3), respectively. Notice also the large variance within the two mineralization styles perhaps indicating heterogeneous trapping of the volatiles. *Cations and Anions:* As for the volatile analyses the cation signature of FI related to Stages I and II mineralization are broadly similar and dominated by Ca^{2+} with variable enrichment of Na^+ and Mg^{2+}. Stage II quartz shows a slight enrichment of Mg^{2+} when compared to Stage I mineralization. The Na/Mg ratio of Stage II stibnite (5.1) is higher than in Stage I pyrite (0.2). On a plot of Br^- vs. Cl^- Stage I quartz displays a higher Br/Cl ratio (3.5) than Stage II quartz (1.0). Stage I pyrite shows less Br^- and more Cl^- when compared to Stage II stibnite (Br/Cl ratios of 3.6 and 1.0, respectively). Quartz and epidote from pillow basalts contain an equal mixture of Na and Ca with little or no Mg and K, thus do not discernibly differ from the mineralizing F regarding their Na content. *Salinities:* Bulk salinities are in excellent agreement with FI data, if the sal and relative abundances of the different types of inclusions present in each sample are taken into account.

Detailed MT, LR, and GC/IC revealed that there is a good agreement between the different techniques albeit the former two are performed on individual FI, whereas the latter on bulk FI fluids. Preliminary results of the GC/IC analyses indicate that G, ions and cation species in both mineralization stages are broadly the same and characterized by a mixture of $H_2O-CO_2-CH_4 \pm N_2 \pm$hydrocarbons. Large variances of CO_2 / CH_4 and CO_2 / N_2 ratios point to heterogeneous trapping of these volatiles. Cations are dominated by Ca with contributions of Na and Mg. There are locally differences in volatile contents between FI trapped in quartz and associated sulfides which might indicate that FI in quartz and sulfides are either not trapped simultaneously and/or were preferentially effected by post-modification processes (see also Ridley and Hagemann, this volume). Further analyses of e.g. iodide might indicate if seawater was part of the paleohydrothermal system. (From authors' abstract by E.R.)

HAGEMANN, S.G. and **BROWN, P.E.**, 1996b, Geobarometry in Archean lode-gold deposits: European J. of Mineral., v. 8, no. 5, p. 937-960.

Full paper for previous abstract (E.R.)

HAGEMANN, S.G., BROWN, P.E., BRAY, C. and **SPOONER, E.T.C.**, 1996, Chemical characterization of an Archean gold-bearing hydrothermal system using gas and ion chromatography on fluid inclusions and sulfides(abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A474. First author at Dept. of Geol., Univ. of Wisconsin, Madison, WI 53706, USA.

The Wiluna lode-gold deposits are located near the northern end of the Archean Norseman-Wiluna greenstone belt in Western Australia. Gold occurs in two stages: (1) Stage I gold-pyrite-arsenopyrite mineralization deposited at 300-350°C, and (2) Stage II gold-stibnite mineralization formed at 250-300°C.

FI from an unmineralized pillow basalt in the mine area consist of 99.4% H_2O, 0.6% N_2, and 0.1% CO_2. The bulk volatile composition of Stages I and II FI are broadly similar and consist of about 60-99 mol% H_2O, 0.1-33 mol% CO_2, 0.01-5 mol% CH_4, 0.02-1.8 mol% N_2, and trace species (< 1 mol%) of hydrocarbons. The CO_2 / CH_4 ratios of FI trapped in early, largely unmineralized quartz-graphite veins (7-148; n = 2), and in quartz related to Stage I (10-1030; n = 8) and Stage II (19-5329; n = 9) mineralization range widely. The large variances of CO_2/CH_4 ratios point to heterogeneous trapping (phase separation) of these volatiles. The cation signatures of FI related to quartz-graphite veins and Stages I and II mineralization are similar and dominated by Ca^{2+} with variable enrichment of Na^+ and Mg^{2+}. Both quartz-graphite and Stage II quartz show a slight enrichment of Mg^{2+} when compared to Stage I quartz. The Na / Mg ratio of Stage II stibnite (5.1) is higher than in Stage I pyrite (0.2). I in quartz and epidote from pillow basalts contain an equal mixture of Na and C with little or no Mg and K, and thus do not discernably differ from the mineralizing F regarding their Na content. Anion ratios of Br /Cl are variable and range from 1.2 ×

10^{-3} in pillow basalts, to 2.2 in quartz-graphite veins, to 1.1 in Stage I and to 2.6 in Stage II. The Br /Cl ratios are distinctively lower than shield brines (3 to 5.5) and cluster broadly between bulk earth (2.38) and seawater (1.54). The Br content of the Wiluna hydrothermal system is low (0.5 to 5.5×10^{-3} mmol/l) when compared to other Archean lode-gold deposits such as Hollinger-McIntyre and Kerr Addison (6 to 13×10^{-3}).

In our model for the evolution of the gold-bearing hydrothermal system at Wiluna the anion ratios of the different hydrothermal events change with time and metal deposition, whereas the G and anions remain broadly the same. Pulses of seawater and deep magmatic/metamorphic waters result in a complex interplay of wallrock alteration processes and F immiscibility in quartz veins and breccias that result in the deposition of gold, stibnite, pyrite and arsenopyrite. (Authors' abstract)

HALL, D.L., 1996, Application of fluid inclusions to petroleum exploration: Some recent advances and case studies (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 59-60. Author at Amoco Tulsa Tech. Center, P.O. Box 3385, Tulsa, OK 74102-3385; e-mail (dhall@trc.amoco.com)

Petroleum geoscientists must continue to develop technologies which lower risks associated with exploring for petroleum, help prevent the unknown drilling of near misses and aid in the efficient production of established reserves. Significant variables which affect exploration success, such as (1) evidence for migration, (2) product type, quality and volumetrics, (3) timing of migration with respect to porosity evolution, and (4) effectiveness of petroleum seals over geologic time can be addressed, to some extent, by FI studies. However, FI techniques remain underutilized in the petroleum industry due, in part, to questions about their significance and a limited understanding of F phase relationships within petroleum FI. This summary is designed to reiterate the importance of exploration-specific FI studies through discussion of recent technical advances and case studies. Six general problem areas are addressed and discussed:

1) Migration detection and migration pathway definition;
2) Extraction and chemical analysis of petroleum from inclusions;
3) Timing relationships;
4) Product type and quality;
5) Seal identification and quality; and
6) Migration mechanisms.

See also Larese & Hall, this volume. (From author's abstract by E.R.)

HALL, D.L. and **LARESE, R.E.**, 1996, Interpreting petroleum migration in siliciclastic rocks: evidence from fluid inclusions (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 3. (Note: this abstract was distributed at the I.G.C. Workshop/Shortcourse, but was not printed in the official 30th I.G.C. Abstracts volumes. E.R.) Authors at Amoco Tulsa Tech. Center, Tulsa, Oklahoma.

The documentation of hydrocarbon FI in rock samples is a powerful tool for tracking petroleum migration and evaluating the relationship between porosity evolution and hydrocarbon emplacement. However, in applying FI technologies to the understanding of petroleum systems it is necessary to 1) insure that oil I document by hydrocarbon migration rather than *in-situ* generation or inheritance of I to recycled clastic material; 2) correctly interpret textural relationships among I and diagenetic/microstructural features, and 3) understand the controls on petroleum I formation. We have combined observations from natural systems with results of hydrothermal compaction and cementation experiments to begin addressing these problems; several of these experiments are described below.

Sieved, angular Brazilian quartz was compacted at 360° or 150°C for 288 hr. with an effective stress (confining pressure-pore P) of 690 bars in the presence of a pore F consisting of 100% natural crude oil. In addition to oil I along healed microfractures, other oil I appear to have exploited pre-existing aq I, apparently through breaching, flushing and refilling of old I cavities. This "exploitation" process appears to be energetically favored at lower T as compared to fracture healing.

Cementation experiments were conducted at 325°C and 690 bars of hydrostatic P using a combination of angular Brazilian quartz, rounded quartz sands and chlorite or hematite coated quartz sands and variable pore F from 100% aq to 100% oil. Texturally P FI were rare within overgrowths and along dust rims; no preference was noted for I formation along coated or uncoated grains. Exploitation oil I were common within detrital portions of quartz grains. Some I along dust rims were incompletely sealed during the experiments, resulting in porous permeable interfaces which continue to be open to later pore F in spite of significant overgrowth formation. We were able to introduce later oil into these dust-rim pores, thereby producing a false texture of P oil I along quartz overgrowth boundaries.

The results of these and other experiments, coupled with our empirical observations on natural samples, imply the following conclusions for interpreting petroleum I textures and distributions in natural rocks:

1) Oil I can form in the burial environment from oil-dominated pore F even in the absence of intergranular cementation and intense compaction, either by diffusive crack healing, or exploitation of old I cavities. The documentation of petroleum I formation mechanisms which do not rely on active cementation suggests that paleomigration events are easier to document in the FI record than previously believed.

2) Textural criteria can be misleading. Exploitation I with no visible F entry points may be mistakenly identified as inherited or pre-overgrowth I. Infiltration and entrapment of oil along weak boundaries between detrital grains and overgrowths can cause deceptive timing relationships and inaccurate interpretations of reservoir quality at the time of migration.

3) Oil and G I can be formed through *in-situ* generation/entrapment processes in nominally non-source intervals if high TOC shale fragments are present. The resulting textures may not be distinguishable from migrated hydrocarbons; hence, thermal maturity must be taken into consideration when interpreting petroleum I distributions. (From authors' abstract by E.R.)

A slightly different form of this abstract was also printed in IGC Abstracts, v. 2, p. 488. (E.R.)

HALLBAUER, D.K. and **BALABAN, Aneta**, 1996, The ionic composition of fluid inclusions in quartz and pyrite from selected Romanian deposits (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 483. First author at Geol. Inst. of Romania, Bucharest, Romania.

Capillary electrophoresis or capillary ion analysis (CIA) has become available as a low cost but fast analytical method for cationic and anionic species in aq solutions. The separation of ionic species by CIA is accomplished within a fused quartz capillary by utilising the differences in the electrophoretic mobility of ionic species. CIA offers in addition the injection of a sample by electromigration or electrolytic pre-concentration and thus an increase in detection limits. CIA possesses the further advantage that anionic sulphur species from charges (2-) to (6+) can be detected and quantified simultaneously. Best suited for this type of analysis is the crush-leach technique which allows the analysis of F in mineral specimens of less than 0.5 g with detection limits of about 5 ppb of elements in solution.

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+}, Mn^{2+}, Fe^{2+}, Zn^{2+} and as minor cationic components Co, Ni, Cu and Ba. Major anions or ligands detected were Cl^-, SO_4^{2-}, HCO_3^-, $HSiO_4^{3-}$ and less frequently SO_3^{2-}, $S_2O_3^{2-}$, 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 show that the FI in quartz are dominated by NaCl rich solutions, except for quartz from the Timpoiele 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 NaCl type. FI in pyrite are all characterised by an increased proportion of SO_4^{2-} and some SO_3^{2-}, while some, like the pyrite from Cavnic and PDH-2, contain significant amounts of $S_2O_3^{2-}$ and traces of HS^-, indicating a lower level of oxygen fugacity. The general content of HCO_3^- of all samples is relatively low. 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 the other F. Also of interest is the presence of MoO_4^{2-} in pyrite from Cavnic, Baia Sprie, PDS-2 and Trimpoiele. The F of the pyrite from Baia Sprie and PDH-2 contain additional and significant amounts of $HAsO_4^{2-}$. Small amounts of F^- were recorded for the F of all pyrite samples.

The results so far strongly indicate the extensive changes took place in the composition of hydrothermal F between the deposition of quartz and associated pyrite. (From authors' abstract by E.R.)

HALLBAUER, D.K., 1996, The application of capillary ion analysis to the geochemistry of natural aqueous fluids and in particular to the analysis of fluid inclusions in various minerals (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 19-20. Author at Dept. of Geol., Univ. of Stellenbosch, Private Bag X1, Matieland, 7602, Rep. South Africa; e-mail (dkh@maties.sun.ac.za)

See Hallbauer and Balaban, (1995) FIR, v. 28, p. 58. (E.R.)

HALTER, W.E., WILLIAMS-JONES, A.E. and **KONTAK, D.J.**, 1996, The role of greisenization in cassitetrite Prcipitation at the East Kemptville Tin Deposit, Novia Scotia: Economic Geology, v. 91 (1996) p. 368-385. First author at Dept. of Earth and Planetary Sci., McGill Univ., 3450 University Street, Montreal, Quebec, Canada H3A 2A7.

The role of F rock (leucogranite) interaction in forming the greisen-hosted tin (Cu-Zn-Ag) deposit at East-Kemptville, Nova Scotia was investigated by evaluating compositional and mineralogical changes in a representative zoned greisen, and by using this information to estimate physicochemical changes in the F-rock system at each step of the alteration. First, or distal to the vein, the leucogranite was converted to a quartz-sericite greisen through the replacement of albite by muscovite. This alteration, specifically the dissolution of albite, created some porosity. Closer to the vein, the neoformed muscovite was converted to topaz and quartz, creating an quartz-topaz greisen; pyrite, sphalerite and cassiterite precipitated in the earlier created pore space.

Mass balance calculations show that during alteration almost all major elements, including aluminum, were mobile. Only silicon was essentially immobile because the F was saturated with quartz due to earlier interaction with the leucogranite. The alteration of the leucogranite resulted in a quantitative removal of the alkalies, Mg and Mn, and an addition of Fe, S, F, Zn, and Sn. The study indicates that there was an increase in the pH of the F and a decrease in ü_{O_2} during alteration, and that these changes were most important close to the vein. Cassiterite deposition occurred contemporaneously with the alteration of muscovite to topaz and quartz and is interpreted to have been caused by the sharp increase in pH that accompanied this reaction. Changes in f_{O_2} and Cl^- acted against cassiterite precipitation, but were apparently insufficient to prevent its saturation. (From authors' abstract by E.R.)

For the purpose of identifying the dominant species in solution, we assumed that T and pressure were constant across the alteration halo. The values used for these parameters were 420°C and 2,800 bars and were based on microthermometric data for P FI, oxygen isotope fractionation between quartz and cassiterite and contact metamorphic mineral assemblages. Based on dissolution temperatures for halite in the FI and on EDS analyses of FI decrepitates the total sal of the F was estimated to be 30 to 33 wt percent NaCl equiv and the Na/K ratio, 10:1. Dissociation constants for NaClo and KClO indicate that at the assumed P-T conditions NaCl and KCl were dominant over Na^+ and K^+ in the F. The distribution of these species was used to calculate the activity of Cl^- in the F and to show in turn that $FeCl^+$ and $ZnClO_2$ were the dominant species of Fe and Zn, respectively. (From authors' text by E.R.)

HALTER, W.E., WILLIAMS-JONES, A.E. and **KONTAK, D.J.**, 1996, The role of greisenization in cassitrite precipitation at the East Kemptville Tin Deposit, Novia Scotia: Economic Geol., v. 91 (1996) p. 368-385. First author at Dept. of Earth and Planetary Sci., McGill Univ., 3450 University Street, Montreal, Quebec, Canada H3A 2A7.

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HAMILTON, P.J., BAI, G.P., EADINGTON, P.J. and **KEENE, J.B.,** 1996, Fluid flow histories in Permo-Triass sediments of the Sydney Basin, SE Australia; isotope and fluid inclusion constraints (abst.): American Assoc. of Petroleum Geologists Annual Meeting Abstracts, v. 5, p. 59. First author at CSIRO Petroleum Resources, Australia.

A petrographic, isotopic and FI investigation of Permo-Triassic sandstones in the Sydney Basin has enabled reconstruction of the history of F flow. Diagenetic cements in Triassic sandstones comprise, in order, grain coating clays and carbonates, pore filling carbonates, kaolin, quartz, late interstitial carbonate and illite. Diagenesis in the Permian sandstones began with pore filling siderite prior to saddle ankerite, followed by quartz and then illite and late carbonates. F rock interaction during burial resulted in increases in pore water $\delta^{18}O$ from depositional values of -17‰ to about -12‰ to -7‰ at the time of quartz overgrowth crystallisation and to between -7‰ to -1‰ at the time of illite crystallisation. Interpretation of FI data and maturity measurements indicates that heat flow increased during the Triassic and Jurassic, reaching a maximum of about 2.1 HFU in the Cretaceous. Late Cretaceous uplift, cooling and erosion was initiated at the same time as, and probably related to, the initiation of Tasman Sea rifting. The rocks had previously been more deeply buried by 1500-2100 m. The uplift resulted in cessation of illite diagenesis timed at 90 Ma and meteoric water invasion of the sandstones in turn causing partial resetting of delta D compositions of the diagenetic clays to less D-depleted values. (Authors' abstract)

HAN, Yujing and **ZHANG, Zeming,** 1996, Fluids in high-pressure and ultra-high pressure metamorphism: Earth Sci. Frontiers (Dixue Qianyuan), v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior p. 222-229 (in Chinese; Engl. abst.). Authors at China Univ. of Geosci., Wuhan, 430074.

This paper emphasizes the significance of studies on FI in high-P and ultra-high P rocks and several points have been discussed: (1) N_2 is present as a characteristic component in eclogites. PFI found in coesite-bearing eclogites from Dabie Mountains were traps [trapped] in the high-P metamorphism stage. CO of 14 mol% was detected in the G component, suggesting F of deep-seated origin. (2) MI were first recognized in eclogites from Dabie Mountains. They are composed of silicate glass-phase and G-phase with the dominant CO_2 and the composition of glass-phase close to that of the host mineral. (3) FI and mineral isotopic compositions (H-C-O) in eclogites as tracers of local F migration during high-P and ultra-high P metamorphism. (4) F-M-rock interaction in high-P and mutra-high P metamorphism is complicated and demonstrates partial melting at eclogite-facies *p*-T conditions. (5) FI data suggest a correlation between metamorphic grade and metamorphic F composition. (Authors' abstract)

HAN, Yujing, ZHANG, Zeming, and **LIU, Rong,** and 1996, Melt inclusions and primary fluid inclusions in eclogites from high-pressure and ultra-high pressure metamorphic belt in Dabie Mountains (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 487. Authors at China Univ. Geosci., Wuhan 430074, PRC.

The M I are isolated in omphacite, kyanite, garnet and coesite, some oriented parallel to crystal axis of host minerals. The Th for M I generally vary between 820 and 950°C. They are composed of sillicate glass-phase and G-phase with the dominant CO_2, some containing aq solution with high sal (15.9-22.0 wt% $NaCl_{eq}$). The composition of glass-phase from eclogite DX1-1 is close to [that of?] kyanite (host mineral)), H_2S and OH^- detected by Raman analyses are molecule and ion in monomer (SiO_4) network structure, respectively. The glass-phase from eclogite SO13 corresponds to a type of frame (SiO_2) network structure, its composition close to host mineral coesite. Thus the host minerals possibly crystallized from the M of such composition and the M are likely of origin of anatexis.

Primary FI were only found in quartz within garnet from coesite-bearing eclogite at Mifengjian, Yingshan, Hubei. They are two-phase H_2O I with low Th of 140-180°C. The corresponding isochores for the densities of 0.99-0.97 g/cm^3 pass through the inferred P-T space for metamorphic conditions of high-P eclogite facies. The P of entrapment is 2.05 GPa for the Tt of 896°C and 1.39 GPa for 850°C. The uplift path for the Mifengjian eclogites is sub-parallel to isochores in P-T space, therefore, the primary FI with high density trapped in eclogite-facies stage were preserved during uplift of the host eclogite (Giaramita and Sorenson, 1994). In addition, CO of 14 mol% was detected in G component, suggesting F source of deep-seated origin. (From authors' abstract by E.R.)

HANSLEY, P.L., 1996a, The Tuscaloosa Formation revisited (abst.): American Assoc. Petro. Geol. Bulletin, v. 80, no. 9, p. 1503. Author at U.S. Geol. Survey, Denver, CO, US.

A petrologic study of the Upper Cretaceous lower Tuscaloosa Formation in the Gulf Coast from depths of 2700 to 6000 m indicates that anomalously high porosity (>20%) in deep G and condensate-bearing sandstones (5000 to 6000 m) is approximately evenly divided between P and S porosity. Two-phase PFI in quartz overgrowths which also contain oil-bearing I have Th between 125 and 134°C. These T combined with a burial history reconstruction indicate that hydrocarbons migrated into Tuscaloosa sandstones during the Miocene. Overpressuring began in the middle Tertiary along with G generation in the Tuscaloosa. These events coincided with the end of deep meteoric flow through the Gulf section and the beginning of a compactional hydrologic regime. Precipitation of quartz overgrowths and hydrocarbons at this time locally created effective P seals. (From author's abstract by E.R.)

HANSLEY, P.L., 1996b, Diagenesis as related to burial history, pressure regimes, and low-permeability zones in the Upper Cretaceous lower Tuscaloosa Formation, Mississippi and Louisiana (abst.): American Assoc. of Petrol. Geologists Annual Meeting Abstracts, v. 5, p. 60-61. Author at U.S. Geol. Survey, Denver, CO, US.

See previous item (E.R.)

HANSON, Benjamin, DELANO, J.W., and **LINDSTROM, D.J.,** 1996, High-precision analysis of hydrous rhyolitic glass inclusions in quartz phenocrysts using the electron microprobe and INAA: American Mineralogist, v.81 (1996) p. 1249-1262. First author at Planetary Materials Branch, SN4/NASA Johnson Space Center, Houston, Texas 77058.

A high-precision electron microprobe (EMP) technique has been developed that is capable of analyzing major, minor, and trace element abundances (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, Cl) in hydrous rhyolitic glasses. The technique was developed to characterize the chemical compositions of rhyolitic glass I in phenocrysts that occur in layers of Paleozoic altered volcanic ash. The compositions of these I serve as excellent chemical "fingerprints" of the altered volcanic ashlayers for use in stratigraphic correlation. The precision and reproducibility of the analyses is sufficient not only to distinguish one altered volcanic ashlayer from another on the basis of I compositions, but also to discern differences in the compositions of different I from the same layer. A high-precision instrumental neutron activation analytical (INAA) technique was also developed that is capable of measuring an additional suite of trace elements (e.g., Sc, Co, Rb, Cs, Sr, Ba, La, Ce, Sm, Eu Tb, Yb, Lu, Zr, Hf, Ta) in rhyolitic glass I in quartz phenocrysts with excellent accuracy and precision after correcting for the presence of the host quartz. The abundances of elements measured by the EMP technique and the corrected abundances determined using the INAA technique are identical within analytical uncertainty, thus demonstrating the internal consistency of the results. (Authors' abstract)

HANSON, Ben, von KIPARSKI, Wolfram and **DELANO, J.W.,** 1996, Correlation of bentonites in the Helderberg Group (Devonian) based on the compositions of melt inclusions in quartz phenocrysts (abst.): The Geological Society of American, 31st Annual Northeastern Section, 1996 Abstracts with Programs, v. 28, no. 3, p. 62, February 1996. Authors at Dept. of Geological Sci., Univ. at Albany, SUNY, Albany, NY 12222.

The chemical composition (determined using the electron microprobe) of MI in quartz phenocrysts have been used to chemically fingerprint the host bentonite layers that occur in the Devonian Helderberg Group limestones from New York and the Central Appalachian Basin (CAB). Si, Al, K, Na, Fe, Ti, Mn, Ca, Mg, and Cl abundances in the MI were determined with enough precision to confidently distinguish one bentonite from another. 10-20 MI were analyzed from each bentonite. Some of the bentonites contain MI that have all suffered post-entrapment crystallization within the host quartz. These I were melted and chemically homogenized in a 1-atmosphere furnace. The compositions of the rejuvenated I provide excellent chemical fingerprints of the host bentonite. (From authors' abstract by E.R.)

HANSON, R.B., 1996, Hydrodynamics of magmatic and meteoric fluids in the vicinity of granitic intrusions: Transactions of the Royal Soc. of Edinburgh: Earth Sci., v. 87, p. 251-259 (also in: The Third Hutton Symposium, Geol. Soc. Amer. Special Paper 315).

Numerical models that account for F flow, magmatic and metamorphic F production, topography and thermal expansion of F following emplacement of a granitic magma in the upper crust reveal controls on the distribution of magmatic F during the evolution of a hydrothermal system.

The exponential decay with depth of the influence of topography on FP results in a persistent zone of mixing at a depth of 1-2 km between these meteoric F and magmatic F despite variations in the strength of the magmatic hydrothermal system. However, in shallow systems where F release is episodic, dramatic changes in the region of mixing are still possible because FP is sensitive to variations in the rates of F production. Together, the patterns are consistent with the distribution and evolution of skarns and hydrothermal ore deposits around granitic magmas. (From author's abstract by E.R.)

HAO, Yanli, CHEN, Peirong, LIU, Changshi, and **SHEN, Weizhou,** 1996, Studies of inclusions in topaz granitic porphyry from Yangbin, Zhejiang Province (abst.): Acta Petrologica et Mineralogica, v. 15, no. 4, p. 333-338 (in Chinese; Engl. abst.). First author at Inst. of Geol., Chinese Acad. of Geological Sci., Beijing 100037.

There exist large numbers of P I in quartz phenocrysts within topaz granitic porphyry from Yangbin, Zhejiang Province. Based on large quantities of analytical work on such aspects of the I as their Th, sal and chemical composition, the authors have classified these P I into five major types, namely M I, hydroxylated silicate M-F I, nonhomogeneous captured polyphase I, : I (including high-sal L I and low-sal L I), and G I. In addition, the formation mechanism of I in this area are studied with respect to magmatic stage, magmatic disaggregation stage, magma/F immiscible stage, and hydrothermal dominant stage, thus convincingly supporting the opinion of magmatic origin for topaz granitic porphyry. (Authors' abstract.)

HARDIE, L.A., 1996, Secular variation in seawater chemistry: An explanation for the coupled secular variation in the mineralogies of marine limestones and potash evaporites over the past 600 m.y.: Geology, v. 24, no. 3, p. 279-283. Author at Dept. of Earth and Planetary Sci., Johns Hopkins Univ., Baltimore, Maryland 21218.

Secular changes in the mineralogies of marine nonskeletal limestones and potash evaporites occur in phase on a 100-200 m.y. time scale such that periods of "aragonite seas" are synchronized with $MgSO_4$ evaporites and periods of "calcite seas" with KCl evaporites. It is proposed that these coupled changes are the result of secular variation in seawater chemistry controlled primarily by fluctuations in the mid-ocean ridge hydrothermal brine flux, which in turn have been driven by fluctuations in the rate of ocean crust production. Quantitative predictions based on this hypothesis yield secular variation in limestone and potash evaporite mineralogies that closely match the observed variation over the past 600 m.y., providing strong support for the thesis that seawater chemistry, rather than remaining constant, has oscillated significantly over geologic time. (Author's abstract)

See also Holland et al., this volume (E.R.)

HARRIS, D.M. and **ROSE, W.I.,** 1996, Dynamics of carbon dioxide emissions, crystallization, and magma ascent: hypotheses, theory and applications to volcano monitoring at Mount St. Helens: Bull. Volcanol., v. 58

(1996) p. 163-174. First author at Dept. of Forest Resources, Utah State. Univ., Logan, Utah 84322-5215.

Measurements of CO_2 fluxes from open-vent volcanos are rare, yet may offer special capabilities for monitoring volcanos and forecasting activity. The measured fluxes of CO_2 and SO_2 from Mount St. Helens decreased from July through November 1980, but the record includes variations of CO_2/SO_2 in the emitted G and episodes of greatly increased fluxes of CO_2. We propose that the CO_2 flux variations reflect two G components: (a) a component whose flux decreased in proportion to 1 $1/\sqrt{t}$ dependence was generated by crystallization in a deep magma body at rates governed by diffusion-limited heat transfer, and (b) the G component with the higher CO_2/SO_2 was released from ascending magma, which replenished the same magma body. The separation of the total CO_2 flux into contributions from known processes permits quantitative inferences about the replenishment and crystallization rates of open-system magma bodies beneath volcanos. These new volcanic G flux separation methods and the existence of relations among the CO_2 flux, crystallization rates, and magma body replenishment rates yield new information about the dynamics of an open-vent, replenished magma body. (From authors' abstract by E.R.)

HARTY, B., APPORA, I., BARRAT, J.-A. A., DENIEL, C., VELLUTINI, P. and VIDAL P., 1993, He, Ar, Sr, Nd and Pb isotopes in volcanic rocks from Afar: evidence for a primitive mantle component and constraints on magmatic sources: Geochem. J., v. 27, p. 219-228.

HARUNA, Makoto and OHMOTO, Hiroshi, 1996, Oxygen and carbon isotope studies on the skarn-type ores at the Tengumori copper deposit of the Kamaishi mine, northeastern Japan: Resource Geol., v. 46, no. 3 (1996) p. 125-136. First author at Dept. of Geosci., Pennsylvania State Univ., University Park, Pennsylvania 16802 (now at the Geological Survey of Japan, 1-1-3 Higashi, Tsukuba, Ibaragi, 305, Japan).

The Tengumori deposit of the Kamaishi mine, northeastern Japan, is a skarn-type copper ore deposit that develops near granitic intrusive rocks of Cretaceous age. Hydrothermal activity at the Tengumori deposit is divisible into three stages: 1) calc-silicate (divisible into clinopyroxene and garnet phases), 2) ore mineralization (chalcopyrite + pyrrhotite + quartz), and 3) calcite. The $\delta^{18}O$ (SMOW) values were determined to be +6.6 to +7.8‰ for clinopyroxene (calc-silicate stage, 7 samples), +4.2 to +7.0‰ for garnet (calc-silicate stage, 14 samples), +12.0 to +13.7‰ for quartz (ore mineralization stage, 13 samples), and +10.6 to +12.8‰ for calcite (calcite stage, 19 samples). the oxygen isotopic temperatures calculated from the coexisting (but not contemporaneous) mineral pairs give consistent values of ~330-460°C. However, they are higher than both of the pressure-corrected homogenization T of FI (~180-330°C) and the uppermost T of stability of chalcopyrite and hexagonal pyrrhotite (325°C). This T discrepancy is the result of changing $\delta^{18}O_{H_2O}$ value from ~+7 to +9‰ in the calc-silicate stage, ~+2 to +7‰ in the ore mineralization stage, and +1 to +5‰ in the calcite stage. The $\delta^{18}O$ values of the calc-silicate stage solution can be interpreted as the unexchanged magmatic water or water in equilibrium with the host rocks. The hydrothermal solution of the ore mineralization stage is either magmatic water partially reequilibrated with the cooling pluton, water in equilibrium with the country rocks, or mixed solution with externally-derived water, e.g., local meteoric water. The $\delta^{13}C$ (PDB) values of calcite crystals (calcite stage) range from -5.44 to -0.37‰. The calculated $\delta^{13}C(H_2CO_3)$ values of the hydrothermal solution range from -5.8 to +1.4‰ and suggest that carbon was derived from both the granitic magma and the host limestone. Contributions of magmatic F to the calcite stage solution were recognized from the high sal values (up to 23 wt.% eq. NaCl) and the $\delta^{13}C$ values of the calcite crystals. (Authors' abstract)

HATTORI, Keiko, 1996, Occurrence and origin of sulfide and sulfate in the 1991 Mount Pinatubo eruption products, *in* Fire and Mud, C.G. Newhall & R.S. Punongbayan, eds., Philippine Inst. of Volcanol. & Seismology, p. 807-824. Author at Ottawa-Carleton Geosci. Centre and Dept. of Geol., Univ. of Ottawa, Ottawa, Ontario, K1N, 6N5, Canada.

Sulfide phases are found in a wide variety of the 1991 eruption products from Mount Pinatubo. Sulfides in early-formed phenocrysts (olivine and augite) in basalt fragments and dome-forming andesite are globular nickel-bearing pyrrhotite, whereas some sulfides in the glass are irregularly shaped and copper-rich. Sulfides in dacitic pumice are mostly copper-rich sulfides.

Anhydrite is commonly surrounded by the matrix glass in gray, white, and banded pumice. Smooth contact between the anhydrite and glass confirms that the dacitic M was in equilibrium with anhydrite immediately before eruption.

The occurrence of sulfide globules in the eruption products indicates that an immiscible sulfide L formed in silicate M and that the M were once reduced. Later formation of anhydrite in dacitic M requires an addition of sulfur and oxidation of the magma. It is proposed that supercritical F released from ascending mafic M beneath Mount Pinatubo provided volatile elements and sulfur. Sulfur that discharged from the hot dry M was mostly SO_2. The reduction of sulfur to H_2S in the cool (~800°C), wet dacite caused oxidation of this dacitic magma. H_2S formed in this way was initially precipitated in the dacite as sulfide minerals together with other volatile elements. Continued influx of SO_2 led oxidation of the dacite and an increase in the sulfur solubility of the M which caused partial resorption of sulfide minerals and led to excess sulfur, which was precipitated as anhydrite. The proposed model is consistent with compositions of iron-titanium oxides, abundant FI in phenocrysts, high contents of volatile elements and hydrophyllic metals in sulfides, strontium isotopic compositions of anhydrite, and sulfur isotopic values of the bulk rocks. (From author's abstract by E.R.)

HATZL, Thomas, 1992, The genesis of carbonatite- and alkali volcanic-associated fluorite-barite-bastnaesite ores of Kizilçaören (Turkey): Munchner Gelogische Hefte, v. 8, 271 pp (in German; Engl. summary).

Extensive investigations on the geological framework, mineralogy and geochemistry have proven a clear genetic association of the fluorite-barite-bastnaesite ores (FBB-ores) near the village of Kizilçaören (Turkey) with Tertiary (Upper Oligocene-Lower Miocene) alkali-volcanics and carbonatites.

—CO_2-H_2O I in apatite of the calcite-carbonatites probably represent P conditions (>2 kbar at T = 600-1000°C) when the carbonatitic and the silicate magma were still in equilibrium (LeBas & Handley, 1979). According to Hamilton (1989), the REE-Kd-values of phonolite/calcite-carbonatite indicate P conditions of about 2 to 4.5 kbar (at T = 1150°C) for the separation process of the silicate and carbonatitic magmas,

—FI in fluorite, barite and calcite of the hydrothermal overprinted carbonatites and FBB-ores show a predominance of Na-rich F and T of the main ore formation of about 200-250°C. (From author's abstract by H.E.B.)

HAURI, E.H., 1996, Volatiles in melt inclusions from Hawaiian volcanoes: an ion microprobe study (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F811, November 12, 1996. Author at DTM, 5241 Broad Branch Rd., NW, Washington, DC 20015; e-mail (hauri@dtm.ciw.edu)

We have developed ion microprobe techniques for the determination of the volatile elements H, C, F, S, and Cl in silicate glasses and minerals, utilizing a newly-installed Cameca IMS 6f. The analysis employs a defocused Cs+ beam and collection of low-energy negative secondary ions. This technique has the advantages of a spatial resolution of 20 microns and an analysis time of 10 minutes, with detection limits approaching 30 ppm for H and <10 ppm for C, F, S, and Cl. This technique has been applied to examine the systematics of these volatile elements in olivine-hosted MI in picrites from the Hawaiian volcanoes Loihi, Kilauea, Mauna Kea, Mauna Loa, and Koolau.

Major element compositions (corrected to equilibrium with host olivine) display variations which parallel their whole-rock hosts, but with somewhat more variability; these major element variations have been shown to be source features as they correlate with isotope ratios in whole rocks (Hauri, 1996, *Nature* 382: 415-419). Importantly, olivines from Mauna Loa and Koolau contain Si- and Al-rich M (up to 61% SiO_2, 18% Al_2O_3) which resemble dacites. These I would be predicted from the eclogite melting model previously proposed (Hauri, 1996).

CO_2 concentrations range from 4-2700 ppm; these variations are probably related to the depth of entrapment of the MI and possibly some subsequent CO_2 loss through cracks in the host olivines during cooling. Entrapment depths calculated from CO_2 abundances, using the CO_2 solubility model of Pan et al. (1991), indicate minimum entrapment depths as deep as 10 km. Concentrations of other volatile elements range from 0.07 to 0.7 wt.% N_2O, 5-2000 ppm S, 400-3200 ppm F, and 60-1800 ppm Cl. S abundances correlate positively with FeO, suggesting sulfur saturation of the trapped M.

Abundances of H_2O, F and Cl correlate with the major element systmatics of the I, as well as the major element abundance variations between Hawaiian volcanoes. In light of the major element-isotope correlations noted for whole rocks, abundances of these volatile elements are probably characteristic of their source regions, with Loihi MI displaying the highest volatile abundances and I from Mauna Loa and Kolau the least. These variations indicate that the recycled slab component in Mauna Loa and Koolau lavas was extensively depleted in volatile elements during ancient subduction. (Author's abstract)

HAYES, S.K., 1996, Epidotization of the sheeted dike-plutonic contact, Troodos Ophiolite, Cyprus (abst.): Keck Research Symposium in Geology. Abstracts, v. 9, p. 221-224. Author at Beloit College, R.D. Salisbury Dept. of Geol., Beloit, WI, US.

Indexed under FI (E.R.)

HAYES, S.K. and **BETTISON-VARGA, Lori,** 1996, Hydrothermal alteration of the sheeted dike-plutonic rock transition zone, Troodos Ophiolite, Cyprus (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A424. First author at Dept. of Geol., Beloit College, Beloit, WI 53511; e-mail (shayes@k12.oit.umass.edu)

Rocks from the sheeted dike-plutonic rock transition zone of the Troodos ophiolite, Cyprus, were affected by at least two distinct hydrothermal events. The first event is characterized by 3-phase, quartz-hosted I which homogenize at T of 305-525°C found in plagiogranite, diorite, and gabbro. These I have sal of 41-68 wt.% NaCl, and homogenize by halite dissolution indicating entrapment in the absence of a V phase. The high sal of these I and lack of evidence for boiling suggests formation from supersaline deuteric F exsolved off a highly crystallized magma.

The second hydrothermal event is represented by 2-phase I found in all lithologies from the sheeted dike-plutonic rock transition zone and in both epidote and quartz grains. The 2-phase I homogenize at T of 221-480°C and have sal of 3-16 wt.% NaCl. T and sal data suggest that this event was caused by seawater modified by water-rock reactions with the greenschist-altered diabase of the sheeted dike complex.

Epidotization occurred during the second hydrothermal event as seawater-derived F enriched in calcium, sodium, and iron permeated the host rock, albitizing and replacing plagioclase with epidote, precipitating epidosite in the sheeted dikes and within fractures in plagiogranite, diorite, and gabbro, and replacing actinolite with epidote. (From authors' abstract by E.R.)

HE, Jiang and **MA, Dongsheng,** 1996, Experimental study on the leaching of gold, antimony, mercury and arsenic from strata by middle-low-temperature sulphur- and chlorine-bearing aqueous fluids: Geological Review (Dizhi Lunping), v. 42, p. 76 (in Chinese; Engl. abst.). Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing, Jiangsu.

According to metallogenic conditions of the western Hunan epithermal mineralization area, the authors carried out a series of experiments of leaching Au, Sb, Hg and As from strata by sulphur- and chlorine-bearing aq F at 100 to 300°C and 40 MPa. The experimental results show that the T and ligand species and concentration of the F are major factors in controlling remobilization of the elements. The experiment gives a remobilization order of Hg-Sb-Au-As. The study suggests that high-S (low-Cl) hydrothermal F with T of 200-250°C are favorable for Au and Sb mineralization, while low-T low-S, high Cl hydrothermal F are favorable for Hg mineralization. The results of the experiment combined with the geochemical study on the ore-bearing formation and FI suggest that the difference of the ore-forming F in T and composition should be a key factor controlling regional zoning of Au, Sb and Hg mineralizations in the western Hunan epithermal mineralization area. (Authors' abstract)

HE, Jiang, MA, Dongsheng and **LIU, Yingjun,** 1996, Geochemistry of mineralization in the Zhazixi antimony ore belt on the margin of the Jiangnan old land: Mineral Deposits, v. 15, no. 1 (1996) p. 41-52. Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing 210093.

Based on a geochemical comparison between ore-control strata and ore deposits, the present paper points out that Sb (Au) mineralizations well-developed in Proterozoic Banxi Group of western Hunan are consistent with high-discretization and multi-kurtosis distribution of ore-forming elements in the ore-control strata. [sic] The high-discretization and multi-kurtosis distribution characteristics of ore-forming elements may serve as favorable geochemical criteria for ore-prospecting in this region. From Woxi Au-Sb (W) mineralization within the Jiangnan old land to Zhazixi Sb mineralization on the margin of the old land

‰S concentration of the mineralizing F decreases obviously, and the proportion of meteoric water gets increasingly larger. Sulfur ligand and its concentration in ore-forming F as well as T of the F constitute major geochemical mechanism controlling Sb, Au mineralization and its zoning in western Hunan, whereas abundances of ore-forming elements in the ore-control strata merely play subordinate role. Ore-forming F characterized by relatively high T (t_{max} 264°C, early average T of the principal ore-forming stage 232°C) and rich sulfur ($X_{‰S}$1.86mol/l) and ore-forming F noted for relatively low T (tmax 222°C, early average T of the principal ore-forming stage 198°C) and low sulfur ($X_{‰S}$0.25 mol/l) control Woxi Au-Sb mineralization and Zhazixi Sb mineralization respectively. (Authors' abstract)

HE, Mingyou, 1996, Physicochemical conditions of differential mineralization of Au and As in gold deposits, southwest Guizhou Province, China: Chinese J. of Geochem., v. 15, no. 2 (1996) p. 189-192 (in Engl.). Author at Inst. of Geochem., Chinese Acad. of Sci., Guiyang, 550002.

FI data pertaining to Au mineralization is presented. (HEB)

HE, Ying, WANG, Dingyi, FENG, Youliang, LIU, Hongying and **SONG, Lailiang,** 1996, Compositions of fluid inclusions and implications in volcanic rocks, Shengli oil field: Geochimica, v. 25, no. 5, p. 468-474 (in Engl.) First author at Geol. Dept., Northwest Univ., Xian 710069.

The compositions of FI in volcanic rocks from the Shengli oil field have been analyzed. There are significant differences in compositions of FI in volcanic rocks between non CO_2 and CO_2 G field. In the CO_2 G field, the contents of CO_2 in FI from Cenozoic volcanic rocks (47.9%–72.7%, average: 62.3%, with $\delta^{13}C$ ranging from -4.8‰ to -5.5‰) are significantly higher than those from non-CO_2 G field (22.7%– 68.2%, average7%, with $\delta^{13}C$ ranging from -10.2‰ to 14.6‰).

Therefore, the natural CO_2 may be derived from the volcanic rocks derived from mantle. (Authors' abstract)

See also next item (E.R.)

HE, Ying, WANG, Dingyi, ZHU, Yongqi, ZHANG, Jingong, LIU, Hongying and **SONG, Lailiang,** 1996a, Gold in volcanic rocks from CO_2 gas field of the Shengli Oil Field, China (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 714. First author at Dept. of Geol., Northwest Univ., Xi'an, China.

Recently, some CO_2 G wells have been found in Shengli Oil Field. In contrast to intrabasinic non-CO_2 G wells in the neighbourhood of olivine tholeiite and olivine basalt, the CO_2 G wells are distributed in the border of the basin and associated with alkali-olivine basalt and quartz tholeiite.

We have also analysed $\delta^{13}C$ for FI and REE concentrations in volcanic rocks. $\delta^{13}C$ ratios for FI (-4.2‰ - -8.5‰, PDB) and LREE element concentrations (average: 113.78) in volcanic rocks from CO_2 G field are significantly higher than those in volcanic rocks from non-CO_2 G fields (-10.2‰ - -14.6‰, PDB and 80.33 ppm, respectively).

Therefore, the gold in volcanic rocks from CO_2 G field may be derived from LREE and volatile component-rich mantle. (From authors' abstract by E.R.)

HE, Ying, WANG, Dingyi, ZHU, Yongqi, ZHANG, Jingong, LIU, Hongying, and **SONG, Lailiang,** 1996b, Carbon isotopes of fluid inclusions in volcanic rocks from the Shengli Oil Field, China (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 3, p. 80. First author at Dept. of Geol., Northwest Univ., Xi'an 710069, China.

The carbon isotope of FI in volcanic rocks from the Shengli Oil Field have been analyzed [given in table 1]. There are significant differences in $\delta^{13}C$ of FI in pyroxene of volcanic rocks between non-CO_2 G field and CO_2 G field. The $\delta^{13}C$ of FI in pyroxene of volcanic rocks from non-CO_2 G field ranges from −14.6‰ to −10.2‰, whereas the $\delta^{13}C$ of FI in pyroxene of volcanic rocks from CO_2 G field ranges from −8.5‰ to −4.8‰ (except those of altered volcanic rocks), close to carbon isotopes of MORB.

The similarities between the $\delta^{13}C$ signatures of FI in pyroxene of volcanic rocks and those of neighbouring well G can be noticed. In the CO_2 G field, the $\delta^{13}C$ of CO_2 for natural G ranges from −5.5‰ to −3.4‰, close to the $\delta^{13}C$ of FI in pyroxene of neighbouring volcanic rocks (−8.5‰ to −4.8‰). Whereas in non-CO_2 G field, the $\delta^{13}C$ of CO_2 for natural G ranges from −11.8‰ to −5.4‰, close also to the $\delta^{13}C$ of FI in pyroxene of neighbouring volcanic rocks)−14.6‰ to −10.2‰).

Therefore, the natural CO_2 may be derived from mantle. (From authors' abstract by E.R.)

See also previous item (E.R.)

HE, Zhili, 1996, Advances and trends in fluid inclusion research in China (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 552. Author at Dept. of Geol., Univ. of Sci. and Tech. Beijing (USTB), Beijing 100083, China.

A review of the last 45 years of FI research in PRC. (E.R.)

HE, Zhili and DU, Jiafeng, 1996a Some advances and trends in fluid inclusion research: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 306-312. First author at Univ. of Sci. and Tech., Beijing, Beijing, 100083.

A review of advances in the analysis of FI composition. (E.R.)

HE, Zhili and DU, Jiafeng, 1996b, Some advances and trends in fluid inclusion research (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 49-50. First author at Univ. of Sci. and Tech., Beijing, China 100083.

A review, see previous item. (E.R.)

HE, Zhili, XU, Jiuhua, DU, Jiafeng, and **YANG, Zhenlin**, 1996, Preliminary study on the ore-forming conditions of the Au-Pb-Quartz vein type ore deposit (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 12. (Note: this abstract was distributed at the I.G.C. Workshop/Shortcourse, but was not printed in the official 30th I.G.C. Abstracts volumes. E.R.) Authors at Dept. of Geol., Univ. of Sci. and Tech. Beijing, 100083 Beijing, China.

There are few Au-Pb-Quartz vein type ore deposits (especially the pre-Tertiary deposit) outside of China. Wendong is a polygenetic and compound ore deposit. Wallrock alterations are dominated by pyritization, silicification, sericitization, chloritization and carbonatization. Native gold and electrum are the major gold minerals. The main minerals associated with gold are pyrite, galena, quartz, ankerite, siderite, etc. Chalcopyrite and sphalerite are minor minerals. Sometimes there are a little magnetite, wolframite and pyrrhotite. Mineral paragenesis, wallrock alteration, FI research and stable isotopic indicate that this is a mesothermal-hypothermal deposit. The mineralization of Xiaoqinling gold field can be divided into 4 stages: I pyrite-quartz; II quartz-pyrite; III ferrous carbonate (or quartz)-polymetallic sulphide and IV calcite-quartz. Stages II and III are the major stages of gold mineralization. From stage I to stage IV, Th, depth of mineralization (D) etc. decrease step by step, while filling degree (F) and density (*p*) of ore-forming F increase gradually. Jintoncha and other deposits lying to the west of it in Xiaoqinling area are the Au-Pb-Quartz vein type ore deposits. And others of this area lying to the east of Jintoncha are the Au-Quartz vein type. This phenomenon stems from the zonal distribution of mineral deposits and the different development of the two major mineralization stages (stage II and III). The results obtained from the FI research have supported the inference. The studies indicate that in some areas with the favourable geological conditions, gold or associated gold mineralization might be found in the Pb-Zn deposits, in its deep part or in the vicinity of it. Suikoushan Pb-Zn deposit is a good example. (From authors' abstract by E.R.)

HE, Zhili, XU, Jiuhua, YANG, Zhenlin and **DU, Jiafeng,** 1996, Preliminary study on fluid inclusions of the Au-Pb-quartz vein type ore deposit, China, (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 38-41. Authors at Dept. of Geol. Univ. of Sci. & Tech., Beijing 100083, China. licylxj@public.bta.net.cn

There are few Au-Pb-Quartz vein type ore deposits in other countries except China. It might be related to the geohistory and geotectonic background. However, this kind of ore deposit has fairly important economic significance in China. Its formation is due to the distinctive geological conditions of China. Wendong Au-Pb-Quartz type ore deposit including Wenyu and Dongchuang in Xiaoqinling gold field is the most typical one. It is a polygenetic and compound ore deposit. The studies of ore-forming FI and isotopes of hydrothermal oxygen and carbon show that the ore-forming F is magmatic water mixed with metamorphic water, with the atmospheric water entering in late stage. The deposit has connection with Wenyu monzonitic granite in the causes of formation and space. Another important mineralizer CO_2 is also from the depth. The studies of sulfur and lead isotopes show that they are also from metamorphic rock series in Taihua group and they come from the depth. The studies of FI show that they are also mesothermal-hypothermal deposits. Wenyu and Dongchuang have the same geological characters. Jintongcha and other deposits lying to the west of it in Xiaoqinling area are Au-Pb-Quartz vein type ore deposits. Others of this area lying to the east of Jintongcha are Au-Quartz vein type. This phenomenon stems from the zonal distribution of mineral deposits and the different development of the two major mineralization stages. The results obtained from the FI research have supported this inference.

Table 1 shows the common characters that from early stage to late stage:

Au-Pb-Quartz vein type deposits form at lower T and are near igneous bodies while Au-Quartz vein type deposits form at higher T and are far away from igneous bodies. (From authors' abstract by E.R.)

Deposit name	Characters of stages of mineralization	I pyrite -quartz	II quartz -pyrite	III carbonate with iron (quartz)-polymetalical sulfides	IV quartz -carbonate
Wendong Au-Pb deposit	F,%	small ←			big
		60-80	78-84	75-88	90-94
	Th,℃ (average)*	high ←			low
		317/290	271/240	251/220	218/205
	ρ, g/cm³	small ←			big
		0.790	0.865	0.8700.	930
	Na^+/K^+	>1	>1	>1	>1
Chucha - Laan shigou Au deposit	Th,℃**	227-333 (240-320)	250-316 (260-300)	230-250	Because of limited samples,only compare this stage with former three stages
	Tt,℃	high →		low	
		365-460	350-410	300-330	
	Pt, MPa	big →		small	
		>150	110	>85	
	D,Km	big →		small	
		>5.5	4.0	3.1	
	ρ, g/cm³	small →		big	
		0.83	0.85	0.90	
	Na^+/K^+	<1	<1	<1	
Xiaoqinling Au ore field(compiled by the data from Fan et al., 1993)	Tt,℃	high →			low
		300-400	250-280	220-240	130-199
	D,Km	big →			small
		4.9-6.6	4.2-5.3	3.8-4.6	3.8
	fO_2	[illegible]	[illegible]	[illegible]	[illegible]
	pH	big →			small
		6.0	4.8-5.6	4.6-5.4	
	ρ, g/cm³	small →			big
		0.789-0.845	0.870-0.901	0.843-1.016	0.969-1.085

* Numerator--Wenyu; denominator--Dongchuang

** The figures between brackets -main range of Th

HEDENQUIST, J.W., AOKI, M., ARRIBAS, A., Jr., REYNOLDS, T.J. and **ILAGAN, P.J.,** 1996, Coupled hydrothermal processes between the porphyry and high-sulfidation epithermal environments (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A332–A333. First author at Mineral Resources Dept., Geol. Survey Japan, 1-1-3 Higashi, Tsukuba 305 Japan.

There are many examples of spatially associated porphyry and epithermal ore deposits; a genetic connection has been suggested by some, and argued against by others. Nowhere is this spatial association better seen than in northern Luzon, Philippines, where the Lepanto high-sulfidation epithermal Cu-Au deposit is supradjacent to the Far Southeast (FSE) porphyry Cu-Au ore body.

Quartz diorite porphyry dikes postdate the Pliocene dacite pyroclastic unit that hosts the epithermal ore. Potassic alteration, centered on the dikes, formed at 1.41 ± 0.05 Ma (6 published K-Ar biotite dates, ± 2 σ); hypersaline L and V-rich I, Th = 550-500°C, are associated with this early alteration and related Cu ore. Quartz-illite-sulfide veins (5 wt.% NaCl eq., Th - 350-300°C) with illite-chlorite alteration followed at 1.30 ± 0.07 Ma (n = 10). Advanced argillic alteration (quartz-alunite; 1.42 ± 0.08 Ma, n = 5) formed over the top of the porphyry and extended NW > 4 km along the basement-pyroclastic rock contact, synchronous with potassic alteration. Leached and alunite-altered rock hosted subsequent enargite-Au epithermal ore (4-2 wt.% NaCl eq., Th = 285-190°C, decreasing from the porphyry; published data on enargite). Chemical and I isotopic zoning of alunite, within crystals and along orebody, indicates lower T away from the porphyry and more reduced conditions with time.

The dated minerals were also analysed for their $\delta^{18}O$ and δD compositions, and hydrothermal water values calculated. Biotite water averaged +6.5 and –40‰, respectively, typical of hypersaline L exsolved from such magma; later illite water had a 10-20% component of local meteoric water (–10 and –70‰). The acidic alunite water formed through the absorption of magmatic V (+7 and –25‰) by meteoric water in proportions ranging from 9:1 to 1:1 with increasing distance from the porphyry. Porphyry (potassic) and epithermal (advanced argillic) alteration thus formed in a coupled hydrothermal system, with V separation leaving hypersaline L at depth; illite overprinting of the porphyry may have led to enargite-Au mineralization. (Authors' abstract)

HEIN, K.A.A., 1994, The structure and geochemistry of gold mineralisation in the Mt. Todd goldfield, Pine Creek Inlier, Northern Territory: Doctor of Philosophy thesis, Univ. of Tasmania, 216 pp and appendices.

The Mt. Todd goldfield, in the Northern Territory, Australia, is host to several discrete ore bodies, hosted Palaeoproterozoic greywackes, siltstones, sandstones and shales. Three deformation events are recognised.

Mineralisation in the goldfield is associated with quartz-sulphide veins and lodes that comprise pyrrhotite, chalcopyrite, arsenopyrite, pyrite, marcasite, löellingite, with minor galena, sphalerite, bismuth-sulphosalts, ISS CuFeS minerals, and gold. Gold is associated with bismuth and CH_4 - rich hypersaline FI (29 - 33 wt.% NaCl eq.) in trails which cross-cut early quartz and sulphide. The general vein/lode alteration assemblage comprises quartz, biotite, muscovite, chlorite, sericite, rutile, accessory tourmaline, chalcopyrite, pyrrhotite, pyrite or marcasite. The quartz-sulphide veins and lodes are typified by extension concomitant to hydrothermal fracturing and/or normal faulting. Across the goldfield, the veins and lodes exhibit a remarkable similarity with respect to strike geometry, morphology, vein forming process and isotopic composition. They are located within the thermal aureole of the Tennysons Leucogranite. Integrated petrologic, isotopic (sulphur and oxygen) and FI studies suggest that the hydrothermal F were chiefly magmatic - metamorphic in origin. The F were enriched in metal and sulphur derived either as magmatic metal or sulphur (from the Tennysons Leucogranite), or scavenged during F-rock reactions from sources in the sedimentary pile, the Yenberrie Leucogranite, or from sulphide-bearing greisens in the Yenberrie Leucogranite. F evolution was controlled by retrograde reactions which accompanied rehydration of the country rock and Tennysons Leucogranite, at low F-rock ratios. The hydrothermal F was reduced in nature and exhibited a tendency to lower fO_2 and fS_2 concomitant to an overall decrease in T and sal for a given pH. $\delta^{34}S$ values of 4.5‰ to 13.3‰ indicate that the source for sulphur was mixed (magmatic - sedimentary). Initial precipitation of crack - seal fibre quartz and subsequent precipitation of quartz and tourmaline accompanied decompressive effervescence and boiling of a surface-derived hydrothermal F at a minimum P of 180-225 bars or a minimum depth of 1.8 to 2.6 kilometres. F sal ranged from 1 to 20 wt.% NaCl eq.: this F interacted with a mixed magmatic-metamorphic F. The precipitation of a silicate-sulphide-carbonate assemblage accompanied an influx of hot (~ 400°C), acidic (pH ~ 4.0 at 330°C), hypersaline brine (30 - 50% NaCl - $CaCl_2$). This metal and sulphur enriched brine was mixed magmatic-metamorphic in origin. The principal cause of metal deposition was F unmixing at a shallow crustal level (minimum depth of 1.8 to 2.6 km) during a decrease in T from approximately 370 to 240°C, a decrease in sal from 30 - 50% NaCl - $CaCl_2$ to 29 - 33 wt.% NaCl eq., and vertical transport of the brine along joints, fractures and faults. Gold precipitation occurred late in the development of the silicate - sulphide - carbonate assemblage from a hot (~ 250°C), acidic (pH of 2.3 - 4.9 at 250°C), hypersaline brine (29 - 33 wt.% NaCl eq.) and accompanied the precipitation of bismuth and the entrapment of CH_4 - rich FI. (From author's abstract by E.R.)

HELLMANN, R., CHEN, T., and GRATIER, J.-P., 1996, The deformation of halite salt by pressure solution (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 20. Authors at Crustal Fluids Group, LGIT-IRIGM BP53X, 38041 Grenoble Cedex, France.

HENDERSON, I.H.C. and McCAIG, A.M., 1996, Fluid pressure and salinity variations in shear zone-related veins, central Pyrenees, France; implications for the fault-valve model: Tectonophysics, v. 262, no. 1-4, p. 321-348. First author at Univ. of Leeds, Dept. of Earth Sci., Leeds, UK.

FI microthermometry data is presented from quartz veins associated with high-angle reverse shear zones cutting the Neouvielle Massif in the central French Pyrenees. A complex series of veins were formed during both normal and reverse movement on brittle faults within the shear zone. Brittle structures developed contemporaneously with quasi-plastic deformation in the shear zones. FI data are presented from a variety of vein types and shows that a wide variation in F density and sal is present in the fault system. These variations occur both within individual veins and between different vein types. T at the time of vein filling are constrained to be in the range of 310-360°C by chlorite microthermometry. The variation in Th is too large to be accounted for by variations in the FT, and is interpreted to reflect variations in FP between lithostatic (differs from 500 MPa) and hydrostatic (differs from 200 MPa) values at the time of quartz growth in the veins. The shear zones carry modest displacements and may not themselves have been seismogenic. A model is presented in which FP variations and stress cycling within the steeply dipping shear zones is controlled by the seismogenic cycle on large underlying thrust structures. The model predicts that the highest maximum trapping P should occur in FI from low-angle veins formed in a high-P_{fluid} compressional regime immediately before earthquake rupture. Lower maximum P are expected in steep veins related to extension and normal fault movement across the shear zones immediately after rupture. The FI data support this model when maximum trapping P are considered, but the majority of I formed at P well below lithostatic values. This suggests that the dominant factor causing quartz precipitation was the sudden P drop immediately after earthquake rupture, regardless of vein type. (Authors' abstract)

HENRY, C, BURKHARD, M and GOFFE, B., 1996, Evolution of synmetamorphic veins and their wallrocks through a Western Alps transect: no evidence for large-scale fluid flow. Stable isotope, major- and trace-element systematics: Chemical Geol., v. 127, no. 1-3 (1996) p. 81-109. First author at Univ. de Neuchatel, Inst. de Geologie, 11 rue Emile Argand, CH-2007 Neuchatel, Switzerland.

Quartz-rich synfolial veins and wallrocks from different areas of a Western Alps cross-section are examined in an attempt to constrain the scale and mechanisms of F flow through metamorphic terrains. Different portions of this cross-section underwent three distinct *P-T* evolutions as reflected by the mineralogy of veins. In order to constrain the provenance of F involved in vein formation, we determined stable isotope (C, O, H), and major- and trace-element compositions in minerals and whole rocks for a large set of veins and wallrocks. These rocks are compared with some non-metamorphic shales from the northern Paris Basin, considered as protoliths of the Alpine schists. Potential F sources, chemical composition of the F phase and the mechanisms of F flow during vein formation are discussed. F flow takes place within tectonic units, at both hectometric and decimetric scale. F may also have migrated along and across the major tectonic contacts but this process is poorly documented. (From authors' abstract by E.R.)

HESS, P.C., 1996, Upper and lower critical points: Thermodynamic constraints on the solution properties of silicate melt: Geoch. Cosm. Acta, v. 60 (1996) p. 2365-2377. Author at Dept. of Geological Sci., Brown Univ., Providence, RI 02912.

Thermodynamic stability analysis both classical and nonclassical is applied to silicate M to examine the possible occurrence of two L fields with upper and/or lower critical temperatures. The conditions for the existence of an upper critical point in a binary silicate M are that the second derivatives of the enthalpy and entropy with respect to composition are both negative in supercritical M. The necessary condition for the existence of a lower critical point is that the excess entropy is negative in near critical M. The excess entropy of olivine-rich M is likely to be negative, implying that a two-L field with a lower critical point may be encountered in superliquidus peridotite M. (Author's abstract)

HEZARKHANI, Ardeshir and **WILLIAMS-JONES, A.E.**, 1996, Physico-chemical controls of alteration and mineralization at the Sungun porphyry coper deposit, Iran (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A44. First author at Dept. of Earth and Planetary Sci., McGill Univ., 3450 University St., Montreal, Quebec, Canada, H3A 2A7.

The Sungun copper deposit is hosted in a porphyritic stock of granodioritic to quartz-monzonitic composition that intruded Eocene volcanosedimentary and Cretaceous carbonate rocks. Economic mineralization (>500 × 10^6 tonnes grading 0.76% Cu, 0.01% Mo) is associated with both potassic and sericitic (phyllic) alteration.

Potassic alteration and mineralization were caused by brines with up to 60 wt.% NaCl eq. at T between 300 and 550°C and P of ~500 bars in the presence of an aq V [FI data, H.E.B.]. Silicification and phyllic alteration mark a transition to cooler, more dilute F. Oxygen isotopic data are consistent with mixed orthomagmatic-meteoric F. A model is proposed in which metals and sulphur were introduced from the magma, and mineralized the rock, largely as a result of cooling during the transition from a boiling orthomagmatic to meteoric-F dominated hydrothermal system. (From authors' abstract by H.E.B.)

HILDRETH, Jr., S.C. and **HANNAH, J.L.**, 1996, Fluid inclusion and sulfur isotope studies of the Tintic Mining District, Utah: implications for targeting fluid sources: Economic Geol., v. 91, p. 1270-1281. Authors at Dept. of Geol., Univ of Vermont, Burlington, Vermont 05405.

The Silver City stock, one of several resurgent intrusions along the margin of the Tintic caldera, has been historically accepted as the source for ore F at Tintic, or at least responsible for the heat to drive the hydrothermal system. FI in quartz from fissure veins, however, reveal a thermal gradient that traverses exposures of the Silver City stock, reaching a thermal maximum 3 km south of the exposed stock. Sulfur isotope values from sulfide minerals in the vein and replacement deposits are typical of igneous values (about 1‰) near the thermal high, but are distinctly lower (as low as -6.8‰) to the north, though still located in the Silver City stock.

Main-stage mineralization at Tintic may have been the product of F emanating from a very late resurgent granitoid intrusion in the Tintic district, one that is still largely unexposed. An apophysis of this intrusion may approach the surface near the thermal high delineated by FI Th. Additional evidence for the existence of such an intrusion includes widespread propylitic alteration of the Silver City stock and surrounding volcanic rocks, a ladder-style pattern of fissure veins traversing the district, and rare exposures of granitic aplite dikes crosscutting the Silver City stock. (Authors' abstract)

HILL, C.A., DUBLYANSKY, Y.V., HARMON, R.S. and **SCHLUTER, C.M.**, 1995, Overview of calcite/opal deposits at or near the proposed high-level nuclear waste site, Yucca Mountain, Nevada, USA: pedogenic, hypogene, or both?: Environmental Geol., v. 26, p. 69-88. First author at 17 El Arco Drive, Albuquerque, New Mexico, 87123, USA.

Calcite/opal deposits (COD) at Yucca Mountain were studied with respect to their regional and field geology, petrology and petrography, chemistry and isotopic geochemistry, and FI. They were also compared with true pedogenic deposits (TPD), groundwater spring deposits (GSD), and calcite vein deposits (CVD) in the subsurface. Some of the data are equivocal and can support either a hypogene or pedogenic origin for these deposits. However, Sr-, C-, and O- isotope, FI, and other data favor a hypogene interpretation. A hypothesis that may account for all currently available data is that the COD precipitated from warm, CO_2-rich water that episodically upwelled along faults during the Pleistocene, and which, upon reaching the surface, flowed downslope within existing alluvial, colluvial, eluvial, or soil deposits. Being formed near, or on, the topographic surface, the COD acquired characteristics of pedogenic deposits. This subject relates to the suitability of Yucca Mountain as a high-level nuclear waste site. (Authors' abstract)

HIPPERTT, J., EGYDIO, S.M., 1996, New polygonal grains formed by dissolution-redeposition in quartz mylonite: J. of Structural Geol., v. 18, no. 11, p. 1345-1352.

Indexed under FI (E.R.)

HITCHBORN, A.D., ARBONIES, D.G., PETERS, S.G., CONNORS, K.A., NOBLE, D.C., LARSON, L.T., BEEBE, J.S. and **McKEE, E.H.**, 1996, Geology and gold deposits of the Bald Mountain Mining District, White Pine County, Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 505-546. First author at Placer Dome U.S. Inc., Bald Mountain Mine, P.O. Box 2706, Elko, NV 89801.

Three general types of mineralization are recognized in the district. These include early skarn, local base-metal-dominated vein stages probably related to magmatic activity, and apparently late gold mineralization of varied geochemical character. No porphyry-type Au or Au-Cu mineralization has been recognized. Known mineral deposits are clustered within a 60 km^2 area around the stock and within the dike swarm.

All gold ores are characterized by high concentrations of As and Sb. High Cu, Pb and (or) Zn contents of some gold ores represent the presence of early base-metal stages.

Some gold deposits in the Bald Mountain mining district are closely associated spatially with porphyry dikes and other intrusive rocks, hypersaline FI are locally present, and the commonly elevated concentrations of Bi, Mo, Te, Sn and other elements suggest a magmatic input to some of the gold-depositing hydrothermal F.

A provisional model involves deposition of gold from a large, meteoric-water-dominated convection system driven by deep intrusive bodies of the Bald Mountain magmatic system. (From authors' abstract by E.R.)

HITCHBORN, A.D., ARBONIES, D.G., PETERS, S.G., McKEE, E.H., NOBLE, D.C., LARSON, L.T., CONNORS, K.A. and **BEEBE, J.S.,** 1995, Geology and gold deposits of the Bald Mountain Mining District, White Pine County, Nevada (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A38. First author at Placer Dome U.S. Inc., Bald Mountain Mine, P.O. Box 2706, Elko, NV 89801.

At least three general types of hydrothermal mineralization–early skarn and other porphyry-related, base-metal dominated, and late gold–are recognized in the district. Garnet-epidote skarns with associated W, Mo, Zn and Sn bordering the Bald Mountain stock are present in the Top pit and Zed Williams areas. Local base-metal dominated stages appear to predate gold mineralization. These include: (1) 500-1,400 ppm Cu with associated Ag, Bi, Te and low gold exposed in the eastern part of the Top pit; (2) Ag-bearing Zn-Pb mineralization intercepted by drill holes beneath the 2-3 and 1 pits; and (3) ores containing abundant pyrite, sphalerite, galena, chalcopyrite and minor stannite and tellurides exposed in the bottom of the RBM pit.

Large hypersaline SFI are present in quartz phenocrysts in the porphyry dike in the RMB deposit. Some of these I contain ten or more dm and some contain one or more major dp that remain after heating to 500°C. High-sal I have not yet been recognized at the Top pit. Small and irregular SFI lacking dp are present in various areas throughout the district and are perhaps related to gold mineralization. The mineralogical, geochemical and FI data suggest that that the RBM and Top deposits possess features of both early porphyry-related and later gold-depositing hydrothermal activity. (From authors' abstract by H.E.B.)

HOCHSTEIN, M.P., BROTHERIDGE, J. and **SIMMONS, S.F.,** Eds., 1995, Proceedings of the 17th New Zealand Geothermal Workshop 1995, Geothermal Inst. and the Univ. of Auckland, 275 pp., ISBN 0-86869-008-2.

HOFMANN, B.A. and **KNILL, M.D.,** 1996, Geochemistry and genesis of the Lengenbach Pb-Zn-As-Tl-Ba-mineralisation, Binn Valley, Switzerland: Mineral. Deposita, v.31 (1996) p. 319-339. First author at Natural History Museum of Bern, Bernastrasse 15, CH-3005 Bern, Switzerland.

The Lengenbach Pb-Zn-As-Tl-Ba mineralisation is located in Triassic dolostones of the Penninic zone in the Swiss Alps where Alpine metamorphism reached upper greenschist to lower amphibolite grade. Geochemical data are used to constrain the origin of this unique occurrence. Two metamorphic redox environments are present: the As(III)-rich zone is controlled by barite-pyrite while the reduced zone contains graphite or pyrrhotite-pyrite and formally zerovalent As. The As(III)-rich zone is characterised by a mineral assemblage consistent with üO_2 in the stability field of barite + pyrite. An As-(Pb, Tl)-rich sulphide M coexisted with a hydrothermal F at >300°C in this zone. The genesis of the unique Lengenbach mineralisation is interpreted as the result of isochemical metamorphic overprinting of a carbonate hosted stratiform sulphide mineralisation. Well-crystallised sulphide minerals in fissures and druses formed during retrograde cooling of a sulphide M in equilibrium with a hydrothermal F. The P mineralisation was probably formed at or close below the sea floor and fed by sulphide-poor hydrothermal F. Sulphide was largely derived from seawater by open system bacterial sulphate reduction. U, V and Mo may be seawater-derived. (From authors' abstract by E.R.)

HOLLAND, H.D., HORITA, Juske, and **SEYFRIED, Jr., W.E.,** 1996, On the secular variations in the composition of Phanerozoic marine potash evaporites: Geology, v. 24, no. 11, p. 993-996. First author at Dept. of Earth and Planetary Sci., Harvard Univ., Cambridge, Massachusetts 02138-2902.

In a recent paper, L.A.Hardie proposed that the secular changes in the mineralogy of marine nonskeletal limestones and in the mineralogy of marine potash evaporite during the Phanerozoic are the result of changes in the composition of seawater caused primarily by fluctuations in the flux of seawater through mid-ocean ridges. We show that the effects of changes in the hydrothermal flux are much smaller than he proposed. An alternative explanation for the variations in the mineralogy of these deposits invokes differences in the degree of dolomitization during the evaporation of seawater. The relative importance of these several effects can probably be determined with certainty only when we have analyses of relatively unaltered seawater from the several Phanerozoic periods. (From authors' abstract by E.R.)

See also Hardie, this volume (E.R.)

HÖLLER, W. and **HOINES, G.,** 1996, Fluid evolution during high-pressure partial melting in the Austroalpine Ulten Zone, Nothern Italy: Mineral. and Petrol., v. 58 (1996) p. 131-144. First author at Inst. of Geological Sci., Mining Univ. Leoben, Leoben, Austria.

FI in high-grade metamorphic rocks of the Ulten Zone (northern Italy) have been investigated by microthermometry and Raman microspectrometry. Two different types of FI can be distinguished: (1) high- to low density $CO_2 \pm N_2 - CH_4$ I in kyanite and quartz of coarse grained garnet-kyanite felses and (2) aq I of high sal in quartz of metapelites, paragneisses and amphibolites as well as migmatitic orthogneisses. The migmatites are thought to have formed on the prograde path to the eclogite-facies event (M1) under F oversaturation. Kyanite and quartz of the garnet-kyanite felses contain a CO_2-dominated F, which may result from a higher solubility of H_2O in the M. A saline, H_2O-rich F occurs as early I forming small clusters in quartz of the leucosome from migmatitic orthogneisses and as late trail-bound I of lower density in quartz of metasediments and amphibolites. During uplift and crystallization of the M, this F was released and together with external highly saline aq F added to the rocks, reequilibration of paragneisses, metapelites and metabasites under amphibolite-facies conditions (M2) was enabled. (Authors' abstract)

HÖLLER, W., TOURET, J.L.R. and **STUMPFL, E.F.,** 1996, Retrograde fluid evolution at the Rampura Agucha Pb-Zn-(Ag) deposit, Rajasthan, India: Mineral. Deposita, v. 31 (1996) p. 163-171. First author at Institut fur Geowissenschaften, Montanuniversitat Leoben, Peter-Tunner-Strasse 5, A-8700, Leoben, Austria.

FI in mineralized graphite-sillimanite-mica schist from the Rampura-Agucha Pb-Zn(Ag) deposit, Rajasthan, northwest India, have been investigated by microthermometry and Raman microspectrometry. Three different main types of FI in quartz can be distinguised: (1) gaseous (CO_2, partially mixed with CH_4 - N_2), (2) low sal aq I (0-8 eq. wt% NaCl) and (3) high sal aq I (NaCl ± $MgCl_2$ - $CaCl_2$). Low density CO_2-rich and low sal H_2O I are contemporaneous and occur, together with CH_4-N_2 I, in close association with sulfide mineral I. This indicates immiscibility between the gaseous and aq phase and participation of these F during the deposition or remobilization of the ore, which occurred over a wide P (1220 to 200 bar) and T (450 to 250°C). Raman spectra of graphite indicate upper greenschist-facies metamorphic conditions, although host rocks have been metamorphosed at upper amphibolite-facies metamorphic conditions. This indicates that graphite reequilibrated with the CO_2-rich phase during retrograde metamorphism. (Authors' abstract)

HOLM, N.G., 1996, Serpentinization of ultramafic rocks and abiotic synthesis of organic compounds (abst.): Short Papers and Abstracts for the Jubilee Meeting–"Current Problems, Ideas, and Results in Geology"–Stockholm 16-18 October 1996 at the celebration of the 125th anniversary of The Geological Society of Sweden; edited by Björn Sundquist; GFF, V. 118, Jubilee Issue, 1996, p. A-52. Author at Dept. of Geol. and Geochem., Stockholm Univ., SE 106 91 Stockholm, Sweden.

Serpentinization of peridote in oceanic crust is probably the most likely geochemical process that would result in Fischer-Tropsch type (FTT) synthesis of organic compounds. Oxidation of Fe(II) of the olivine $(Mg, Fe)_2 SiO_4$ in peridotite to magnetite would lead to the reduction of water and the formation of H_2. The reaction may be registered by the pH increase due to the occurence of free OH^-. The FTT synthesis is likely to be most significant in fractured rock where degassing of CO_2 from the mantle occurs and percolation of water leading to serpentinization of olivine is efficient. This is also the type of environment where fresh surfaces of potential mineral catalysts are abundant. Such minerals would, e.g., be the magnetite that is formed during serpentinization and different metal sulfides like chalcopyrite, pyrite, pyrrhotite and sphalerite.

(From author's abstract by E.R.)

The author reviews papers by various authors that are pertinent to the formation of carboxylic acids, acetate, aromatic compounds, straightchain hydrocarbon, etc. (ER)

HOLTZ, F., SCAILLET, B., BEHRENS, H., SCHULZE, F. and PICHAVANT, M., 1996, Water contents of felsic melts: application to the rheological properties of granitic magmas: Transactions of the Royal Soc. of Edinburgh: Earth Sci., v. 87, p. XXX-XXX (also in: The Third Hutton Symposium, Geol. Soc. Amer. Special Paper 315).

New experimental determinations of water solubility in haplogranitic M (anhydrous compositions in the system Qz-Ab-Or and binary joins) and of the viscosity of hydrous $Qz_{??}Ab_{38}Or_{34}$ M (normative proportions) and natural peraluminous leucogranitic M (high Himalaya) are used to constrain the evolution of viscosity of ascending magmas, depending on their P–T paths.

Comparison of the properties of natural and synthetic systems suggests that both water solubility and the viscosity of multicomponent natural felsic M (with less than 30-35% normative Qz) can be extrapolated from those of the equivalent synthetic feldspar M. (From author's abstract by E.R.)

HOPKINSON, L. and ROBERTS, S., 1996, Fluid evolution during tectonic exhumation of oceanic crust at a slow-spreading paleoridge axis; evidence from the Lizard Ophiolite U.K.: Earth and Planetary Sci. Lett, v. 141, no. 1-4 (1996) p. 125-136.

Zoned quartz crystals within late syntectonic veins from brittle-ductile shear zones situated within the lowermost plutonic rocks of the Lizard ophiolite contain three groups of FI. Type I are a phase separated P and PS group. L-rich I contain 3.2-8.0 wt% NaCl eq. with a mode at 5.7 wt% NaCl eq. V-rich I contain 0.0-6.1 wt% NaCl eq. with a mode at 2.6 wt% NaCl eq. I homogenize either by disappearance of the L or V phase, with a mode at 380°C. Type II I contain 2.1-5.7 wt% NaCl eq. with a mode at 4.1 wt% NaCl eq. I homogenize by disappearance of the V phase (L+V<- ->L) with a mode at 230°C. Type III I are a PS and S group, with textures which are suggestive of underpressure-induced reequilibration. They contain methane and a low sal aq solution (0.3-2.2 wt% NaCl eq.). L-rich satellite I homogenize at 310-240°C (L+V<- ->L>). V-rich I homogenized by disappearance of the L phase (L+V<- ->V) at 370-320° C. By assuming that the range in sal is exclusively the product of phase separation of a 3.2 wt% NaCl seawater solution, and by applying microthermometric data to the NaCl-H_2O system, analysis of the data suggests two-phase boundary constrained conditions of crystal growth, initiated within the supercritical field at around differs from 410°C, with declining T passing into subcritical portions of the system, beyond which the F entered single-phase L conditions of crystal growth. Microthermometric and petrographic data, in comparison with present day ocean-ridge hydrothermal systems, is consistent with a reaction zone situated within an inferred decollement at or near the petrological Moho, from which F were derived from and expelled along intersecting listric faults, at T broadly comparable to shallow subsurface levels within present-day systems. This interpretation suggests that high vent T were maintained as the heat flux waned, and that the hydrothermal system migrated downward through the uplifting gabbros, culminating in the reaction zone intersecting the upper mantle during the terminal pulses of tectonic exhumation. (Authors' abstract)

HORITA, Juske, WEINBERG, Andrew, DAS, Nachiketa and HOLLAND, H.D., 1996, Brine inclusions in halite and the origin of the Middle Devonian Prairie evaporites of Western Canada: J. of Sedimentary Research, v. 66, no. 5, p. 956-964. First author at Chemical and Analytical Sci. Div., Oak Ridge Nat'l. Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831-6110, USA.

Brines were extracted from FI in Lower Salt halite of the Middle Devonian Prairie Formation in Saskatchewan, Canada. The brines were analyzed by ion chromatography and were found to be of the Na-K-Mg-Ca-Cl type. They do not fall along a simple evaporation trend. Brines from clear, diagenetic halite are significantly lower in Na^+ and higher in Mg^{2+}, Ca^{2+}, and Cl^- than brines from cloudy, subaqueously formed halite with chevron structures. The isotopic composition of strontium and sulfur in anhydrite associated with the halites was found to be the same as that of Middle Devonian seawater. The composition of the I brines can be derived from that of modern seawater by evaporation, extensive dolomitization of limestone, and albitization of clay minerals. Other evolution paths are, however, also feasible, and it is impossible to rule out effects due to the addition of nonmarine waters (hydrothermal solutions, surface runoff, and groundwater), or dissolutional recycling of existing evaporites within the Prairie evaporite basin. Our analyses and published data on brine I in halite from a number of Phanerozoic evaporite deposits show that the Na-K-Mg-Ca-Cl type brine is more common than the Na-K-Mg-Cl-SO_4 type, which is expected from evaporation of modern seawater. (Authors' abstract)

HOU, Zengqian and **MO, Xuanxue,** 1996, The present and future investigation of the modern seafloor hydrothermal processes and mineralization: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 263-273. First author at Inst. of Mineral Deposits, CAGS, Beijing, 100037.

This paper reviews the history, current situation and future of the studies on modern seafloor hydrothermal mineralization. In mid-oceanic ridges free from sediments, sulfide ore deposits are small and rich in Cu-Zn, whereas along mid-oceanic ridges covered by sediments, sulfide deposits are large and rich in Pb-Zn. In the back-arc basin and/or intra-arc rifts, a complete spectrum from Pb-Zn and Zn-Pb-Cu to Cu-Zn ore deposits is developed in the trough and depression. Although the hydrothermal mineralization occurs in the island-arc and within plate environments, sulfide deposits with industrial significance have not yet been found. The new concepts on metallogeny emphasize: (1) the seafloor hydrothermal mineralization processes are related to rifting and subsidence events, (2) ore-forming metals come from host volcano-sedimentary rocks and underlying basement through which hydrothermal F circulated, (3) sulfide accumulation occurs under a solid crust consisting of chimney fragments and sulfide mounds, by filling of sulfides into open space and replacing of high-T F into low-T sulfide minerals, (4) the hydrothermal F constitutes a double-diffusive convection system. (From authors' abstract by E.R.)

HOU, Zengqian and **URABE, Tetsuro**, 1996, The alterations at two stratigraphic levels and double convective hydrothermal system in the Gacun Kuroko-type deposit, southwestern China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 657. First author at Inst. of Mineral Deposits, Chinese Acad. of Geological Sci., Beijing, China.

The Gacun deposit, a typical Kuroko-type deposit, is hosted in rhyolitic rocks associated with the underlying mafic rocks. The alteration pipe of diameter about 2 km shows a similar mineralogical zoning to Kuroko deposits of Japan. The chlorite core occurs in the root part of the alteration pipe and downwards transfers into epidote-chlorite and epidote-quartz vein swarm extending 500 m downwards. The felsic rocks away from the orebody and alteration pipe took place district-scale alteration, which has typical low-T mineral association: illite + albite + quartz + calcite. The altered rocks from the pipe show remarkably $\delta^{18}O$ enrichment, and bulk-rock $\delta^{18}O$ values decreased gradually toward stockwork orebody from 15.1-15.75‰ in zeolite-like zone and 12.05-[14.2?]‰ in sericite-quartz zone to 11.3-14.4‰ in quartz-hyalophane zone. The filled T of FI in quartz and sphalerite lie in the ranges of 280-320°C for quartz-hyalophane zone and 250°-297°C for sericite-quartz zone. The estimated $\partial^{18}O$ values of hydrothermal fluids are 7.98‰ and 3.2‰, respectively, based on quartz $\delta^{18}O$ data in the deposit.

The lower conformable alteration is considered to be approximately coeval with the alteration pipe, based on the SiO_2 concentration in the F, which restrict the main fluid-rock reaction zone to be located in mafic horizon by quartz barometer, and metal element flux calculation and sulfide-epidote vein system developed both in alteration systems. High-sal FI in gangue quartz (>8% eq. NaCl) from stockwork ore and in quartz phenocryst (>40% eq. NaCl) in footwall rhyolite strongly suggest the existence of hot-saline brine to react with mafic complex and leach metal components, which probably originates mainly from magmatic fluid derived from high-level acidic magmatic chamber. The brine later located in mafic unit possibly heats and drives the overlying single-pass convective seawater reacting with felsic rocks. The sulfide mineralization and alteration pipe is interpreted as [an] effect of the "density window" between brine and cold seawater cells through which the mixed F of brine with seawater adiabatically discharges upwards. (From authors' abstract by E.R.)

HOWE, L.K., LOWENSTEIN, T.K., KU, T.-L. and **LUO, Shangde,** 1996, 150 ka paleoclimate history and chemical evolution of evaporites, Saline Valley, California (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A457. First author at Dept. of Geol. Sci., Binghamton Univ., Binghamton, NY 13902-6000; e-mail br00277@bingsuns.cc.binghamton.edu)

A 96 m core from Saline Valley contains alternating layers of saline minerals and siliciclastic sands and muds that preserve a 150 ka record of sedimentation and climate. Th of FI in halites from lacustrine periods 15-55 ka and 130-150 ka (Tmax = 15-23°C) give brine T approximately 5°C below the Th of FI in modern halites (Tmax = 25-28°C). FI in halite analyzed via ESEM show that the major element chemistry of brines in Saline Valley has fluctuated due to different proportions of various inflow waters, probably related to climate.

The chemical evolution of modern inflow waters to Saline Valley simulated by computer, indicates a complicated pathway of mixed inflow waters (25% cc Ca - HCO_3-rich water from the southern and eastern margins of the basin plus about 75% SO_4-rich groundwater from the western margin of the basin) undergoing evaporative concentration, recycling (dissolving of pre-existing salts), and precipitation of gypsum, glauberite, halite, and thenardite. (From authors' abstract by E.R.)

HU, Shanting, YANG, Qi, PAN, Zhigui and **ZHANG, Huiliang,** 1996, Hydrothermal metamorphism of coal in Jixi coalfield: J of China Coal Soc. (Meitan Xuebao), v. 21, no. 4 (series no. 85), p. 343-347 (in Chinese, Engl. abst.). First author at Central South Univ. of Tech.

Coal metamorphism of Jixi coalfield is complicated. There are various types of coal metamorphism. Coal in Erlu area of the western part of northern belt coal-bearing zone in Jixi coalfield experienced hydrothermal metamorphism. Quartz, calcite and pyrite veins and carbonation, silication and kaolinization occurred in this area. Distribution of coal ranks were controlled by hydrothermal F activity and the contents of ash, sulphur and phosphorus also increased. The average measured T of FI in quartz vein was 207.3°C. Stable isotope analysis of FI indicated that coal rank also increased due to the heat brought by circulation water penetrated through the fault of F_{19}. (Authors' abstract)

HU, Yuzhao, CUI, Yinliang and **LIU, Weihua,** 1996, On the geological characteristics and genesis of the Chahe Cu deposit, Yuanjiang: in "Yunnan Geology", v.

15, no. 2 (1996) p. 154-163 (in Chinese with Engl. abst.) First author at Dian-Qiang-Gui Petroleum Inst..

The Chahe Cu deposit is a polygenetic mineral deposit in the Kang-Dianearth axis. In this paper, the original rock of the Chahe metamorphic rock series is recovered according to the macroscopic and microscopic characteristics, chemistry, trace elements and heavy minerals; the metamorphic rock is correlated in isotope dating, REE and stratigraphical characteristics with the related strata of the Kang-Dian area; 3 macroscopic and microscopic geological characteristics of this mineral deposit are described and the properties of metallogenetic F are discussed by using the test results of Th and composition of I. In the end, the relation between the metallogenesis and the evolution of Archaeozoic and Early Proterozoic earth crust is discussed basing upon the theory of the rift. (Authors' abstract)

HU, Wenxuan, DUAN, Zhenhao, REN, Quijiang, MOLLER, Nancy and **WEARE, J.H.,** 1996, Study of immiscibility and physico-chemical conditions of the Shaxi porphyry Cu(Au) deposit, eastern China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 766. First author at Dept. of Earth Sci., Nanjing Univ., Nanjing, China.

This paper discusses F immiscibility in the Shaxi porphyry Cu(Au) deposit, eastern China, in fluid inclusion (FI) study and the equation of state (EOS) for the system $NaCl-H_2O-CO_2$ developed recently by Duan et al., 1995. The important evidence for the F immiscibility include coexisting vapor FI with high sal FI, gas-rich FI with water-rich FI and "boiling" FI, as well as zonal occurrences of alteration, mineralization and different types of I. Constraints on immiscibility are studied using the EOS. High T-low P conditions and high concentrations of NaCl and/or CO_2 favor the onset of F immiscibility. Two types of F immiscibility, degassing and H_2O removing, are distinguished according to their different effects. The H_2O-removing immiscibility, which takes place at high T-low P condition, is responsible for the formation of highly saline F and the concentration of ore metals in L-rich F. The FI studies using the EOS suggests that the F immiscibility in the Shaxi deposit occurred under the conditions of 400°C to above 500°C and 150 to 400 bars and that immiscibility was a critical mechanism for the formation of the deposit. Using these field and theoretical results, a new metallogenic model for the porphyry Cu(Au) deposit has been developed. (Authors' abstract.)

HUA, Renmin, WU, Peihong and **CHEN, Kerong,** 1995, A discussion on the origin of ore fluid of the Yinshan polymetallic deposit, Jiangxi, China: Geological J. of Universities, v. 1, no. 2 (1996) p. 37 (in Chinese; Engl. abst.). Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing 210093.

On the basis of geological and geochemical characteristics of the Yinshan polymetallic deposit, Jiangxi pro-vince, and from the view point 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. Oxygen isotope compositions of altered rocks and F (FI) 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 down going meteoric water and phyllitic wall rocks which 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)

HUA, Yongfeng, and **LIU, Youping,** 1996, A genetic model for the Wanshan super-large mercury deposit, Guizhou: Guizhou Geology, v. 13 (1996) p. 61-66. Authors at Guizhou Bureau of Geological Survey, Corporation of Nonferrous Metal Industry, China.

Based on the geologic study of the Wanshan super-large mercury deposit for over 30 years, the paper, beginning with deposition and ending on completion of the mineralization, analyzes in 4-dimension space-time the total process of origin, evolution and formation of the mercury deposit, and then, proposed the mineralization model for the mercury deposit. (Authors' abstract)

Briefly discusses FI evidence. (HEB)

HUGHES, Peta, COOKE, D.R., KITTO, P.A. and **LARGE, R.R.,** 1996, The Exe River Sn-Pb-Zn-(Cu) prospect, NW Tasmania; physico-chemical controls on ore deposition: Geol. Soc. of Australia Abstracts, v. 41, p. 205.

Indexed under FI (E.R.)

HUIZENGA, J.M., JELSMA, H.A., and **TOURET, J.L.R.,** 1996, Fluids at Shamva gold mine, Zimbabwe (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 762. First author at Geol. Dept. Rand Afrikaans Univ., Johannesburg, South Africa.

Shamva gold mine, one of the largest producers in Zimbabwe, is hosted within the central part of the Shamva greenstone belt. Like most Archaean lode gold deposits the mineralization is related to a steeply dipping reverse oblique crustal shear zone. The host rocks are pyritiferous metasediments, derived from the reworking of felsic pyroclastic rocks. F infiltration resulted in widespread sulphidization, potassium alteration, chloritization, silicification and CO_2-metasomatism (carbonation).

Three types of quartz veins have been studied for FI: (1) gold-mineralized sulphide ± carbonate veins; (2) molybdenite-bearing veins; (3) late tensional barren veins. Molybdenite-bearing veins contain only aq I whereas the other vein types contain H_2O, mixed H_2O-CO_2 and gaseous CO_2 inclusions. The CO_2-rich part of some mixed H_2O-CO_2 and the gaseous CO_2 I show a significant depression of $T_m(-58.5°C)$. Raman analysis was not possible because of high background radiation caused by carbonates.

The combination of $T_h(\pm 10°C)$ and $T_m(-58.5°C)$ can be explained by addition of $N_2(\pm 10$ mol%) or $CH_4(\pm 5$ mol%). Mixed H_2O-CO_2, gaseous CO_2 and pure H_2O I are explained by heterogeneous trapping of a H_2O-CO_2 F at conditions of immiscibility. Intersection of the different isochores constrains the PT conditions of vein formation and gold deposition at 300°-400°C at 2-2.5 kbar using equations of state for pure H_2O and CO_2. The similar P conditions found for gold mineralization and peak metamorphism (500°C and 2-2.5 kbar) implies that the retrograde PT path followed isobaric cooling.

The FI results from gold mineralization can be used to calculate the initial metamorphic F composition which was responsible for gold mineralization. The calculations were carried out using the computer program COHFLUID. The following conditions were used: (1) the G-phase of the FI is a mixture of CO_2 and CH_4 with $XCO_2/(XCO_2+XCH_4) = 0.95$; (2) XH_2O of the initial metamorphic F is assumed to be 0.8; (3) fO_2 of the metamorphic F was buffered by QFM; (4) Graphite is absent, thus calculations were performed for graphite activities (a_c) less than 1; (5) F movement in the shear zone occurred in a chemically closed system; (6) Gold mineralization did not significantly change the F composition. No difference in F composition between mineralized and barren veins was observed.

The calculation results show that: (a) the initial F was close to graphite saturation ($0.9<a_c<1$); (2) $XCO_2/(XCO_2+XCH_4)$ of the metamorphic F ranged between 0.75 and 0.85; (3) XH_2O of the gold mineralizing fluid ranged between 0.85 and 0.90; (4) metamorphic T ranged between 500°C and 530°C, very similar to the assumed value of the metamorphic T. (From authors' abstract by E.R.)

HULEN, J.B. and **WAVREK, David,** 1996, Oil-bearing, Carlin-type, gold deposits in the southern Alligator Ridge district, Nevada–evidence for gold mineralization and oil-reservoir evolution in a moderate-temperature geothermal system (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A86. First author at Earth Sci. and Resources Inst., Dept. of Civil and Environmental Engineering, Univ. of Utah, 1515 East Mineral Square, Salt Lake City, UT 84112.

Carlin-type, disseminated gold deposits in the southern Alligator Ridge (SAR) district contain considerable quantities of oil. The deposits are hosted by fractured and altered Paleozoic siltstones and limestones near the crest of a gentle anticline and sealed above by shales and hydrothermal clays. Oil in and around the deposits occurs as FI in hydrothermal vein calcite and quartz, and as fracture coatings in unoxidized host rocks. Petrographic analysis and P-corrected Th suggest that the oil I and coexisting dilute aq (< 3.5 wt.% NaCl eq.) I were trapped in the T range 60-160°C, with most between 100 and 120°C. There are no S minerals in the deposits indicating, unambiguously, paleotemperatures higher than this range. T-dependent biomarker transformations preserved in FI likewise suggest that the oils were probably never heated above about 120°C. These are unusually low T for Carlin-type deposits, but identical to those prevailing in nearby, geologically similar, producing oil fields which coincide with and appear to have formed in actively convecting, amagmatic geothermal systems. We suggest that in the SAR, one or more such moderate-T systems may have (1) caused the generation of oil from otherwise (regionally) submature hydrocarbon source rocks, (2) transported oil to entrapment sites in thermal F at times enriched in gold and affiliated metals, and (3) formed an oil reservoir, at some point during the filling of which gold was also locally deposited. The role of hydrocarbons in actually transporting gold or focusing mineralization, if any, remains to be determined. (Authors' abstract)

HURAIOVA, Monika, KONECNY, Patrik, KONECNY, Vlastimil, SIMON, Klaus and **HURAI, Vratislav,** 1996, Mafic and salic igneous xenoliths in late Tertiary alkaline basalts; fluid inclusion and mineralogical evidence for a deep-crustal magmatic reservoir in the western Carpathians: European J. of Mineral., v. 8, no. 5, p. 901-916.

Full paper for previous abstract (E.R.)

Explosive Late Tertiary alkaline basalts have ejected pyroxenite, hornblendite, anorthoclasite and quartz-bearing tonalite-trondhjemite xenoliths in the northern margin of the Pannonian Basin. One tonalite sample contains P CO_2 - H_2O I with up to 20 vol.% of aq. phase. Remaining tonalites, anorthoclasites and mafic rocks trapped CO_2 I without detectable water. Except for hornblendites, the CO_2 I coexist with silicate M. Additional, not yet detected volatiles are responsible for depression of the CO_2 final melting T, which clustered mostly around -58°C in all rock-types. Maximum densities of the CO_2 I tend to decrease from pyroxenites (0.92 g/cm^3), through anorthoclasites (0.89 g/cm^3), to tonalites (0.85 g/cm^3) and hornblendites (0.75-0.87 g/cm^3), thus reflecting decreasing depth of formation. Equilibration PT conditions for clinopyroxenes ranged between 1220°C at 10 kbar and 1068°C at 4.3 kbar, with the 50% of estimates projecting between 6.5-7.5 kbar. Postcumulus hornblende, coexisting with An_{53-64} plagioclase, crystallized at 928-1074°C. Most of the PT data for pyroxenites indicate depths between 23-26 km, close to recent Moho discontinuity (27-29 km), while those for tonalites and hornblendites reflect their middle crustal emplacement (15-20 km). Cumulate textures, varying modal composition and essentially CO_2 - dominated P I suggest formation of the xenoliths by fractional crystallization in a large reservoir of mantle-derived basaltic magmas. The cumulate origin of tonalites and anorthoclasites is corroborated by nearly identical whole-rock REE distribution, showing pronounced positive Eu anomaly and enrichment in LREE. Contrasting calc-alkaline and alkaline affinities of clinopyroxenes and hornblendes in selected mafic xenoliths might result from heterogeneity of the parental basaltic magma generated either in metasomatised lithospheric mantle or in upwelled asthenosphere.

HUTCHEON, Ian, 1996, The origin of H_2S by thermal sulfate reduction: American Assoc. of Petrol. Geologists Bulletin, v. 80, no. 11, p. 1827-1828.

Indexed under FI (E.R.)

IMAI, Hideki, TAKAHASHI, Mikio, and **YAMAGUCHI, Mitsuo,** 1996, Relation between volcanic-hosted precious- and base-metal deposits and geothermal systems: Resource Geol. v. 46, no. 2, p. 73-94.

The geological and geochemical similarity between the hydrothermal deposits in "Green-Tuff" regions and the geothermal areas in Quaternary volcanic regions, allows to speculate that epithermal deposits of the adularia-sericite type were formed from hot-water geothermal F, while those of the acid-sulfate type were formed from V-dominated geothermal F. In acid-sulfate type gold deposits, gold exists (i) as a substitutional solid solution in pyrite or aurostibite ($AuSb_2$) molecule in pyrite, (ii) as native gold associated with enargite and luzonite, and (iii) in limonite associated with scorodite, Ba-pharmacosiderite, barite and tripuhyite [triphylite or triplite?]. The occurrence of (iii) would be due to hypogene S (oxidation) processes. (From authors' abstract by H.E.B.)

Published FI data is discussed in relation to the various deposits. (H.E.B)

INOHARA, Y., 1988, Investigations on hydrothermal activities by fluid inclusions in granodiorite and veins distributed in the Kurobe hot dry rocks, Toyama Prefecture, Japan: Report of Abiko Research Lab., Central Research Inst. of Electric Power Industry, No. U87051, 25 pp (in Japanese, Engl. abst.).

Detailed studies [of] the formation process of veins and FI observed by the naked eye, the microscope and the CL images of the scanning electron-microscope reveal that granodiorite in the Kurobe tunnel [borehole?] called "Kurobe hot dry rocks" has five formations of veins and FI. And, Th of FI have been measured.

The T of water accompanied with the hydrothermal activities tend to range from 300 to 200°C and to decline every the formation of veins and FI [sic]. These tendency suggest that the T of the geothermal resource is similarly declining. (Authors' abstract)

INVERNIZZI, Chiara, VITYK, M.O. and **BODNAR, R.J.,** 1996, Remnants of subduction-related fluid inclusions in quartz-calcite veins from high pressure/low temperature rocks from the oceanic-derived Diamante-Terranova unit (the Calabrian Arc, southern Italy) (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 61. First author at Dip. Scienze della Terra, Universita' di Camerino, Camerino, Italy 62032.

The Diamante-Terranova Unit (DIATU), in the Calabrian Arc of southern Italy, is part of an ophiolitic sequence which was involved in a high pressure/low temperature (HP/LT) event (P = 8 kb; T = 400°C) followed by re-equilibration at greenschist facies conditions (P = 3 kb; T = 300°C). In this study we present data on microthermometric and textural analysis of FI found in quartz-calcite veins from metabasalts in the DIATU. Most of the I are clearly S (i.e. related to healed fractures), and a large percentage of them (about 40%) were modified after entrapment. The modified I contain water and display a highly irregular dendritic texture. The dendritic texture is similar to that produced experimentally during laboratory-induced deformation of synthetic aq I in quartz. In experimental studies, this texture was obtained *only* under conditions of internal underpressure, simulating either isobaric cooling or isothermal compression. In both the isobaric cooling and compression experiments, the dendritic texture was generated at high confining P (about 5 kbar) and low T (300 - 400°C). Internal underpressure in I in quartz from the DIATU was generated at high P and low T during nearly isothermal compression associated with subduction-accretion processes.

Quartz samples from the DIATU also contain a large number of low sal (0 - 5 wt.% NaCl) I which display a rounded and/or negative-crystal habit. Some of these I contain L and V and homogenize to the L (Th 135-180°C), whereas others contain only L at room T. Both the two and one-phase I occur in the same fractures, and were presumably trapped at greenschist facies conditions during the exhumation of the HP/LT rocks. The one-phase I and the two-phase I are thought to record the same trapping event, with the one-phase I remaining metastable L at room T.

Microstructural analysis and FI studies allowed us to reconstruct the P-T conditions of deformation for the Diamante-Terranova rocks. The results of this study provide convincing evidence that I with a highly irregular dendritic morphology represent early I that have survived prograde conditions in a HP/LT metamorphic environment (but have been modified). The HP/LT "implosion" texture is apparently preserved over geological time, even after being overprinted by internal overpressure conditions generated during retrograde decompression. We suggest that I that have survived prograde metamorphism are common in HP/LT rocks, but often not identified as such due to their morphology which makes their recognition difficult. (Authors' abstract)

INVERNIZZI, Chiara, VITYK, Maxim, CELLO, Giuseppe, and **BODNAR, Robert,** 1996, P-T history of the Diamante-Terranova unit (Calabria, Southern Italy): A fluid inclusions study from rock samples and experimental data (abst), Ofioliti, v. 21, no. 2, p. 165.

Data on microthermometry and textural analysis of F found in quartz-calcite veins from the metabasalts of the Diamante-Terranova unit (DIATU, Calabrian Arc, Southern Italy) are presented. The DIATU is part of an ophiolitic sequence which was involved in a HP/LT event in blueschist facies conditions (400°C, 8 kbar) followed by re-equilibriation in greenschist facies conditions (300°C, 3 kbar). It has been interpreted as part of a lithospheric section underlying a narrow oceanic basin located between the European and Iberic plates. The metamorphic and structural signature of DIATU rocks reveal a long history of SE dipping subduction and collision-related deformation. The aim of this work is to reconstruct the P-T history of this unit. FI are one of the commonly used techniques for determining T and P along the P-T-t paths. Most often, FI are used to constrain the retrograde portion of the P-T-t path. However, and understanding of the types of changes that might occur during prograde metamorphism may provide a means of better constraining the prograde segment of a complete P-T-t path. We have performed some experiments to re-equilibrate synthetic FI along P-T paths similar to the prograde P-T path proposed for natural samples, and have compared the textures of the synthetic FI to those occurring in quartz-calcite veins collected from the DIATU. Two vein systems from metabasalts have been studied folded: (early) veins and planar (late) veins. I showing a dendritic morphology were observed in quartz from folded veins in DIATU rocks which were subducted. A similar dendritic texture was produced experimentally during laboratory-induced deformation of synthetic aq I in natural quartz under conditions of internal underpressure (5 kbar) that were simulated during isothermal compression (ITC). The dendritic texture was generated only at high confining P (5-6 kbars) and low T (300-400°C). Quartz samples from the DIATU contain also a large number of pure-water S I which display a negative-crystal habit. Some of these I contain L and V (Th 135-180°C), whereas others contain one-phase L. Both the two and one-phase I occur within the same fractures. These I were observed in the earliest folded veins as well as in the late planar veins. The absence of bubble nucleation suggests that the one-phase I might involve simple metastability, as observed in some cases during the experimental work. The results of this study provide convincing evidence that I with a highly irregular dendritic morphology represent early I that have survived prograde conditions in a HP/LT metamorphic environment. This HP/LT "implosion" texture is apparently preserved over geological time, even after being overprinted by internal over-pressure conditions generated during retrograde decompression. Quartz-calcite veins from blueschist rocks of the DIATU contain no I with isochores that project through the peak metamorphic conditions. The large number of low sal I, which display a negative-crystal habit, observed in the earliest folded veins as well as in the late planar veins, was trapped during a later greenschist decompression event. In conclusion, the P-T path derived from FI analysis of DIATU rocks shows three distinct features: a steep nearly isothermal, compressional trajectory, which caused implosion of FI under very high (ca 5 kbar) internal underpressure; a nearly isothermal decompression path, ending with a greenschist overprint associated with entrapment of regularly-shaped aq I; a final decompression segment which resulted in reequilibration of late aq FI under conditions of moderate internal overpressure. (Authors' abstract)

IVANOVA, G.F., CHERKASOVA, E.V. and **NAUMOV, V.B.,** 1996, Mineral composition and formation conditions of the Piaotang tin-tungsten deposit, south China: Geol. Ore Deposits, v. 38, no. 2, p. 157-171 (in Russian, translated in Geology of Ore Deposits, v. 38, no. 2, p. 137-150). First author at Russian Acad. Sci., Vernadskii Inst. Geochem. and Analytical Chem., Ul Kosygina 19, Moscow 117975.

The formation conditions of giant tungsten deposits were examined on the example of the largest tungsten deposits of south China (Piaotang and Xihuashan). The existence of a homogeneous source of mineral-forming F responsible for the formation of the deposits under study was proved by data on mineral composition of the ore-bearing zones, the chemical composition of individual minerals (wolframite, triplite, sphalerite, and stannite), and the distribution of rare-earth elements in wolframite, scheelite, and fluorite. As was evidenced by thermometric and cryometric studies of FI in the minerals of these deposits, the minerals were formed at 350-115°C in slightly mineralized H_2O-CO_2 solutions with minor concentrations of CH_4 and N_2 (up to 4.1 mol%). The magmatic origin of ore-forming F and their mixing with meteoric waters late in the F evolution were established from data on the oxygen and carbon isotopic compositions in different minerals. The geochronological data available on granites and minerals of quartz-wolframite veins of the Piaotang and Xihuashan deposits point to the close age relation between the tungsten ores and granites. The analyses of radiogenic isotopes in granites and fluorites from the ore veins testify that the crustal matter (probably the matter of the ancient crust) was involved in the rock and ore formation. (Authors' abstract)

IVANOVA, G.F., KOLESOV, G.M. and **CHERKASOVA, Ye.V.,** 1996, The REE in granites, topazes, and fluorites from Mongolian tungsten-ore regions: Geokhimiya, 1996, no. 8, p. 1157-1177. (In Russian, translated in Geoch. Int'l, v. 33, no. 7, p. 100-123.)

Abstract in FIR, v. 28 (E.R.)

JADHAV, G.N., 1996, Fluid-melt inclusion studies and its importance in characterization, source and emplacement of pegmatitic fluids in southern parts of Nellore-mica-belt, Andhra Pradesh, India (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 480. Author at Dept. of Earth Sci., Indian Inst. of Tech., Bombay 400 076, India.

M I studies in quartz [show] two types: (i) Biphase-containing glass and bubbles and (ii) Crystallites-only crystalline M in the form of tiny well developed crystals embedded in host mineral of quartz.

Based on the content, P and PS FI are classified in four types, viz., (i) Monphase G (CH_4 ?) or V. Here negative crystal cavity shapes are predominant (ii) V-rich-biphase - V phase dominates and occupies more than half of the I volume (iii) L-rich-biphase - L phase dominates with a small bubble, and (iv) immiscible L/CO_2 bearing FI - characterized by the presence of two immiscible L (CO_2L and low saline F). Microthermometric studies of F and M I are carried out using Chaix-Mecca-heating-freezing stage and Leitz-1350-heating stage, respectively. Microcryometric studies are obtained on L rich biphase and CO_2 bearing FI. Few readings are also obtained on the monphase G (CH_4), heterogenizing, around -82°C on cooling with L N_2.

The data show permissive-cum-forceful emplacement of low saline residual F and must have undergone magmatic, vesiculation, metasomatic and finally hydrothermal stages of crystallization. (From author's abstract by E.R.)

JAMES, L.P. and **WORLEY, B.W., Jr.,** 1996, The mesothermal-epithermal transition in Philippine porphyry-related Cu-Au systems: Discrete events vs. evolution (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A335. First author at Exploration Pty, Ltd., 1658 Cole Blvd., #6-210, Golden, CO 80401.

Three Au and Cu bearing sulfide systems on the island of Luzon, closely associated with Tertiary dioritic igneous rocks, were studied during the course of exploration and mining. The Acupan gold deposit(s) near Baguio, Genguet province, and the Dizon porphyry operation, Zambales Province are well-known mines of Benguet Corp. The Exciban prospect, Bamarines Norte province produced Au + Cu in the 1930s-40s and was explored in the 1980s. All show features interpreted as epithermal at the surface. Exciban, a Bi-Te bearing quartz vein system, shows halite-rich FI, a decrease in Au values, and potassic alteration at depth along structures. (From authors' abstract by H.E.B.)

JAMES, R.H., and **ELDERFIELD, Henry,** 1996, Chemistry of ore-forming fluids and mineral formation rates in an active hydrothermal sulfide deposit on the Mid-Atlantic Ridge: Geology, v. 24, no. 12, p. 1147-1150. Authors at Dept. Earth Sci., Univ. Cambridge, Cambridge CB2 3EQ, United Kingdom.

The chemical composition of diffuse effluent from the TAG hydrothermal mound, 26°N Mid-Atlantic Ridge, directly demonstrates that mixing of entrained seawater and high-T black smoker F leads to the precipitation of sulfides, silica, and anhydrite and to the zone refining of metals, including Cu, Zn, U, and the rare earth elements in an actively forming sulfide ore body. Rates of mineral formation deduced from these data are extremely rapid and are up to an order of magnitude greater for anhydrite (5-15×10^7 kg/yr) than for sulfides (10^6-10^7 kg/yr). Comparison with mineral inventories for TAG suggests that virtually all of the anhydrite in the TAG mound is contemporary, and confirms that the sulfide precipitated episodically during the history of mound growth and that much of it has been lost by oxidation and reworking. (Authors' abstract)

JAMI, M. and **MOORE, F.,** 1996a, Physico-chemical characteristics of fluids responsible for fluorite and lead mineralization at Kamar-Mehdi mine, Tabas area, Iran (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 674. Authors at Dept. of Geol., College of Sci., Shiraz Univ., Shiraz, Iran.

The data obtained from field and geothermometric studies and also the REE composition of fluorite associated with lead mineralization at the Kamar-Mehdi mine are compatible with a structurally controlled, fissure filling, epigenetic, hydrothermal origin. Th and last ice melting for P FI trapped in fluorite crystals indicate that the mineralization of fluorite and the associated (cogenetic?) lead has taken place over a T range of 115-125°C. The mineralizing F were dilute and do not show any apparent change in T and sal with depth. The dm are mostly Ca, K, Al, Si, Cl phases. (Authors' abstract.)

JANÁK, M., O'BRIEN, P.J., HURAI, V. and **REUTEL, C.,** 1996, Metamorphic evolution and fluid composition of garnet-clinopyroxene amphibolites from the Tatra Mountains, Western Carpathians: Lithos, v. 39, p. 57-79.

Relics suggesting an early high-P eclogite facies stage have been identified in the garnet and clinopyroxene-bearing amphibolites of the Tatra Mountains, in the Variscan basement of the Western Carpathians, Slovakia. In these rocks, P omphacite (Cpx 1) has been wholly converted to symplectites of diopside (Cpx II) and plagioclase. Apart from minor I in the garnet cores, amphibole and plagioclase are secondary minerals, formed in the kelyphitic rims between garnet and clinopyroxene. Several generations of amphibole (pargasite, hornblende, cummingtonite, actinolite) are evidence of a transformation down to greenschist facies conditions. Thermobarometric calculations from mineral I in the garnet cores yield 670-700°C and 10-15 kbar, recording the initial path from upper amphibolite to eclogite facies conditions. The attainment of the eclogite facies stability field is inferred from the composition of a "reconstructed" omphacite (Jd36), implying a minimum peak-P of 15-16 kbar. Conditions of around 650°C and 8-10 kbar record the post-eclogite breakdown and partial reequilibration in the amphibolite facies region.

The earliest FI contain high-density nitrogen-dominated, water-absent F. Younger are polyphase brines and two-phase $H_20+N_2+CH_4$ I with signs of heterogeneous entrapment of coexisting G-rich and water-rich immiscible phases. Pure nitrogen (±0.5 mol.% CH_4) is considered to have been the major component during the high-P metamorphism. In contrast, the later, aq I are interpreted to represent retrogression-related F. The brines have originated by leaching and re-entrapment of saline M I observed in tonalitic-trondhjemitic layers of the amphibolite enclosing the eclogitic relics. A similar mechanism is assumed for the origin of the $H_20+N_2+CH_4$ I. These represent relics of the P, eclogite facies-related N_2 I, reequilibrated and re-entrapped during retrogression under increasing water activity. A possible source of N_2 and Cl-rich F was P amphibole, which decomposed during the prograde metamorphism from the amphibolite to the eclogite facies.

The metamorphic *PT* path is generally clockwise, reflecting a steep increase in P and T during burial, followed by decompression and cooling. The retrograded eclogites occur in boudins within an allochthonous unit of an inverted metamorphic sequence. Their exhumation was facilitated by tectonic transport along a ductile shear zone during the Variscan orogeny. (Authors' abstract)

JANECKY, D.R. and **MUSGRAVE, J.A.**, 1996, Jemez volcanic field, New Mexico: An example of the continuum from magmatic-hydrothermal to epithermal geothermal systems (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A335. First author from CST-7, MS J514, Los Alamos Nat'l. Laboratory, Los Alamos, NM 87545; e-mail (janecky@lanl.gov)

Surface and borehole sampling of this system has provided important constraints on the range and sequence of hydrothermal processes. Geologic evidence points to the former caldera lake systems in the moat region of the Valles caldera. These caldera lakes, especially at Sulphur Springs, had a profound effect on the dynamics of the hydrothermal system. The lakes permitted near surface F T and P that were much higher than those possible for the present purely subaerial system. Increased solubility of both metals and G are observed in FI samples of past geothermal waters. Analysis of present day hydrothermal F and FI indicate a clear magmatic signature with an average ^3He / ^4He of 4.5 times the air value and elevated ^{40}Ar, which may be derived from a magmatic source. Stable isotopes of carbon and sulfur also suggest a magmatic source component. (From authors' abstract by E.R.)

JANNAS, R.R., 1995, Reduced and oxidized high sulfidation deposits of the El Indio District, Chile: doctoral thesis at Harvard Univ., Cambridge, MA, US, 421 pp.

Two types of high sulfidation precious-metal deposits are identified in the El Indio District, Chile: 1) Reduced-type high-sulfidation deposits (RHS-type) are characterized by enargite-pyrite and quartz-gold mineralization in complex vein systems typified by the El Indio mine and 2) Oxidized-type high-sulfidation deposits (OHS-type) are composed of barite-alunite-gold (± enargite) mineralization mainly in breccia pipes within the Tambo subdistrict.

El Indio (RHS-type): Hypogene mineralization at the El Indio subdistrict was grouped into two main ore-forming assemblages, copper and gold (gold veins cut copper veins). A pre-ore, period of acid-sulfate wall rock alteration is followed by copper-stage mineralization, characterized by wide veins filled with massive coarse-crystalline enargite and pyrite. The occurrence of multiple successive bands of alunite and enargite + pyrite suggest different F conditions during formation of sulfates and sulfides. Early gold-stage mineralization is represented by minor deposition of base-metal sulfides and tellurides, pervasive replacement of copper-stage enargite by tennantite and first gold occurrence. The principal gold mineralizing period is characterized by the precipitation of significant amounts of native gold accompanied by quartz in thin veinlets, which constitutes the spectacular high-grade gold mineralization at El Indio. FI Th and Tm data show both stages had Th = 250° ± 30°C and moderate to low sal (Cu-stage 2.9-4.6 and Au-stage 0.0-3.0 eq. wt.% NaCl). O and H isotope data for coeval sericite indicate a dominant meteoric-water component in the F during enargite-pyrite copper mineralization and gold-quartz ore deposition. Chemical equilibria modeling using the FI and mineral assemblage data indicate that the F responsible for copper and gold mineralization have similar compositions. This modeling suggests that the mechanism favored for enargite-pyrite precipitation is decreasing T and for high-grade gold deposition is mixing with an acid F.

Tambo (OHS-type): Circulation of a pre-ore acidic-F enhanced the permeability of the breccia pipes through which the gold-bearing solutions were later channeled (stage 1). The breccia tuff fragments are cemented mainly by sulfates. Appearance of native gold as electrum is coeval with barite deposition, associated with galena, enargite and tellurides as I in barite growth planes (stage 2). The sulfides and tellurides in stage 2 are linked with the early gold-stage at El Indio. Precipitation of fine-grained alunite corroding barite characterizes stage 3 at Tambo. Native gold deposited in alunite vugs and barite cleavages correlates stage 3 gold mineralization at Tambo with the principal period of gold precipitation at El Indio. FI data show Th = 230° ± 20°C and sal between 0.0 and 3.5 eq. wt.% NaCl, during gold precipitation. O and H isotope data for alunite and barite (only O) show a large magmatic signature. The heavy $\delta^{34}S$ values in barite and light values in coeval enargite indicate the sulfur in the stage 2 gold-bearing F was produced by disproportionation of magmatic SO_2. Alunite appears to have formed by condensation of a magmatic V rich in SO_2.

Stable isotope compositions, field evidence and chemical equilibria modeling demonstrate that sulfide and gold ores at El Indio and Tambo could not have formed from the same solution as the intra-mineralization alunites. It is concluded that within a limited range of total dissolved sulfur concentrations and solution pH, one parent magmatic-hydrothermal solution could evolve to produce RHS- and OHS-type Au-Cu mineralization at El Indio and Tambo. (Author's abstract)

JAWECKI, C., 1996, Fluid regime in the Austrian Moldanubian Zone as indicated by fluid inclusions: Mineral. and Petrol., v. 58, p. 235-252. Author at Inst. of Petrol., Univ. Vienna, Austria.

Petrographic and FI studies were carried out on amphibolites, metapelites and calc-silicate rocks from the Varied Group and the Gföhl Unit of the Austrian Moldanubian Zone. Thermobarometric calculations yield 670-770°C and 7-10 kbar as highest grade conditions for the studied samples. Four FI types were identified and measured by microthermometry and Raman analysis: CO_2-($\pm H_2O$) rich, aq, CH_4- and N_2-rich I. The oldest F, seen as mixed CO_2-H_2O I in quartz, infiltrated the Moldanubian rocks at temperatures between 650 and 400°C, causing widespread retrograde metamorphism, as a consequence of thrusting of the Moldanubian rocks over those of the Moravian Zone. During successive uplift stages, F continually evolve to CO_2-richer compositions and lower densities by selective water leakage and density re-equilibration mechanisms. Finally, low sal aq and CH_4- and N_2-rich F were trapped during the very late retrograde stage of Variscan metamorphism. (Author's abstract)

JAWOROWSKI, Zbigniew, 1996, Reliability of ice core records for climatic projections: in The Global Warming Debate, John Emsley, Editor, 1996, The Report of the European Science and Environment Forum; ISBN 0952773406; published by Bourne Press, Ltd., Dorset, UK, 288 pp., p. 96-105.

Ice core records are widely used for projections of climatic change, yet there has been no quantitative evalutation of migration of G in firn, and of chemical and physical processes which cause fractionation of G in air I. There is a need for experimental studies which would provide basic information for understanding these processes. High contamination of inner parts of ice cores by drilling procedures demonstrates that the cores do not fulfill the absolutely essential closed-system criterion. The low pre-industrial level of greenhouse gases accepted from glacier studies results from invalid assumptions, processes in the ice sheets, artifacts in the ice cores, and arbitrary selection of data. (Authors' abstract.)

JEAN-BAPTISTE, Ph., and **FOUQUET, Y.,** 1996, Abundance and isotopic composition of helium in hydrothermal sulfides from the East Pacific Rise at 13°N: Geochimica et Cosmochimica Acta, v. 60, no. 1, p. 87-93.

The helium isotopes composition of F trapped in hydrothermal sulfides from the East Pacific Rise (13°N) were measured. Two extraction techniques, i.e. crushing and heating, were tested and sulfides of different mineralogical types were studied. The comparison between the two extraction methods suggests that both should give similar results, provided the crushing efficiency is sufficiently high. Sulfides $^3He/^4He$ ratio for crushed samples are in the range 6.85-8.10 times the atmospheric ratio ($R_a = 1.38 \times 10^{-6}$) and the measured helium concentration is of the order of 5.5×10^{-5} cm^3 STP per gram of trapped F. Comparison with the helium isotope composition of the hydrothermal vent F themselves shows that the mineral phases formed at the highest T (i.e., with less dilution by the ambient seawater) retain the helium information most effectively, with values almost indistinguishable from the endmember vent F. (Authors' abstract)

JÉBRAK, Michel, MARCOUX, Eric, and **FONTAINE, Denise,** 1996, Hydrothermal silica-gold stalactites formed by colloidal deposition in the Cirotan epithermal deposit, Indonesia: Canadian Mineralogist, v. 34, p. 931-938.

Hydrothermal stalactites have been discovered in the deepest level of the Cirotan mine (Western Java), an adularia-sericite type of precious metal epithermal deposit of Pliocene age. These stalactites show a succession of colloidal silica and gold-rich sulfide bands. Oxygen isotope geochemistry indicates that hydrothermal F were of meteoric origin, similar to present rain water in the area. Quartz textures indicate early deposition by gel related to silica supersaturation, then of alternating bands related to deposition and drying, as shown by desiccation marks. Stalactite formation and the origin of alternating bands could be related to local input of magmatic G. (Authors' abstract)

Quotes FI data from Nehlig and Marcoux, 1992 (this volume). (E.R.)

JENDRZEJEWSKI, N., JAVOY, M. and **TRULL, T.,** 1996a, Quantitative measurements of water and carbon concentrations in natural basaltic glasses by infrared spectroscopy. Part I: Carbon: Comptes Rendus Acad. Des Sci., Serie II: Sciences De La Terre Et Des Planetes, v. 322, no. 8, p. 645-652.

JENDRZEJEWSKI, N., JAVOY, M. and **TRULL, T.,** 1996b, Quantitative measurements of water and carbon concentrations in natural basaltic glasses by infrared spectroscopy. Part II: Water: Comptes Rendus Acad. Des Sci., Serie II: Sciences De La Terre Et Des Planetes, v. 322, no. 9, p. 735-742.

JI Hongbing and **LI Chaoyang,** 1996, Geochemistry of the Jinman vein-type copper deposit, Western Yunnan Province, China -- I. Element geochemical characteristics: Chinese J. of Geochem., v. 15, no. 2, p. 172-184. Authors at Inst. of Geochem., Chinese Acad. of Sci., Guiyang, 550002.

The Jinmen [sic] copper deposit, which is situated on the northern margin of the Lanping-Simao back-arc basin, western Yunnan Province, is a silver-bearing, high-grade vein-type copper deposit. Comprehensive element geochemical studies of the host rocks and hydrothermal minerals revealed the regularities in the distribution, mobilization and transport of elements from the host rocks to hydrothermal minerals. In conjunction with the FI and isotope data, it is suggested that the ore-forming F was derived mainly from a deep source characterized by CO_2 enrichment and reduction in nature. It is also suggested that the ore-forming minerals come largely from a deep source, although the contribution of the country rocks should not be ruled out.

It is also found that some hydrothermal minerals are possessed of MREE-enrichment patterns. It is deduced that the REEs in the deep-source ore F were transported in the form of CO_3^{2-} complexes and were deposited in a continental basin (or a hot-spring basin). (Authors' abstract.)

JI, Jinsheng, XUE, Chunji, ZENG, Zhangreng and YANG, Xingke, 1996, Study on Kangguertage gold ore of the eastern Tianshan (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 656. Authors at Xi'an College of Geol., Xi'an, China.

There are shallow low T hydrothermal type and ductile shear belt altered rock type and magmatic hydrothermal quartz vein type of gold deposits in the ore zone. The metallogenic F all belong to Na-K-Cl type and contain less Ca, Mg, reductive G CH_4, C_2H_6, CO. Their compositions are similar. But the three types of gold deposits also have some differences. (Authors' abstract)

JI, Shukai, Metallogeny of super large Tongkuangyu copper deposit (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 791. Author at Shanxi Inst. of Geol. Sci., Taiyuan, China.

The super-large Tongkuangyu copper deposit is hosted in the meta-volcanic sedimentary sequence. Dominated by Cu, the ore also contain Co, Mo and Au. Sulfur, H and O isotope studies suggest a magmatic water dominated F source, with contributions to some extent from metamorphic F, sea water and meteoritic water. FI studies suggest that ore-forming F belong to a $NaCl\text{-}CaCl\ (KCl)\text{-}Ca\ SO_4\text{-}H_2O$ system, in which Na^+ and Ca^{2+} dominate. pH value of the F is around 6.2. Th is between 180-600°C. Moderate-high T hydrothermal activity characterizes the early stage of mineralization, whereas the later stage is marked by low T. The minimum P for the mineralization is 2-10 Mpa. The Tongkuangyu copper deposit is strata-bound, and pluton- and tectonic-controlled. (From author's abstract by E.R.)

JIA, Yueming, 1996, Investigation of fluid ore-forming systems and processes: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 253-258. Author at China Inst. of Geol. and Mineral Resources Information, Beijing 100037.

Active F ore-forming systems are those in which P ore transport is currently underway, such as the black smokers, the Red Sea, Salton Sea brines of USA, and the Tengchong hot springs of Yunnan, China. Investigating these systems will allow ore-carrying F to be sampled and [permit] monitoring of their actual pathways. [These can then be used to evaluate evidence from] fossil ore-forming systems. (From author's abstract by E.R.)

JIANG, Ha and **MA, Dongsheng,** 1996, Experimental study on the leaching of gold, antimony, mercury and arsenic from strata by middle-low-T sulphur- and chlorine-bearing aq fluid: Geological Review (Dizhi Lunping), v. 42 (1996) p. 76 (in Chinese; Engl. abst.) Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing, Jiangsu.

According to metallogenic conditions of the western Hunan epithermal mineralization area, the authors carried out a series of experiments of leaching Au, Sb, Hg and As from strata by sulphur- and chlorine-bearing aq F at 100 to 300°C and 40 MPa. The experimental results show that the temperatures and ligand species and concentration of the F are major factors in controlling remobilization of the elements. The experiment gives a remobilization order of Hg-Sb-Au-As. The study suggests that high-S (low-Cl) hydrothermal F with temperatures of 200-250°C are favorable for Au and Sb mineralization, while low-T low-S, high Cl hydrothermal F are favorable for Hg mineralization. The results of the experiment combined with the geochemical study on the ore-bearing formation and FI suggest that the difference of the ore-forming F in T and composition should be a key factor controlling regional zoning of Au, Sb and Hg mineralizations in the western Hunan epithermal mineralization area. (Authors' abstract)

JIANG Neng and **ZHANG Wenhuai,** 1996, Physicochemical conditions and mechanism of mineralization of Lianhuashan gold deposit, Chifeng, Inner Mongolia: Geochimica, v. 25, no. 1, p. 73-83.

Microthermometry and compositional analysis are carried out on FI hosted in quartz which is intimately associated with gold mineralization. The composition, sal and density of mineralizing F, the *p-T* condition of F entrapment and other physico-chemical parameters such as pH, Eh, f_{O_2} and f_{S_2} are calculated based on the theory of F inclusion geochemistry. Finally, two kinds of mechanism are suggested for the precipitation of gold. They are boiling-degassing and mixing of F. (Authors' abstract)

JIN, F., 1996, Mode of occurrence of ore minerals and mineralization of the Dalingkou silver deposits, Tiantai County, Zhejiang Province, eastern China: J. Japan. Assoc. Mineral. Petrol. Econ. Geol., v. 91, p. 133-144. (In Japanese with Engl. abst.)

A Pb-Zn orebody with high Ag concentration is situated in the Cretaceous rhyolites in Dalingkou, Tiantai County, Zhejiang Province, eastern China. The orebody occurs in brecciated and fissured zones. Unlike many other shallow-seated hydrothermal gold-silver ore deposits in North America and Japan, the Ag/Au ratio of the ore is very high and ranges from 97 to 60,000 (average: 970). Main silver minerals are polybasite, tetrahedrite, argentite, and pyrargyrite. The gangue mineral assemblage is characterized by abundant rhodochrosite and the absence of adularia. Chemistry of FI suggests that ore-forming conditions, such as sal 0.2-4.1 wt.%, pH=3.4-5.6 and pressure 98.3-186.8 kbars, are not much different from those of the other Ag-Au deposits. The ore body is an epithermal fracture-filling, Ag-Au-bearing, base metal ore deposits. (Author's abstract)

JIN, Mingxia and **XHEN Su,** 1996, Genesis and transport loci of Sn and W ore-forming fluid on the western margin of the Yangzi Plate, China (abst): 30th Int'l Geol. Cong., Abstracts, v. 1., p. 413. Authors at Chengdu Inst. of Geol. and Mineral Resources, China.

The many natures of ore-forming F show that their origin relate to intermediate-acid granitic magma of S-type crust-remelted. The remelting T of crust material is about 1150°C, which is estimated by T measurements of crystalline apatite I in the quartz of granites. The T that magmatic M was going up is about 700°C to 900°C, which is estimated by T measurements of melting crystalline I and glass I. The F boils take place in the end period of magmatic crystallization. Ore bodies seem to form after boiling of hydrothermal F. The T for four times of boiling were measured: 445°C-440°C, 400°C-395°C, 367°C-361°C and 335°C-330°C. The sal during boiling was 34-46 wt% NaCl. Again, the density was 1.1g/cm^3. The boiling F were mixed with such as pore water of country rocks and the ground water. A series of thermal diffusion halos from high to low T were formed during F transport. In the Chahe mining district, the granite and country rocks from inner to outer contact zones in proper order as greisen type, skarn type, sulfide type Sn deposits, farther Cu-Pb-Zb-Ag-Au deposits (mineralization). The ore-forming T range from 420°C to 149°C and P are in a range of < 500 bar, corresponding to depths of 1-1.5 km below the surface. The sal of F during ore-forming were 6.8-9.5 wt% NaCl and the density were 0.65-0.81g/cm^3. The T in vertical zoning of drilling hole of thermal halo from lower to upper were 400°C to 200°C sum up the ore-forming F transport loci from lower to upper along the Anning River deep fracture in vertical directions and from granites to round country rocks in the side directions. Ore-forming elements were carried by the F of high T, high P, high sal and precipitated deposits forming the environments of relatively lower T, P, and sal. (From authors' abstract by E.R.)

JOHAN, Zdenek, 1996, New evidence for a fluid-rich PGE-ore forming system in mafic and ultramafic complexes (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 672. Author at BRGM, Orléans, France.

A detailed mineralogical study of several Alaskan-type intrusions (Fifield, N.S.W., Australia; Nizhni Tagilsk, Russia), mineralized in platinum-group elements (PGE) reveals the important role of F-rich magmatic L in the concentration of these noble metals. The isoferroplatinums also show silicate I which are excellent markers of the composition of magmatic L coexisting with metallic phases at the moment of their precipitation. The I fill Pt_3Fe negative crystals and contain systematic clinopyroxene associated with hydroxyl-bearing silicates (tremolite + muscovite or biotite), local albite, and accessory apatite, titanite and anhydrite and residual glass: the residual glass is quartz- and corindon [corundum?]-normative and contains 11 to 15 wt.% water (estimated from electron microprobe analyses). The composition of original magmatic L was calculated from the image analysis. The result shows that the L was water-rich (5 to 10 wt.%) and quartz-normative and, in some cases (Milverton, N.S.W.), corindon [corundum?] normative. This composition in incompatible with olivine-rich cumulates hosting this type of chromite-associated PGE mineralization and indicates a high T immiscibility process induced by concentration of volatile components among which the water played a major role.

In the Bushveld stratiform intrusion, Raman spectroscopy of FI shows a variable CO_2/CH_4, and CH_4-rich PGE horizons. G chromatography reveals that the Merensky reef is four times richer in CH_4 than underlying pyroxenites and chromitites. The distribution of REE within the various cumulates of the Upper Critical Zone (UCZ) is remarkable and cannot be explained by simply magmatic fractionation. The occurrence of REE-bearing minerals in volatile-rich intercumulus indicates REE transportation in F phase. The F induces a strong variation in fO_2, modifying the Eu^{3+}/Eu^{2+} ratio in the magmatic L and consequently the concentration of Eu in the F phase. These observations again demonstrate an important role of the F-rich phase in PGE concentration within the stratiform intrusions. (From author's abstract by E.R.)

JOHARI, G.P., HALLBRUCKER, Andreas, and **MAYER, Erwin,** 1996, Two calorimetrically distinct states of liquid water below 150 Kelvin: Science, v. 273, p. 90-92.

V-deposited amorphous solid and hyperquenched glassy water were found to irreversibly transform, on compression at 77 kelvin, to a high-density amorphous solid. On heating at atmospheric P, this solid became viscous water (water B), with a reversible glass-L transition onset at 129±2 kelvin. A different form of viscous water (water A) was formed by heating the uncompressed V-deposited amorphous solid and hyperquenched L water. On thermal cycling up to 148 kelvin, water B remained kinetically and thermodynamically distinct from water A. The occurrence of these two states, which do not interconvert, helps explain both the configurational relaxation of water and stress-induced amorphization. (Authors' abstract)

Pertinent to low-T FI phenomena? (E.R.)

JOHN, D.A. and **PICKTHORN, W.J.,** 1996, Alteration and stable isotope studies of a deep meteoric-hydrothermal system in the Job Canyon Caldera and IXL Pluton, southern Stillwater Range, Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 733-756. Authors at U.S. Geol. Survey, Menlo Park, CA.

Petrographic, oxygen and hydrogen isotope, and FI studies of the late Oligocene Job Canyon caldera reveal a fossil meteoric-hydrothermal system that circulated large amounts of heated meteoric ground waters to depths greater than 7 km in caldera fill and in the upper parts of the underlying, cogenetic IXL pluton. Later tilting allowed study of the circulation of meteoric-hydrothermal F to paleodepths of ≈10 km.

Oxygen isotope analyses of about 185 whole-rock samples indicate that caldera-related volcanic rocks are strongly depleted from magmatic values. A large variation in whole-rock $\delta^{18}O$ is present in the upper 1 km of caldera fill. Limited hydrogen isotope analyses of biotite and chlorite from the IXL pluton range from -90 to -155 per mil. P water calculated for the least altered plutonic rocks are within the range of "primary magmatic waters." Compositions of hydrothermal F calculated from the most strongly altered granitic rocks at 300° to 400°C are close to the meteoric water line but shifted to higher $\delta^{18}O$ values, probably the result of wallrock exchange.

FI in 4 samples of quartz veins are two phase, L-rich I that have low sal (0-3 wt.% NaCl eq.) and moderately high Th (265° to 310°C). Estimated Tt are 290° to 370°C. Calculated water compositions for these veins are $\delta^{18}O$ = -13.5 to -16.7 per mil, which are similar to published estimates of isotopic compositions of Late Tertiary meteoric waters from nearby epithermal gold-silver deposits.

The stable isotope and FI data are interpreted to result from circulation of large amounts of ^{18}O-enriched meteoric water throughout caldera fill to depths of 5 km, and circulation of lesser amounts of meteoric water in underlying plutonic rocks and in wallrocks of the pluton to depths of at least 7 km. Permeability was much smaller in most parts of the IXL pluton than in the lava flows and tuff, and consequently, hydrothermal alteration and oxygen isotope exchange with low $\delta^{18}O$ F was generally much less. The absence of epithermal precious-metal mineralization may be due primarily to the lack of boiling of hydrothermal F in preserved parts of the caldera. (From authors' abstract by E.R.)

JOHNSON, C.A., CARDELLACH, E., TRITLIA, J. and **HANAN, B.B.,** 1996, Cierco Pb-Zn-Ag vein deposits: Isotopic and fluid inclusion evidence for formation during the Mesozoic extension in the Pyrenees of Spain: Economic Geol., v. 91, no. 3, p. 497-506. First author at U.S. Geol. Survey, Box 25046, MS 963, Denver, CO 80225.

The Cierco Pb-Zn-Ag vein deposits, located in the central Pyrenees of Spain, crosscut Paleozoic metasedimentary rocks and are in close proximity to Hercynian granodiorite dikes and plutons. Galena and sphalerite in the deposits have average $\delta^{34}S$ values of -4.3 and -0.8‰ (CDT), respectively. Coexisting mineral pairs give an isotopic equilibration T range of 89-163°C which overlaps with the 112-198°C range obtained from PFI. Coexisting quartz has a $\delta^{18}O$ value of 19 ± 1‰ (VSMOW). The F which deposited these minerals is inferred to have had $\delta^{18}O_{H_2O}$ and $\delta^{34}S_{H_2S}$ values of 5 ± 1 and -1 ± 1‰, respectively. Chemical and microthermometric analyses of FI in quartz and sphalerite indicate sal of 3 to 29 wt.% NaCl eq. with Na^+ and Ca^{2+} as the dominant cations in solution. The Br/Cl and I/Cl ratios differ from those characteristic of magmatic waters and pristine seawater, but show some similarity to those observed in deep ground waters in crystalline terranes, basinal brines, and evaporated seawater. Barite, which postdates the sulfides, spans isotopic ranges of 13 to 21‰, 10 to 15‰, and 0.7109 to 0.7123 for $\delta^{34}S$, $\delta^{18}O$, and $^{87}Sr/^{86}Sr$, respectively. The three parameters are correlated providing strong evidence that the barites are products of F mixing.

We propose that the Cierco deposits formed along an extensional fault system at the margin of a marine basin during the breakup of Pangea at some time between the Early Triassic and Early Cretaceous. (From authors' abstract by E.R.)

JOHNSON, J., NIELSEN, R.L., and FISK, M.R.,1996, Plagioclase-hosted melt inclusions in the Steens Basalt, southeastern Oregon: Petrologiya, v. 4, no. 3, pp. 228-239, (in Russian, translated in Petrol., v. 4, no. 3, p. 209-220). First author at Dept. of Geosci., Wilkinson Hall 104, Oregon State Univ., Corvallis, Oregon, 97331-5506 USA.

The 16 Ma Steens Basalt is an extensive suite of continental tholeitic basalts and basaltic andesites that covered over 15000 km^2 of SE Oregon. Their chemistry is similar in many ways to enriched mid-ocean ridge basalts (MORB), but unlike plagioclase-hosted M I from many oceanic basalts, the I analyzed from the Steens Basalts exhibit a narrow range of composition and are more evolved than their host lavas. This implies that they formed late in the petrologic history of the system, and that the phenocrysts crystallized in a well-mixed system. Evidence derived from petrography, mineral chemistry, and phase equilibria modeling, supports the contention that the site of crystallization was shallow (<2-3 kbar), above the level where clinopyroxene is stable in these compositions. Taken together, this information indicates that the lavas were produced in a mid-crustal magma chamber. The lack of diversity in the Steens inclusions indicates that the diversity exhibited by the I in the oceanic lavas is not due to a post-entrapment reaction with the plagioclase, but is an inherent characteristic of the magmas from which the host crystallized. (Authors' abstract.)

JONES, D.M., MACLEOD, G., LARTER, S.R., HALL, D.L., APLIN, A.C. and CHEN, M., 1996, Characterization of the molecular composition of included petroleum (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 64-65. First author at Newcastle Research Group In Fossil Fuels and Environmental Geochem., Postgraduate Inst., Newcastle upon Tyne, Drummond Building, Univ. of Newcastle, Newcastle upon Tyne, NE1 7RU, UK.

Obtaining accurate molecular characterisation of the minuscule volumes of petroleum contained in petroleum-bearing FI hosted in diagenetic cements remains difficult and non-routine. Thorough cleansing of the surface of the cements hosting the petroleum I is required to remove non-included petroleum contamination. The cleaned mineral grains hosting the petroleum-bearing I of interest, are then crushed below solvent (crush-leach), and the organic molecular marker compounds or "biomarkers" concentrated and analysed. A vital step in the process is detailed, pre-analytical petrographic analysis to allow generations or populations of petroleum FI to be identified and enable geochemists to accurately interpret what is being analysed.

Within the laboratories of the Newcastle Research Group, we have suspected that the petroleum being analysed during our "crush-leach analysis" of petroleum FI was at times not just included petroleum, but also petroleum firmly adhered to the surface of the cements being analysed. To address this potential problem, we have developed an analytical methodology in which surfaces of the cements being crushed are spiked with standard compounds, and successive cleaning and GC analysis of the solvent washings, indicates when all surface-adhered petroleum compounds and standards have been removed. Then, and only then, is the host cement crushed below solvent, and the liberated petroleum analysed via GC-MS.

Two studies serve to illustrate the technique. Carbonate-hosted petroleum I were identified in several dry holes from frontier portions of the Veracruz Basin where there is limited well control and limited petroleum production. Identification of L petroleum bearing FI in these rocks, including fairly shallow and young lithologies, suggests that some petroleum migration has occurred in the recent geological past. Microthermometric data suggests three general hydrocarbon zones as a function of depth: 1) shallow, heterogeneous oil and G; 2) intermediate, near-bubble/dew point oil/condensate; and 3) deep, undersaturated condensate. Biomarker analysis of oil I ties migrated petroleum to marine, carbonate-sourced oils of variable maturity with similarities to produced oils.

We will also present data from a North Sea reservoir, where "biomarker" and compositional analysis of included petroleum has been combined with micro-thermometry to construct a filling history for the reservoir. The compositional and microthermometry data have also been used to identify and time compartmentalisation of the reservoir. In the past, the reservoir units contained a homogenous black oil, and were in F and P communication. Now, however, the reservoir is pressure-compartmentalised and contains condensate and black oil. Such information has a direct impact on production strategy and near field exploration plans. (From authors' abstract by E.R.)

JOREAU, Pascal, FRENCH, B.M., and DOUKHAN, J.-C., 1996, A TEM investigation of shock metamorphism in quartz from the Sudbury impact structure (Canada): Earth and Planetary Science Lett., v. 138, p. 137-143.

The Sudbury basin in Canada is an elliptical feature (approx. 60 × 27 km in size) that is now widely believed to be part of a large (approx. 200 km diameter) meteorite impact structure which formed about 1.85 Ga ago and was subsequently deformed and metamorphosed. Despite prolonged debate over the origin and original size of the Sudbury structure, strong evidence for meteorite impact has been provided by the discovery in its rocks of a wide range of shock-metamorphic features, especially the optically observable traces (FI arrays) of former Planar Deformation Features (PDFs) in quartz parallel to {1013} planes. In this new examination of Sudbury samples, no preserved original PDFs (glassy lamellae) were observed optically in quartz grains from basement rock fragments in the Onaping Formation, a unit interpreted as a "fallback breccia" deposited within the original crater. However, TEM revealed other thin lamellar features preserved in the quartz; these are identified as Brazil twin lamellae parallel to the basal plane (0001). These lamellae are 15-200 nm thick, show a typical spacing of 30 nm to several microns apart, and are occasionally decorated with FI (≤ 0.5 μm in size), which probably formed during post-shock alteration and annealing. Numerous subgrain boundaries (SGBs) were also detected, many of them oriented roughly parallel to the basal plane (0001). The SGBs apparently formed during post-shock recrystallization, leading to the local disappearance of Brazil twin lamellae. Experimental evidence suggests that such basal Brazil twins are the unique product of high-pressure shock waves. The features in the Sudbury samples are identical to those observed in the Vredefort structure, South Africa, which is also widely accepted as an ancient impact structure about 2.0 Ga old. The recognition of basal Brazil twins in quartz at Sudbury provides additional evidence for meteorite impact origin and also emphasizes the high value of these durable shock features for identifying old and tectonically metamorphosed impact structures. (Authors' abstract)

JURKOVIC, I., and **PALINKAS, L.,** 1996, Late Variscan, Middle-Upper Permian, Post-Variscan and Middle Triassic rifting related ore deposits in the Northwestern and Central Dinarides: Plate Tectonic Aspects of the Alpine Metallogeny in the Carpatho-Balkan Region, Proceedings of the Annual Meeting, Sofia, UNESCO-IGCP Project No. 356, v. 1, p. 19-27.

On the basis of tectonic settings, stable isotope data, FI study, paragenetic characteristics, [and] spatial and temporal relations to the magmatic events, authors classified all ore occurrences found in the Paleozoic and Triassic rocks of the central and northwestern Dinarides into four different groups: (1) Late Variscan (siderite and epigenetic barite vein deposits); (2) Middle-Upper Permian (sandstone hosted U, Cu, Mn-hematite and evaporite deposits); (3) Post-Variscan (siderite-barite and barite deposits) and (4) those related to the intracontinental Middle Triassic rifting processes of the Alpine cycle (Mn, vein-type and disseminated Pb-Zn-Fe, massive Zn, Pb and Fe-sulfide of volcanic and volcano-sedimentary rocks, cinnabar in carbonates, MVT deposits, marine oolitic Fe accumulations, bentonite deposits, pyrite-barite mineralization in Shabka facies rocks, magnetite-hematite skarn and vein deposits, and stratiform hematite-siderite-manganese deposits).

FI data are as follows: (1) siderite deposits: Te = -33°C- -18°C, Tm = -9°C- 0°C, CO_2-rich I in some mineralization. (3) barite deposits: Te = -51°C- -21°C, Tm = -22°C- +4°C (hydrohalite melting), Th = 190-210°C. Sulfur isotopic data are listed for many deposits. (Authors' abstract extended by F. Molnar)

KADIK, A.A., 1996, Formation of the volatile components of the Earth's mantle: Development of Vinogradov's Ideas: Geochem. Int'l, v. 34, no. 4, p. 95-108. Author at Vernadskiy Inst. for Geochem. and Analytical Chemistry, Russian Acad. of Sci.

A review. (E.R.)

KADIK, A.A. and **SHILOBREEVA, S.N.,** 1996, The behaviour of volatile compounds of C, H, N at melting and uprising mantle magma to the surface of the earth (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 436. Authors at Vernadsky Inst. of Geochem. and Analytical Chem., Moscow, Russia.

KALOGEROPOULOS, S.I., KILIAS, S.P., and **ARVANITIDIS, N.D.,** 1996, Physicochemical conditions of deposition and origin of carbonate-hosted base metal sulfide mineralization, Thermes ore-field, Rhodope Massif, northeastern Greece: Mineralium Deposita, v. 31, p. 407-418.

Two major vein and stratabound base metal sulfide varieties occur in the Thermes ore-field, Rhodope Massif, NE Greece, hosted in marbles. The first comprises brecciated vein Pb-Zn mineralization; the second comprises stratabound (manto) polymetallic, and Pb-Zn replacement ores with associated veins. On the basis of ore geochemistry, as well as field and textural evidence, these two ore varieties form part of a vein associated skarn-replacement base metal sulfide ore system. Based on FI data in quartz, together with the iron content of sphalerites and existing lead and sulfur isotope data, it is suggested that after the cessation of the regional amphibolite facies metamorphism circulating evolved meteoric waters, probably with magmatic F contributions, deposited sulfide ores at temperatures of 200°-400°C, and P < 300 bar. Ore was deposited as a result of increase in pH of the mineralizing F due to F-rock interaction, and adiabatic cooling and/or simple cooling accompanying F boiling. Thermochemical considerations indicate a pH increase from about 4 to 7 and a decrease in f_{S_2} and f_{O_2}. (From authors' abstract, by E.R.)

KALYUZHNYI, V.A. and **ZINCHUK, I.M.,** 1996a, Investigations and genetic interpretation of the hydrocarbon fluid inclusions in minerals physico-chemical features (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 551. Authors at Inst. of Geol. & Geochem. of Combustible Minerals, Ukrainian Nat'l. Acad. of Sci., Lviv, Ukraine.

A review of the nature of hydrocarbon I from various geological environments. (E.R.)

KALYUZHNYI, V.A. and **ZINCHUK, I.M.,** 1996b, Investigations and genetic interpretation of the hydrocarbon fluid inclusions in minerals physicochemical features (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 14-15. Authors at Inst. of Geol. & Geochem. of Combustible Minerals, Ukrainian Nat'l. Acad. of Sci., Lviv, Ukraine.

A review. (E.R.)

KAMALI, C., and NORMAN, D.I., 1996, Mineralization at the Lone Tree gold deposit (abst): SME Annual Meeting Tech. Program, March 11-14, 1996, Phoenix, AZ, p. 48.

The Lone Tree gold deposit, Nevada, is hosted in Paleozoic calcareous sedimentary rocks. The first stage of mineralization containing quartz veins, pyrite, marcasite, arsenopyrite, and gold is brecciated and overprinted by a second stage comprising barite, pyrite and marcasite. Free gold grains associated with quartz and pyrite are observed. Main alteration types are decarbonization, silicification in the form of quartz veining, and argillization (kaolinite, illite/smectite, and alunite). FI data indicates stage 1 f had T of 237° to 281°C, sal 3 to 7.3 eq. wt.% NaCl and stage 2 F had T 103° to 147°C, sal 1.2 to 1.7 eq. wt.% NaCl. Acidic and moderately saline F were responsible for the first stage of mineralization. Both textural and FI data suggest stage 1 and stage 2 events were distinct separate events, perhaps separated by a significant length of time. (Authors' abstract)

KAMENETSKY, Vadim, 1996, Methodology for the study of melt inclusions in Cr-spinel, and implications for parental melts of MORB from FAMOUS area: Earth and Planetary Science Letters, v. 142, p. 479-486.

M I trapped in Cr-spinel in mid-ocean ridge picrites (FAMOUS area, Atlantic Ocean) were studied using a heating stage and analyzed with both electron and ion microprobes. This new technique can provide information on the most primitive magma compositions, olivine-spinel-M compositional relationships, crystallization T and geochemical diversity of parental M. The study of M I in spinel can be applied to different high-Mg suites to show the effects of shallow level fractionation, mixing and contamination that usually affect the composition of volcanic rocks and glasses (Author's abstract)

KAMENETSKY, Vadim, and **CLOCCHIATTI, Robert,** 1996, Primitive magmatism of Mt. Etna: insights from mineralogy and melt inclusions: Earth and Planetary Science Lett., v. 142, p. 553-572.

Data on the mineralogy and petrology of primitive ancient and prehistoric basaltic magmas of Mt. Etna (Sicily) are scarce. A systematic study of the mineralogy and magmatic inclusions in olivine phenocrysts from the most Mg-rich tholeiitic (Aci Castello, Aci Trezza and Adrano), transitional (Paterno) and alkaline (Mt. Maletto, Mt. Spagnolo and Timpa di Acireale) basalts has been undertaken, using the electron microprobe and heating/freezing stages.

The maximum Fo content in olivine increases from 86 mol% in tholeiites, to 88 mol% in transitional basalt and up to 89-90.5 mol% in alkaline basalts. The relationship between Fo of the most primitive olivine from alkaline samples and the Cr# of coexisting spinel indicates that their parental M were near P. Clinopyroxene Mg# values (maximum and range) correspond closely to those of olivine, suggesting their early co-crystallization. Orthopyroxene (Mg# 86 mol%) has been found as I in the most magnesian olivine in the tholeiitic lavas only.

Crystallization T determined from M I studies revealed no contrast between samples of different affinity, and range from 1240° to 1100°C. The P of crystallization is believed to be higher than 2 kbar (up to 6 kbar), as indicated by the density of P CO_2 I in olivine, and indirectly, by the early clinopyroxene crystallization.

M I in olivine from theolitic lavas form a continuous trend for Q-normative, low potassium and low phosphorous (0.2 wt%) to Si-undersaturated, Ne-normative compositions, enriched in K_2O and P_2O_5 (~ 1.6 wt%). The range in M I compositions cannot be accounted for by crystal fractionation and was probably generated during partial melting.

The M reconstructed from M I in olivine phenocrysts from a Mt. Maletto alkaline lava define a compositional trend consistent with early clinopyroxene + olivine fractionation. The M equilibrated with the most primitive olivine ($Fo_{90.5}$), clinopyroxene (Mg# 92) and Cr-spinel (Cr# 80) is considered to be a near-P M (Mg# 71-74 mol%; CaO/Al_2O_3 ~ 1.3), formed by the melting of a clinopyroxene-rich source. The likelihood of a single parental to both the tholeiitic and alkaline suites is confidently ruled out.

Comparison of characteristic features of the magmatism of Mt. Etna and adjacent areas (Mt. Iblei and the Aeolian arc) testifies to progressive depletion of a mantle source by continuous magma extraction, and its heterogeneous chemical and modal modification. (Authors' abstract)

KAMENETSKY, Vadim, MÉTRICH, Nicole and **CIONI, Raffaello,** 1995, Potassic primary melts of Vulsini (Roman province): evidence from mineralogy and melt inclusions: Contrib. Mineral. Petrol., v. 120, p. 186-196. First author at Vernadsky Inst. of Geochem., Moscow, Russia.

The origin and the relationships between the high potassic and potassic suites of the Roman Comagmatic Province and the nature of their P magmas have been intensively debated. We have addressed these problems by a study of mineralogy (olivine Fo_{92-87}, Cr-spinel and diopside) and MI in olivine phenocrysts from a scoria sample of Montefiascone (Vulsini area). This rock is considered as one of the most primitive (MgO = 13.5 wt.%, NiO = 340 ppm; Cr = 1275 ppm) in the northern part of the Roman Comagmatic Province. The compositions of both the olivine and their MI are controlled by two main processes. The high and constant Mg# of studied M and their variable Si, K, P, Ca, Al, S contents could be explained by the M of a refractory lithospheric mantle source, heterogeneously enriched in phlogopite and clinopyroxene (veined mantle source). (From authors' abstract by E.R.)

KAMENETSKY, V.S., SOBOLEV, A.V., JORON, J.-L. and **SEMET, M.P.,** 1995, Petrology and geochemistry of Cretaceous ultramafic volcanics from Eastern Kamchatka (citation lost.) First author at Vernadsky Inst. of Geochem., Russian Acad. of Sci., Kosygin Str., 19, Moscow 117975, Russia.

The origin, evolution and PM compositions of late Cretaceous high-K ultramafic volcanics and associated basalts of Eastern Kamchatka are discussed on the basis of a study of the mineralogy and geochemistry of the rocks and magmatic I in phenocrysts. The exceptionally primitive composition of the phenocryst assemblage provides direct evidence of the mantle origin of PM, which were highly magnesian compositions. The PM were produced under high-P (30-50 kbar) and high-T (1500-1700°C) conditions by partial melting of a refractory peridotitic mantle. (From authors' abstract by E.R.)

KAMILLI, R.J. and **CRISS, R.E.,** 1996a, Fluid-inclusion and oxygen-isotope studies of the Silsilah tin deposit, Kingdom of Saudi Arabia: Open-File Report, U.S. Geological Survey OF-96-1, IR-922, 40 pp.

The Silsilah tin deposit (lat. 26°06'N., long 42°40'E.) consists of a group of pervasively greisenized, flat-topped granite cupolas within a 12-km-diameter ring complex. The greisens contain varying amounts of disseminated cassiterite and minor wolframite. The deposit is genetically associated with a highly differentiated, peraluminous alkali-feldspar granite (587±8 Ma) that is part of a mostly peralkaline igneous ring complex intruded into Late Proterozoic, immature sandstones of the Murdama Group.

We recognize four distinct phases of the peraluminous granite. Only the smallest, most highly differentiated cupolas contain significant tin-greisen mineralization. Greisenization was localized by aplitic carapaces that overlie the granite and created impermeable barriers to rising volatiles. The geometry of the cupola correlates strongly with the intensity of alteration: cupolas with the smallest cross-sectional areas and steepest marginal contacts have the most intensely greisenized apexes.

The paragenetic sequence can be divided into five stages: pegmatite formation, locally pervasive albitization, locally pervasive greisenization and deposition of cassiterite, deposition of quartz-wolframite veins, and deposition of quartz veins with minor base-metal sulfides.

P-corrected FI filling temperatures indicate that the hydrothermal system generally cooled as it evolved, and the $\delta^{18}O$ value of the hydrothermal quartz increased from +10.8 to +15.7 per mil. Calculated $\delta^{18}O$ values of the hydrothermal F varied concomitantly from the pegmatite stage ($\delta^{18}O$ fluid ~+8.16 per mil; T≈550°C) to the greisen stage (+5.4 and +5.6 per mil, T≈360°C), the quartz-wolframite vein stage (+6.3 and +7.5 per mil; T≈390°C), and the late vein stage (+4.0 and +5.1 per mil; T≈270°C). This evolution probably reflects the admixture of generally increasing amounts of meteoric or formation water having a lower $\delta^{18}O$ value into the cooling magmatic-hydrothermal system.

In $\delta^{18}O$-$\delta^{18}O$ plots for mineral separates from fresh to altered samples of the peraluminous granite the values for quartz and feldspar conform to a steep, positive-sloped disequilibrium trend that indicates interaction with high-^{18}O hydrothermal F, mirrored by a negative-sloped disequilibrium trend for quartz and mica. These complementary trends suggest strongly that individual granite cupolas were essentially closed systems during alteration.

The sandstone country rock has whole-rock $\delta^{18}O$ values of +12.4±2.0 per mil. The highest values (>+13 per mil) form a ~3-km-wide high-$\delta^{18}O$ annulus immediately peripheral to the ring complex. The data suggest that the country rocks were pervasively exchanged with an outward-migrating, high $\delta^{18}O$ F moving down a T gradient. This F was probably a formation water that previously had flowed radially inward toward the pluton at a deeper level, forming a largely horizontal, unicellular flow system that had fluid-flow lines nearly vertical next to the intrusion, and directed upward and outward at higher levels. Low-$\delta^{18}O$ F that formed quartz associated with the tin-tungsten mineralization and later veins are inferred to be the result of a subsequent and distinct phase of the hydrothermal system. (Authors' abstract)

See also next abstract (E.R.)

KAMILLI, R.J., and **CRISS, R.E.,** 1996b, Genesis of the Silsilah Tin Deposit, Kingdom of Saudi Arabia: Economic Geol., v. 91, p. 1414-1434.

See previous abstract (E.R.)

KAMONA, A.F., 1996, Lead and sulphur isotopes of the Kabwe Pb-Zn deposit, Zambia (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 83. Author at UNZA, Geol. Dept., ZAMBIA.

The carbonate-hosted Kabwe Pb-Zn deposit consists of massive pipe-like sphalerite-galena-pyrite ores with minor to trace amounts of chalcopyrite, briartite and renierite within Precambrian metacarbonates. Lead and sulphur isotope ratios of the sulphides have homogeneous values indicative of upper continental crustal source rocks and of sedimentary sulphur, respectively.

FI studies show that ore deposition took place at about 320°C, indicating that the sedimentary sulphides were leached by circulating hydrothermal F to produce an H_2S dominant ore F with an average value of -15.52‰ H_2S [sic] during ore deposition. (From author's abstract, by E.R.)

KANEOKA, I., 1993, Noble gas signatures of magmatic sources and processes: Geochem. J., v. 27, p. 201-211.

KAUFFMAN, E.G., ARTHUR, M.A., HOWE, B., and **SCHOLLE, P.A.,** 1996, Widespread venting of methane-rich fluids in Late Cretaceous (Campanian) submarine springs (Tepee Buttes), western interior seaway, U.S.A.: Geology, v. 24, no. 9.

KELLEY, D.S., 1996, Methane-rich fluids in the oceanic crust: J. of Geophysical Research, v. 101, no. B2, p. 2943-2962. Author at Sch. of Oceanography, U. of Washington, Seattle.

Analyses of FI in plutonic rocks recovered from the slow-spreading Southwest Indian Ridge (SWIR) record CH_4 concentrations of 15-40 times those of hydrothermal vent F and of basalt-hosted volcanic G and provide the first direct sampling of CO_2-CH_4-H_2O-H_2-C-bearing F in the oceanic crust. Compositional, thermal, and spatial analyses of these F are used to model the evolution of volatiles during the crystallization and cooling of mid-ocean ridge magma chambers and to assess the potential importance of carbon-bearing F in geochemical processes in the lower crustal component of hydrothermal systems. Results from these analyses show that the earliest F to be exsolved from the M are dominated by CO_2-rich V, which with progressive fractionation evolved to more H_2O-rich compositions. These later F were most likely exsolved under immiscible conditions and involved the development of CO_2-H_2O-rich V and CO_2-H_2O-NaCl brines that were trapped during mineral growth, as well as during later high-T fracturing events. CO_2+CH_4±H_2O-rich F in olivine and plagioclase minerals that contain up to 30-50 mol% CO_2 and 33 mol% CH_4 may reflect respeciation of magmatic CO_2 during cooling and attendant graphite precipitation. Phase equilibria suggest that these F reequilibrated at ~500°-600°C and at fO_2's ~ -3 log units below, to close to QFM conditions. Alternatively, the I may record respectation of magmatic F attendant with the inward diffusion of H_2 into the I and reduction of entrapped CO_2 during degassing and cooling of the gabbros throughout the subsolidus regime. Subsequent seawater reaction, at minimum T of ~400°C with mafic-rich layers within the gabbroic rocks or with ultramafric material that underlies the plutonic sequence resulted in the formation of CH_4-H_2O F that contain up to 40 mol% CH_4, molecular H_2, and graphite(?) dm. These data provide strong evidence that the CH_4-H_2O-rich F produced during serpentinization reactions were trapped under equilibrium conditions in the presence of graphite at very near to QFM conditions. The ubiquitous occurrence of CH_4-rich F in oceanic crustal layer 3 rocks from the SWIR indicates that these F may be a significant and previously unrecognized source for these volatile species in some hydrothermal systems venting on the seafloor and that the deep-seated F most likely play an important role in the transfer of carbon from the lithosphere to the hydrosphere. (Authors' abstract)

See also Evans, this volume. (E.R.)

KELLEY, D.S., and **MALPAS, John,** 1996, Melt-fluid evolution in gabbroic rocks from Hess Deep: Proc. of the Ocean Drilling Program; Scientific results, 147, p. 213-226; Hess Deep rift valley; covering Leg 147 of the cruises of the Drilling Vessel JOIDES Resolution, San Diego, California, to Balboa Harbor, Panama, sites 894-895, 22 November 1992-21 January 1993.

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

KELLEY, K.D., STEIN, H.J., SNEE, L.W., BEATY, D.W. and **THOMPSON, T.B.,** 1996, Genesis of epithermal gold-telluride deposits and associated alkaline igneous rocks in the Cripple Creek district, Colorado, western U.S. (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 796. First author at U.S. Geological Survey, USA.

The deposits occur within a small (18 km^2) Oligocene volcanic complex that is surrounded by Proterozoic basement rocks. The deposits are spatially associated with the alkaline rocks. There are two P types of deposits: high-grade Au-Te veins and low-grade disseminated Au deposits. Vein paragenesis proceeds from quartz-fluorite-adularia-pyrite to base-metal sulfides to Au-bearing tellurides. Alteration consists of pervasive flooding of K-feldspar-pyrite. FI studies suggest that early F were hot (up to 510°C), saline (>40 eq. wt.% NaCl), and contained CO_2; ore stage F were low T (<200°C) and dilute (<9 eq. wt.% NaCl).

Initial magmas ascending to the surface may have encountered water and erupted explosively to form volcanic breccias and diatremes. Subsequent intrusion of felsic-intermediate phonolite was followed by intrusion of mafic phonoloite and lamprophyre dikes, Au-Te-bearing magmatic hydrothermal F, rich in CO_2, and fluorine, evolved from the phonolitic magmas and mixed with meteoric water at shallow crustal levels. The mixing caused cooling, dilution, and oxidation of the magmatic-hydrothermal solutions, which precipitated Au-Te minerals and native gold. (From authors' abstract by E.R.)

KERR, R.A., 1996, Ice bubbles confirm big chill: Science, v. 272, no. 14, p. 1584-1585.

A review of modern work on rapid climate change in the last 12,000 years, as revealed by studies of N_2 and CH_4 in gas I, and $^{16}O/^{18}O$ of the ice (E.R.)

KESLER, S.E., MARTINI, A.M., APPOLD, M.S., WALTER, L.M., HUSTON, T.J., and **FURMAN, F.C.,** 1996, Na-Cl-Br systematics of fluid inclusions from Mississippi Valley-type deposits, Appalachian Basin: Constraints on solute origin and migration paths: Geochim. et Cosmochim. Acta, v. 60, p. 225-233.

This study evaluated Na-Cl-Br systematics of FI-hosted brines in Mississippi Valley-type (MVT) deposits from the Appalachian Basin. Unlike other geochemical tracers such as lead and strontium isotopes which constrain metal sources, Na-Cl-Br systematics identify sources of brine sal. Saline formation waters can vary systematically within and between basins with regard to their Na-Cl-Br compositions depending on the importance of halite dissolution relative to retention of subaerially evaporated seawater for the halogen budget. Oil field brine compositions from the Illinois and Appalachian basins are quite distinct in their Na-Cl-Br systematics. Compositions of saline FI in MVT deposits generally are consistent with these regional differences. These results shed new light on the extent of regional flow systems and on the geochemical evolution of saline F responsible for mineralization.

Nearly all FI analyzed from the Appalachian MVT deposits have Na/Br and Cl/Br ratios less than modern seawater, consistent with ratios observed in marine brines involved in halite precipitation. The Na-Cl-Br systematics of the brines responsible for Appalachian MVT deposits may be inherited from original marine brines refluxed into the porous carbonate shelf sediments that host these deposits. The Cl/Br and Na/Br ratios of most FI-hosted brines from Appalachian MVT sphalerites and fluorites fall into two compositional groups, one from the Lower Cambrian paleoaquifer and another from the Lower Ordovician paleoaquifer. Leachates from most MVT barite deposits form a third compositional group having lower Na/Br and Cl/Br ratios than the other two. Appalachian MVT leachate compositions differ significantly from those in MVT deposits in the Cincinnati arch-midcontinent region suggesting that these two MVT provinces formed from brines of different origin or flow path. (Authors' abstract)

KHETCHIKOV, L.N. and **PAKHOMOVA, V.A.,** 1996, Inclusions in minerals as indicators of the composition and parameters of mineral-forming solutions: Results of a study on synthetic quartz grown in NaOH+KOH solution: Geol. of Pac. Ocean, v. 12, p. 561-566.

I have been studied in quartz with known conditions of synthesis. T and solution concentrations inferred from the I appeared to be similar to the experimental ones. The composition of salts in the I was found to be identical to that of the parent solution. New data were obtained on the behavior of the NaOH + KOH + H_2O system on cooling in a cryogenic chamber. (Authors' abstract)

KHIN, Zaw, 1991, The effect of Devonian metamorphism and metasomatism on the mineralogy and geochemistry of the Cambrian VMS deposits in the Rosebery-Hercules district, western Tasmania: Doctor of Philosophy thesis, Univ. of Tasmania, about 500 pp. [Also listed as Zaw, Khin]

The Rosebery, Hercules and South Hercules deposits in western Tasmania are composed of polymetallic massive to disseminated sulphide mineralization hosted in felsic volcanics. The deposits have been affected by regional metamorphism of upper greenschist facies and associated tectonic Devonian deformation. Three major replacement zones can be distinguished: (1) magnetite-biotite ± chalcopyrite zone, (2) pyrrhotite - pyrite zone and, (3) tourmaline - quartz ± magnetite zone. Other metasomatic minerals such as fluorite, garnet and helvite are present. The main Hercules deposit occurs 10 km south along strike from Rosebery and lies in a similar tuffaceous shale unit. The deposit consists of a number of disconnected strata-bound Zn-Pb-Cu-Ag-Au ore lenses with similar metal distribution and alteration features to the Rosebery ores. The VMS carbonates from both north- and south-ends of the Rosebery deposit display slightly constrained and similar isotopic patterns. The isotopic patterns imply that no later isotopic changes have taken place although the south-end of the Rosebery deposit was strongly overprinted by the high T (> 300°C), pervasive Devonian replacement process. The $\delta^{18}O$ values of biotite and magnetite from the F(J) lens replacement zone were used to calculate the oxygen isotopic composition of the Devonian hydrothermal F. The calculated $\delta^{18}O_{H_2O}$ values for the overprinting Devonian hydrothermal F vary from 8.0‰ to 12.0‰ and are consistent with a magmatic F. FI studies indicate that early formed low-T (ca. 200°C), low-sal (< 5 NaCl eq. wt.%) Type I inclusions with no appreciable CO_2 may be interpreted as P, Cambrian exhalative F that have survived Devonian recrystallisation. FI characteristics of necking down and healed microfractures together with trapped carbonate and barite dm identified by laser Raman spectroscopy suggest an extensive remobilisation and recrystallisation of carbonate minerals during the Devonian overprinting processes, which corroborates [correlates?] with the redistribution and recrystallisation of P Cambrian sulphides (e.g. sphalerite) and gold, during Devonian metamorphic and metasomatic processes. Although the VMS deposits in the Rosebery-Hercules area display no evidence for large-scale chemical remobilisation of ore constituents during metamorphism, the post-orogenic Devonian granite intrusion below the south-end of the Rosebery mine resulted in chemical remobilisation of the ore lenses. The early replacement assemblages in the F(J) lens formed from interaction of moderate to high T (≥ 330°C), saline (≥ 20 NaCl eq. wt.%) F with the original lead-zinc mineralisation. The later stage tourmaline veining and associated replacement assemblages resulted from lower T (≤ 300°C), less saline (≤ 20 NaCl eq. wt.%) F. During the Devonian metasomatic event gold may have been remobilised and recrystallised either as $Au(HS)_2^-$ or $AuCl_2^-$ complexes but the high T and sal conditions favour the $AuCl_2^-$ complex. Copper also appears to have been recrystallised during the replacement process with minor remobilisation. In comparison to copper and gold, zinc, lead and silver have been dissolved and removed as the very soluble chloride complexes. (From author's abstract by E.R.)

Some CO_2 was recognized by laser Raman. Unidentified, rounded to subhedral, birefringent dm were a constant puzzle. These birefringent minerals were commonly found in quartz, barite, sphalerite, fluorite and helvite from the Rosebery, Hercules and South Hercules deposits. Most of the birefringent dm obtained Raman shifts with major lines at 1085.5 - 1086.7 cm^{-1}. These lines suggest that the carbonates are not dolomites which have 1099 cm^{-1} as a major line. The results are more consistent with calcite, rhodochrosite and kutnahorite, but these three cannot be accurately distinguished. Two of the dm were checked for minor lines which yielded 720.8 - 1424.5 - 1726.1 cm^{-1} and 1419.7 - 1745.4 cm^{-1}. The carbonate dm in sample 16L-3 which has the major Raman line of 1086.7 cm^{-1} and minor lines of 720.8 - 1424.5 - 1726.1 cm-1 is probably kutnahorite (Fig. 10.12). The dm in a FI in quartz from the barite-rich H lens yielded a Raman shift at 987.4 - 1141.4 cm^{-1} which is the characteristic Raman spectra of barite given by Griffith (1970). (From author's text, p. 10.19, by E.R.)

KHIN, Zaw, 1996, Ore fluid chemistry and genetic significance of hydrothermal processes: examples from Australian and Myanmar gold and base metal deposits: Warta Geologi, v. 22, no. 4, p. 301-303. Author at Centre for Ore Deposit and Exploration Studies, Univ. of Tasmania, Hobart, Tasmania.

The Hellyer and Mt. Chalmers deposits are mound-style volcanic-hosted massive sulphide (VHMS) deposits in Tasmania. At Mt. Chalmers, Type I I up to 20 µm are found in quartz from the mineralised zone, and these I yielded Th of 160-268°C and sal of 5-8 NaCl eq. wt.%. Laser Raman spectroscopic (LRS) analysis indicates the presence of CO_2 (<1mol%) in the Mt. Chalmers VHMS systems. Semi-quantitative SEM/WEDS microprobe analyses of FI decrepitates indicate that the Mt. Chalmers ore F were enriched in potassium and calcium but depleted in magnesium relative to seawater. PIXE microanalysis of FI in quartz also indicates a significant base metal concentration in these F. Cation composition and higher sal 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.

Gold-copper-bismuth mineralisation in the Tennant Creek goldfield of the Northern Territory occurs in pipe-like, ellipsoidal, or lensoidal lodes of magnetite ± hematite ironstones which are hosted in turbiditic sedimentary rocks of Proterozoic age. FI studies have revealed four major I types in quartz associated with mineralised and barren ironstones at Tennant Creek: (1) L-VI with low L/V ratios (Type I), (2) L-VI with high L/V ratios or high V/L ratios and characteristic dark bubbles (Type II), (3) L-V-halite I (Type III), and (4) L-VI with variable L/V ratios (Type V). Type I inclusions are present in the barren ironstones and the unmineralised portions of fertile ironstones, whereas Types II and III inclusions are recognized in fertile ironstones. Type I FI have Th of 100 to 350°C with a mode at 200 to 250°C. Type II inclusions in mineralised ironstones (e.g. Juno, White Devil, Eldorado, TC8 and Gecko K-44 deposits) have Th of 250 to 600°C with a mode of 350°C. Type I FI have a sal range of 10 to 30 NaCl eq. wt.%. Sal measurements on FI in the mineralised zones gave a range of 10-50 NaCl eq. wt.%. with a mode of 35 NaCl eq. wt.%.

FI studies indicate that the Tennant Creek ironstones were formed from a relatively low T and moderately saline F, whereas gold and copper mineralisation was deposited from later hydrothermal F of higher T and sal. G analysis indicates the presence of N_2 and CO_2, with very minor CH_4 in Types II inclusions but no N_2 or CH_4 G in Type I inclusions. Microprobe analysis of the FI decrepitates indicates that the I from Tennant Creek contain sodium and calcium as dominant cations and potassium in a subordinate amount.

The high T (Ú350°C), high sal (Ú35 NaCl eq. wt.%) and cation composition of the Tennant Creek ore F suggest that the ore F were derived from upward migrating heated basinal brines, although contribution from a magmatic source cannot be ruled out. Close association of V-rich Type IIb and salt-rich Type III inclusions in the mineralised ironstones (e.g. Juno, White Devil, Eldorado, TC8 and Gecko K-44) indicates heterogeneous trapping of ore F. This heterogeneous trapping is interpreted to be due to unmixing (exsolution) of a G-rich (e.g. N_2) F during the upward migration of the metal bearing brines and/or due to degassing caused by reaction of oxidised ore F and host ironstones. FI data have important implications regarding the deposition of gold in the ironstones, and can be used in discriminating fertile from barren ironstones in conjunction with other exploration techniques.

The Kyaukpahto gold deposit in Myanmar is located at Latitude 23°47'55" N and Longitude 95°56'35" E in the Kawlin-Wuntho district, Sagaing Div.. Gold mineralisation is hosted in turbiditic sandstone of Male Formation (Lower to Middle Eocene) and occurs as stockwork and dissemination. Gold mineralisation is also associated with intense silicification, sericitisation and argillic alteration. Major sulphide minerals are pyrite and arsenopyrite with minor galena, chalcopyrite, and sphalerite. Gold occurs predominantly as free gold grain (electrum) in stringery quartz veins, and native gold as electrum is also a dominant mineral in the oxidized and supergene zones. The gold grains vary in size from 1 µm to 250 µm and electron microprobe analysis of the grains yields a range of fineness from 844 to 866. Preliminary FI study at Kyaukpahto gold deposit reveals three major FI types in quartz in the ore zone: (1) Type I, two-phase, H_2O L, V and CO_2 LI and (3) Type III, two-phase, L-RI with variable L and V ratios. Primary Type I FI are 5-15 µm across and yielded Th of 239-310°C and sal of 1.2-10.9 NaCl wt.%. Present geological, mineralogical and FI characteristics demonstrate that the Kyaukpahto gold deposit is comparable to the Carlin type sediment-hosted gold deposits. (From author's abstract by H.E.B.)

KHIN, Zaw, GEMMELL, J.B., LARGE, R.R., MERNAGH, T.P., and **RYAN, C.G.,** 1996, Evolution and source of ore fluids in the stringer system, Hellyer VHMS deposit, Tasmania, Australia: Evidence from fluid inclusion microthermometry and geochemistry: Ore Geol. Reviews, v. 10, p. 251-278.

The Hellyer deposit is a classic, large tonnage, high-grade, mound style volcanic hosted massive sulphide (VHMS) deposit in the Cambrian Mt. Read Volcanic belt of western Tasmania. In the footwall directly underlying the deposit, there is an extensively altered pipe which contains a well developed and preserved stringer zone.

The vein paragenesis at Hellyer indicates that premineralization Stage 1 veins consist entirely of quartz, and occur throughout the alteration pipe. The synmineralization Stage 2 veins are the most abundant veins in the stringer zone and consist of three sub-stages: Stage 2A veins of crustiform quartz, pyrite, and carbonate with minor amounts of chalcopyrite, sphalerite and galena, Stage 2B veins with abundant base metal sulphides, minor quartz, carbonate and barite gangue and Stage 2C veins of coarsely crystalline barite with variable amounts of pyrite, sphalerite, galena and carbonate. Stages 3-6 veins are postmineralization veins and are related to the Devonian Tabberabberan Orogeny.

Textural, petrographic and microthermometric investigations of FI in the Hellyer stringer system indicate that Type I, P, L-V I occur along growth planes of crustiform quartz crystals or within colour banding of zoned sphalerite. These I are 10-15 µm size, and yielded 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 sal remained between 8-11 NaCl eq. wt.% in all Stage 2 veins.

Chalcopyrite-bearing P FI have been recognized in the base metal-rich Stage 2B veins.

No evidence for presence of CO_2 (e.g. formation of clathrates) was recorded by microthermometry. However, Laser Raman spectroscopic (LRS) analysis indicates the presence of CO_2 (< 1 mole%) in the Stage 2B veins, and no detectable CO_2 in 2A and 2C vein stages. Semi-quantitative SEM/WDS microprobe analyses of FI decrepitates indicate that the Hellyer ore F was enriched in potassium and calcium but depleted in magnesium relative to seawater. PIXE microanalysis of FI in quartz indicates that the Stage 2B ore F have a significantly higher base metal concentration compared to the Stage 2A veins. The post mineralization Stage 4 veins have a variable but lower base metal content.

In this study, there was no FI evidence of boiling. Cation composition, higher sal relative to seawater and the presence of CO_2, suggest that recycled seawater alone cannot be the sole source of the ore F. This interpretation is in agreement with previous isotopic studies in the Hellyer stringer system. Although direct input of bulk ore constituents from a magma chamber cannot be demonstrated from the present FI data, such a contribution of ore F from a magmatic source cannot be ruled out. The possible input from the magmatic source may have occurred during the base metal-rich Stage 2B vein formation characterised by the intensifying T of deposition, higher base metals and CO_2 contents. (Authors' abstract)

KHIN, Zaw, HUNNS, S.R., RYAN, C.G., and **MERNAGH, T.P.**, 1996, Chemical composition of fluid inclusions from the Mt. Chalmers VHMS deposit, Australia bearing on source of ore-forming fluids (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 552. First author at CODES Key Centre, Univ. of Tasmania, Hobart, Tasmania, Australia 7001.

See preceding item. (E.R.)

KHIN, Zaw and **LARGE, R.R.,** 1996, Petrology and geochemistry of sphalerite from the Cambrian VHMS deposits in the Rosebery-Hercules district, western Tasmania: Implications for gold mineralisation and Devonian metamorphic-metasomatic processes: Mineral. and Petrol., v. 57, 1996, p. 97-118. Authors at Centre for Ore Deposit and Exploration Studies, Univ. of Tasmania, Hobart, Tasmania, Australia.

The bimodal distribution of FeS content in Rosebery sphalerite suggests that the P VHMS mineralisation underwent at least two periods of post-depositional reequilibration. The FeS content in sphalerite in equilibrium with hexagonal pyrrhotite and pyrite indicates that the Devonian replacement occurred at a P of 3.0 ± 0.5 kb, corresponding to 8.0 ± 0.1 km in depth. The relationship between FeS content in sphalerite and gold grades at Rosebery, Hercules and South Hercules displays complex patterns that reflect either variations in the initial depositional conditions on the seafloor (pH, T and aS_2), or later Devonian metamorphic and metasomatic recrystallization. (From authors' abstract by E.R.)

KHIN, Zaw, LARGE, R.R. and HUSTON, D.L., 1996, Petrological and geochemical characteristics of a Devonian replacement zone in the Cambrian Rosebery massive sulphide deposit, western Tasmania: Geol. Soc. of Australia, Abstracts, v. 41, p. 489.

Indexed under FI (E.R.)

KIEFERT, Lore, SCHMETZER, Karl, KRZEMNICKI, M.S., BERNHARDT, H.-J., and **HÄNNI, H.A.,** 1996, Sapphires from Andranondambo area, Madagascar: J. Gemm., v. 25, no. 3, p. 185-209.

Apatite I are common and may be accompanied by rosette-like fissures in type I or by tubes perpendicular to the growth direction in type II sapphires. Calcite and spinel I were also observed. Type III sapphires commonly show three-phase inclusions parallel to the basal pinacoid, consisting of L and gaseous CO_2 and diaspore. (From authors' abstract by H.E.B.)

KIEFERT, Lore, and SCHMIDT, S.Th., 1996, Some tanzanite imitations: Gems & Geol., v. 32, no. 4, p. 270-276.

Solid and G I are described and illustrated. (H.E.B.)

KILIAS, S.P., 1991, Geochemical and thermobarometric characteristics of fluids associated with quartz-scheelite veins of Metaggitsi-Salonikio, E. Chalkidiki Peninsula: Bulletin of the Geological Society of Greece, v. XXV, no. 2, p. 145-159. (In Engl., Greek abst.)

Primary aq CO_2-bearing FI with variable CO_2/H_2O volumetric rations coexist in quartz and scheelite from vein systems hosted by two-mica gneisses and schists of the Vertiskos Formation in the Pirgadikia, Metsggitsi-Salonikio area, E. Chalkidiki. I with low CO_2 volumetric percentage of 5-25 vol% homogenize to the H_2O-phase at T between 230 and 325°C, whereas those with high CO_2 volumetric percentage of 55-85 vol% homogenize to the CO_2 phase at T ranging from 220 to 331°C. Sal are less than 10 eq. wt.% NaCl. These veins formed from boiling CO_2-laden F at T of 250-400°C and P between 1 and 2 kbars during retrograde greenschist facies metamorphism. (Author's abstract)

KILIAS, S.P., 1996, Fluid inclusion evidence for the genesis of the Kastri vein-quartz deposit, Thessaloniki district, Northern Greece: Plate Tectonic Aspects of the Alpine Metallogeny in the Carpatho-Balkan Region, Proceedings of the Annual Meeting, Sofia, UNESCO-IGCP Project No. 356, v. 1, p. 117-124.

The kastri vein-quartz deposit, Thessaloniki district, is hosted by two-mica gneisses and biotite gneisses of the polymetamorphic Paleozoic or older Vertiskos Formation of the Serbo-Macedonian Massif in northern Greece. Study of FI in vein-quartz reveals three types (with subtypes) of P FI: (1) Type I, carbonic CO_2 ($\pm CH_4$) I; (2) Type II, moderately saline (0.4-12.3 eq. wt.% NaCl) aq-carbonic H_2O - CO_2 - NaCl ($\pm CH_4$) I and (3) Type IIIa, aq H_2O - NaCl ($\pm CO_2$) (2.2 to 11.3 eq. wt.% NaCl) I; S aq H_2O - NaCl type IIIb (1.8-12.7 eq. wt.% NaCl), as well as type IV decrepitated and/or leaked I are also present. It is indicated that the Kastri vein formed at T of 400°C (or higher) to 140°C in a depositional environment characterized by continuous P decrease causing mineralising F CO_2 ($\pm CH_4$) and H_2O ($\pm$NaCl)) phase unmixing at T of 200°C to 350°C and P of 2-3 kb. Vein growth may have commenced at P as high as 4.5 kb. Vein formation F P-T and T-sal data are compatible with regional Alpidic retrogressive greenschist facies metamorphism of the gneissic host-rocks and syn- to post-metamorphic uplift allowing introduction of meteoric waters in the mineralizing system. (Author's abstract)

KILIAS, S.P., KALOGEROPOULOS, S.I. and **KONNERUP-MADSEN, J.,** 1996, Fluid inclusion evidence for the physicochemical conditions of sulfide deposition in the Olympias carbonate-hosted Pb-Zn (Au, Ag) sulfide ore deposit, E. Chalkidiki peninsula, N. Greece (citation lost).

The Olympias Pb-Zn (Au, Ag) sulfide ore deposit, E. Chalkidiki, N. Greece, is hosted by marbles of Paleozoic or older age. Microthermometry of FI in gangue syn-ore quartz indicates three types of P and pseudosecondary I: (1) H_2O-rich, 1-18 wt.% NaCl eq., <3.6 mol% CO_2; (2) H_2O-CO_2 I, < 4 wt.% NaCl eq., with variable CO_2 contents, coexisting in both undeformed and deformed ore; (3) aq, high-sal (28-32 wt.% NaCl eq.) I found only in undeformed ore. Type 2 I are differentiated into two sub-types: (2a) relatively constant CO_2 content in the narrow range of 8-15 mol% and homogenization to the L phase; (2b) variable CO_2 content between 18 and 50 mol% and homogenization to the V phase. Type 1 and 2b I are consistent with trapping of two F by unmixing of a high-T, saline, aq, CO_2-bearing F of possible magmatic origin, probably trapped in type 2a I. F unmixing and concomitant ore mineralization took place at T of 350±30°C and fluctuating P of < 500 bar, for both undeformed and deformed ores. The wide sal range of type 1 I probably represents a complex effect of sal increase, due to F unmixing and volatile loss, and dilution, due to mixing with low-sal meteoric waters. High solute enrichment of the residual L, due to extreme volatile loss during unmixing, may account for the extreme volatile loss during unmixing, may account for high sal type 3 I. The Olympias FI sal-T gradients related to Pb-Zn ores formed in "granite"-hosted, low-T distal skarn, skarn-free carbonate replacement and epithermal environments. (From authors' abstract by E.R.)

KIRILOV, A.S., BELYAEV, A.M, SHEBANOV, A.D. and **LYALINOV, D.V.,** 1996, Gas composition of FI in quartz xenocrysts as an indicator of interaction processes between mafic and rapakivi granite magmas (abst.): The Seventh Int'l. Symposium on Rapakivi Granites and Related Rocks; Abstract Volume, Haapala, I, Ramo, O.T., and Kosunen, Paula, eds., p. 35.

KITA, I., NAGAO, K., TAGUCHI, S., NITTA, K, and **HASEGAWA, H.,** 1993, Emission of magmatic He with different $^3He/^4He$ ratios from the Unzen volcanic area, Japan: Geochem. J., v. 27, p. 251-259.

KITTO, P.A., 1994, Structural and geochemical controls on mineralisation at Renison, Tasmania: Doctor of Philosophy thesis, Univ. of Tasmania, 484 pp.

Renison Sn mine is Australia's largest P tin producer, with an identified mineral resource totalling 9.5 Mt at 1.4% Sn. It is hosted by subaerial to shallow marine, Late Precambrian to Early Cambrian dolomitic and clastic sediments, in major brittle structures formed during the forceful emplacement of the highly fractionated, reduced, ilmenite series Pine Hill Granite. Beneath Renison, an apophysis of late stage quartz-feldspar porphyry granite generated a high T boron and fluorine-rich F, which caused in-situ sericitisation, albitisation and tourmalinisation. Four phases of brittle deformation allowed magmatic-hydrothermal F access to the dolomitic host sequence. A high T oxide-silicate vein stage (qz-asp-cass) formed during fault. FI associated with this event have Th ranging from > 400°C at the base of the fault (3000 m beneath the Devonian palaeosurface), to 300°C near the top of the mine workings. These early NaCl - KCl - H_2O brines had average sal between ~ 8 and 12 eq. wt.% NaCl, and F P of 250 bars (hydrostatic). $\delta^{18}O_{fluid}$ values of 9‰ are clearly magmatic, consistent with a F which ascended and cooled before interacting with the wallrocks in the higher mine levels. $\delta^{34}S_{fluid}$ values from the oxide-silicate stage are < 6‰ and indicate the probable source of sulphur is magmatic. Later faulting released a second generation of magmatic-hydrothermal F, depositing the pyrrhotite + cassiterite - quartz - fluorite - stannite - chalcopyrite ± arsenopyrite stratabound carbonate replacement orebodies that characterise the Renison deposit. During this stage of mineralisation, mineral deposition in the fault occurred over a T range from < 350°C, immediately above the Pine Hill Granite, to ~ 200°C at the top of the mine workings. The deep-level NaCl - KCl - H_2O - rich magmatic-hydrothermal brines evolved to $CaCl_2$ - $MgCl_2$ - NaCl - H_2O - rich F during F-rock reactions with carbonates in the upper mine levels. Sal averaged between 8 and 12 eq. wt.% NaCl throughout the sulphide stage. Contoured tin values and Th from FI clearly outline two high T tin-rich dilational jogs on the fault, as do variations in $\delta^{34}S_{mineral}$ values. $\delta^{34}S_{fluid}$ values remained constant at ~ 5‰ throughout the sulphide stage, which is consistent with a homogeneous magmatic sulphur source.

The late stage minor uneconomic base metal veins were formed by low T (150 to 200°C), bimodal sal (< 2 and ~ 10 eq. wt.% NaCl), NaCl - KCl - H_2O brines that formed via mixing of contemporary meteoric groundwaters with magmatic-hydrothermal F. $\delta^{34}S_{fluid}$ values (~ 5‰) remained unchanged, indicating that magmatic F continued to supply sulphur to the Renison system over a protracted period. The only FI evidence for phase separation at Renison occurs in these late stage veins.

FI results from the oxide-silicate stage, in association with thermodynamic modelling, 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, $a_{H_3AsO_3}$ between 10^{-5} and 10^{-1}, $a_{Na+} \approx 0.1742$, $a_{K+} \approx 0.085$, m_{Mg2+} between 1.6 x 10^{-5} and 6.2 x 10^{-2}, m_{Ca2+} between 7.96 x 10^{-3} and 12.61 [sic], m_{F-} between 1.05 x 10^{-5} and 4.16 x 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 ΣSn. At lower T, $Sn(OH)_2Cl_2$ complexes became dominant. (From author's abstract by E.R.)

See also FIR, v. 27, p. 66 (E.R.)

KITTO, P.A., COOKE, D.R., and **LARGE, R.R.,** 1996a, Rension tin mine-hydrothermal system, western Tasmania (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 797. Authors at Geol. Dept./CODES, Univ. of Tasmania, Australia.

Deposition of a high T Stage 1 oxide-silicate vein assemblage (qz-asp-cass) was associated with initial faulting. FI Th for this stage from >400°C at the base of the Federal-Bassett Fault to 300°C near the top of the mine workings. These early NaCl-HCl-H_2O brines had average sal between ~8 and 12 eq.wt.% NaCl, and FP of 250 bars (hydrostatic). CH_4 was detected by Raman spectroscopy in the V phase of PFI throughout the Federal-Bassett Fault. Alternatively, CO_2 V was only detected in CH_4-bearing FI (CO_2/CH_4 = 0.5) in the upper sections of the Federal-Bassett Fault where dolomite horizons are intersected. $\delta^{18}O_{fluid}$ values of 9‰ and $\delta^{34}S_{fluid}$ values between 5 and 6‰ characterize the entire fault for Stage 1 mineralization.

Stage 2 sulfide vein assemblage occurred over a T range from <350°C, immediately above the Pine Hill Granite, to ~200°C at the top of the mine workings. The deep-level NaCl-KCl-H_2O-rich brines evolved to $CaCl_2$-$MgCl_2$-NaCl-H_2O-rich F during F-rock reactions with carbonates in the upper mine level. Sal averaged between 8 and 12 eq. wt.% NaCl throughout the Stage 2 sulphide mineralisation. CH_4 was detected by Raman spectroscopy in the V phase of P Stage 2 FI throughout the Federal-Bassett Fault. Contoured tin values and Th from FI clearly outline two high T tin-rich dilational jogs on the Federal-Bassett Fault, as do variations in $\delta^{34}S$ mineral values, $\delta^{34}S_{fluid}$ values remained constant at ~5‰ throughout the sulfide stage. Minor uneconomic Stage 3 base metal veins (rhos-gn-sph-qz), associated with minor fault reactivations, overprint the earlier vein stages, as do Stage 4 vug-fill carbonate-quartz veins (qz-carb±flu±py). Stage 3 and 4 veins were associated with low T (150-200°C), bimodal sal (<2 and 10 eq. wt.% NaCl), NaCl-KCl-H_2O brines. Raman spectroscopy detected CH_4 in the V phase of PFI associated with Stage 3. However, variable CO_2, CH_4 and N_2 was detected in the V phase of SFI from Stage 4. The only FI evidence for phase separation at Renison occurs in the late stage veins, $\delta^{34}S_{fluid}$ values (~5‰) remained constant within the Federal-Bassett Fault during base metal mineralisation.

FI microthermometry, Raman spectroscopy and stable isotope studies indicate that Sn mineralisation at Renison was associated with NaCl-KCl-H_2O-rich (CH_4-bearing) magmatic-hydrothermal F derived from the underlying Pine Hill Granite. Minor uneconomic late stage mineralisation occurred from NaCl-KCl-H_2O-rich brines that formed via mixing of contemporary meteoric groundwaters derived from N-bearing sediments with (CH_4-bearing) magmatic hydrothermal F. (From authors' abstract by E.R.)

See also adjacent item (E.R.)

KITTO, P.A., COOKE, D.R., and LARGE, R.R., 1996b, Evolution of the Renison hydrothermal system, western Tasmania: Geol. Soc. of Australia Abstracts, v. 41, p. 232. First author at Univ. of Tasmania, CODES Key Centre, Hobart, Tasmania, Australia.

See adjacent item (E.R.)

KLEMD, Reiner, HUNKEN, Ulf and OLESCH, Martin, 1996, Fluid composition and source of Early Proterozoic lode gold deposits of the Birimian volcanic belt, west Africa: Int'l. Geol. Review, v. 38, p. 22-32. Authors at FB-Geowissenschaften, Univ. of Bremen, P.O. Box 330440, 28334 Bremen, Germany.

Gold-bearing veins of Early Proterozoic lode gold deposits of Ghana and Burkina Faso contain predominantly CO_2-N_2-rich FI, often displaying a very high density (up to 1.15g/cm^3), in contrast to most other lode gold deposits of greenstone affiliation. Mineral modeling shows that retrograde and upper-level F will have higher X_{H_2O} because of wall-rock interaction. The high-density CO_2-N_2-rich F is considered to represent the internal unbuffered ore-F composition, which may have originated in the deep crust or mantle. (From authors' abstract).

Includes table giving FI data for seven districts, from literature (E.R.)

KLOMINSKY, Josef, PARTINGTON, G.A., McNAUGHTON, N.J., HO, S.E. and GROVES, D.L., 1996, Radiothermal granites of the Cullen Batholith and associated mineralisation (Australia): Czech Geological Survey Special Papers, 532, no. 5, 44 pp.

The Lower Proterozoic Cullen Batholith in the Pine Creek Geosyncline is associated with a very broad scale of hydrothermal deposits (gold, tin, tungsten, base metals, tantalum, and uranium) which show contrasting geological relationships, spatial distribution and style, T and timing of the mineralisation.

Economic tin and gold mineralisation is located within the inner zone of the thermal aureole spatially and temporally related to the 1800-1835 Ma Cullen Batholith. Spatial distribution of both types of deposits is generally controlled by the geometry of the granite contact. The granite contacts may be either inward or outward dipping. Generally older tin mineralisation occurs within endo- and exocontact areas, mostly associated with TIS plutons. Economic gold mineralisation is more distal, mostly located within the country rocks of the batholith. Tin mineralisation is genetically related to the late YIS granites as their post-magmatic continuum, showing definite distribution patterns along their endo- and exo-contact. On a regional scale the gold mineralisation shows similar zonation, more distal from the granite roof and/or contact, but in detail more controlled by depositional traps. FI data indicate high-medium formation T for tin mineralisation (500-300°C) and gold mineralisation (300-100°C). The main period of gold deposition is younger than high T greisen-type mineralisation. The age history of the Cullen Batholith fully covers the timing of the tin and gold mineralisation. The age-thermal history of the Cullen Batholith is within the range from 1835 Ma at about 800°C, to 1650 Ma at about 300°C. It may indicate a time gap between magmatic and hydrothermal T within the Cullen Batholith: about 20 Ma for tin deposition, and about 40 Ma for gold deposition. The hydrothermal-mesothermal gold mineralisation in the Pine Creek Geosyncline is a multistage (sedimentary preparation, metamorphic upgrading and hydrothermal mobilisation by the heat of the batholith), long-term process which is represented by a number of quartz vein generations. It is interpreted to have started prior to the Cullen Batholith emplacement (stage I and II), culminated during the heating and subsequent cooling of the country rock around the batholith (stage III) and ceased after the batholith roof cooled below 300°C. The end of the process is documented by late quartz veins containing gold which crosscut the YIS plutons (e.g., Mount Shoobridge Granite). The scenario which has been recognized for the origin of the gold deposits in the Pine Creek Geosyncline is generally compatible to a number of major styles of gold deposits in Australia (Tanami, The Granites, Selwyn and Telfer). (From authors' abstract by H.E.B.)

KNIGHT, J.T., RIDLEY, J.R., GROVES, D.L. and McCALL, C., 1996, Syn-peak metamorphic gold mineralization in the amphibolite-facies, gabbro-hosted Three Mile Hill deposit, Coolgardie Goldfield, Western Australia: A high-temperature analogue of mesothermal gabbro-hosted gold deposits: Trans. Inst. Min. Metall. (Sect. B: Appl. Earth Sci.), v. 105, p. B175-B199.

Three Mile Hill, located in the amphibolite-facies Coolgardie Goldfield, Western Australia, is one of several distinctive gabbro-hosted gold deposits in the Eastern Goldfields Province of the Archaean Yilgarn Craton.

Hydrothermal wallrock alteration in deposits at Kalgoorie, Mt. Pleasant, Kambalda and Broad Arrow in the southern part of the Eastern Goldfields Province comprises assemblages of quartz-sericite (biotite) ankerite/dolomite-albite-chlorite, with pyrite as the dominant sulphide and with tellurides common. Gold deposition took place after the peak of metamorphism at T-P conditions in the respective ranges 250-400°C and 1-2 kbar and was accompanied by enrichments in Ag, As, Bi, Pb, S, Sb, Te, W, large-ion lithophile elements and CO_2. Alteration at Three Mile Hill consists of hornblende-plagioclase-calcite-quartz with minor biotite, garnet and chlorite and with arsenopyrite and yrrhotite as the dominant sulphides.

Tellurides and pyrite are absent. As, Cu, S, and Na are co-enriched with gold; Sb, Te, W, K, Rb and Ba, however, are all depleted or only weakly enriched. Geothermobarometric data suggest that gold was deposited at 520±50°C at 2.8-3.8 kbar. The siting of gold in undeformed quartz reefs with P vein textures, together with the equilibrium textural relationships between gold and the high-T gangue, and the high thermodynamic variance of the silicate alteration assemblage suggest that mineralization at Three Mile Hill occurred during amphibolite-facies metamorphism.

FI and C, O and H isotope data indicate that gold mineralization at Three Mile Hill is the result of deposition from a low-sal H_2O-CO_2-CH_4 F of either metamorphic or magmatic origin, similar to that identified at Kalgoorie, Kambalda and Broad Arrow.

Three Mile Hill differs from the other gabbro-hosted gold deposits in the Eastern Goldfields Province in its high-T wallrock-alteration assemblages, peak-metamorphic timing of gold deposition and distinct geochemical associations. Nevertheless, it forms a brittle strata-bound orebody, which suggests structural and gold-depositional mechanisms in common with those of the other gabbro-hosted gold deposits. (From authors' abstract by E.R.)

KNUDSEN, T.-L., 1996, Petrology and geothermobarometry of granulite facies metapelites from the Hisoy-Torungen area, south Norway: New data on the Sveconorvegian P-T-t path of the Bramble sector: J. Metamorphic Geol., v. 14, p. 267-287.

The high grade rocks have gone through four successive stages of metamorphic P-T-t path. M1 is connected to the thermal effect of the gabbroic intrusions prior to the main (M2) Sveconorvegian granulite facies metamorphism at a very reduced water activity in the rocks and XH_2O=0.25 in the C-O-H F system was calculated for a metapelitic unit. Strongly banded metapelites are retrograded to (M3) amphibolite facies assemblages. A P-T estimate of 1.7-5.6 kbar, 516-581°C is obtained from geothermobarometry. M4 greenschist facies conditions yielded chlorite-rich, calcite-bearing veins cutting the foliation. (From author's abstract by E.R.)

KNUDSEN, T.-L. and **LIDWIN, Arne,** 1996, Magmatic CO_2, brine and nitrogen I in Sveconorwegian enderbitic dehydration veins and a gabbro from the Bamble Sector, Southern Norway: European J. of Mineral., v. 8, no. 5, p. 1041-1063.

Full paper for previous abstract (E.R.)

Four metamorphic stages, called M_1 to M_4, can be recognized in the core of the granulite facies Bamble sector of Southern Norway. M_1 conditions of p = 3.1 - 4.1 kbar, T = 750-850°C, are connected with the emplacement of numerous gabbro intrusions (1230-1110 Ma). The following M_2 high-grade Sveconorwegian metamorphism (1150-1070 Ma) is estimated at 5.9 - 9.1 kbar, 790-840°C, and involves intrusion of mm to one meter wide enderbitic veins. M_3 involves isoclinal folding and restricted retrograde mineral growth in the rocks. It occurred at p-T conditions of 1.7 - 5.6 kbar, 510-350°C (M_4).

Brine I with a sal of approximately 80 wt.% and pure nitrogen I of relatively low molar volume (minimum 44 cm^3/mole), are present as early F in the wyn-M_1 gabbro-pegmatites and were probably introduced from the surrounding metapelites during gabbro crystallization. FI textures indicate that the brine and nitrogen were immiscible during entrapment.

Enderbitic veins intruding at M_2 carry CO_2 as a magmatic F which induced a 4-5 mm wide dehydration zone in the surrounding rocks. The width of this zone is independent of the width of the enderbitic veins. Pure nitrogen I (with minimum molar volume similar to nitrogen I in the gabbro-pegmatite) occur mainly in those enderbitic intrusions which crosscut metapelites.

All rocks show similar F density distributions suggesting that the densities of the early FI were reset along the steep early retrograde uplift path and that CO_2 was introduced in the gabbro-pegmatite along S trails at this stage. F evolution during the (M_3) isoclinal folding of the rocks is dominated by decrepitation and retrapping of the earlier trapped FI along S trails.

The present data highlight differences in metamorphic F present in the high-grade Bamble sector during the Sveconorwegian evolution: Brine ± nitrogen and CO_2 ± nitrogen are present at low to medium P M1 conditions and at granulite-facies M_2 conditions respectively. (Authors' abstract)

KOEHLER, Geoff and **KYSER, T.K.,** 1996, The significance of hydrogen and oxygen stable isotopic fractionations between carnallite and brine at low temperature: Experimental and empirical results: Geochimica et Cosmo. Acta, v. 60, no. 14, p. 2721-2726.

KOGARKO, L.N., 1996, CO_2, F, S in the upper mantle and the role of sulphide-carbonate-silicate liquid immiscibility in the genesis of Ca-carbonatites (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 434. Author at Inst. of Geochem. and Analytical Chemistry, RAS, Russia.

A P carbonate phase with Ca/(Ca+Mg) in the range 0.85-0.95 has been identified in a metasomatized, depleted harzburgite nodules from Montana Clara Island, Canary Islands. Its textural relations show that this carbonate represents a quenched liquid. Although magnesian carbonate M have been described in upper-mantle peridotites, this is the first reported occurrence of a P magma within peridotite nodules which has the composition of calciocarbonatite -- by far the most common carbonatite type crustal instrusive complexes.

We have investigated using the piston-cylinder apparatus the immiscibility in the system Ca-rich carbonate-Fe, Ni sulphide-silicate M of phonolitic composition containing F. Experiments were conveyed at 1250°C and 4-15 kbar. Double Pt capsule method has been employed in order to control oxygen fugacity. The immiscibility has been observed in the investigated system exhibited in the complete separation of carbonate and silicate L, whereas sulfide M was present in the form of small globules in both L. Therefore the investigated unique mineral assemblage including carbonate and glass can be considered as a micro model of the generation of the carbonatitic magmas during the processes of the partial melting of wehrlitized and carbonatized mantle. (From author's abstract by E.R.)

KOHN, S.E., 1996, Solubility of H_2O in nominally anhydrous mantle minerals using 1H MAS NMR: American Mineralogist, v. 81, p. 1523-1526. Author at Dept. of Geol., Univ. of Bristol, Wills Memorial Bldg., Queens Rd., Bristol, BS8 1RJ, U.K.

The dissolved H_2O concentrations of experimentally produced, Fe-free, nominally anhydrous minerals (NAMS) have been measured using, for the first time, 1H magic-angle-spinning NMR spectroscopy. At least two types of hydrous species are present in all the samples studied, leading to peaks of different widths: (1) a broad resonance probably due to clustered OH such as that in static H_2O molecules within the structure, clusters of OH or hydrogarnet substitution, and (2) narrower peaks presumably due to nonclustered OH associated with point defects. The solubility of H_2O in clinopyroxene close to the Di-CaTs join is 0.26-0.41 wt.% H_2O at 1000-1100°C and 1.5 Gpa. The solubility of H_2O in enstatite and forsterite is 0.087 and 0.18 wt.%, respectively, under similar conditions. It is possible that the broad components result from submicroscopic hydrous mineral or glass impurities or static H_2O molecules at grain boundaries; if only the narrow peaks are considered to be due to hydrous species within the structure of the NAM, the solubilities are 0.12-0.24 wt.% for the clinopyroxene, 0.024 wt.% for enstatite, and 0.056 wt.% for forsterite. (Author's abstract)

KOIVULA, J.L., KAMMERLING, R.C., DEGHIONNO, Dino, REINITZ, Ilene, FRITSCH, Emmanuel and JOHNSON, M.L., 1996, Gemological investigation of a new type of Russian hydrothermal synthetic emerald: Gems and Geol., v. 32, no. 1, p. 32-29 [sic].

Tairus, in Novosbirsk, has produced yet another new type of Russian hydrothermal synthetic emerald, now being marketed in Bangkok. Examination of eight faceted samples revealed that, with the exception of certain characteristic [solid] I, the basic gemological properties shown by this new synthetic are essentially the same as those encountered in other hydrothermally grown synthetic emeralds and some natural emeralds. If the characteristic I are not present, distinctive spectral characteristics in both the mid- and near-infrared regions of the spectrum will serve to separate these synthetic emeralds from their natural counterparts. (Authors' abstract)

KOMATSU, R., IKEUCHI, K., DOI, N., SASAKI, M. and **UCHIDA, T.,** 1996, Boundary between hydrothermal convection and thermal conduction zones found at WD-1 in the Kakkonda geothermal field, Japan (2) Confirmation by fluid inclusion study: 1996 Annual Meeting of the Geothermal Research Society of Japan, Abstracts with Programs, p. 67 (in Japanese).

KOMNINOU, A. and **SVERJENSKY, D.A.,** 1996, Geochemical modeling of the formation of an unconformity-type uranium deposit: Economic Geol., v. 91, p. 590-606.

Petrologic studies of alteration associated with uranium mineralization in unconformity-type uranium deposits have established a detailed paragenetic sequence of the preore and synore alteration. In addition, FI studies have determined the presence of two distinct F, and thermodynamic analysis of the alteration assemblages has defined their basic characteristics. These F were probably basinal brines derived from the overlying sandstones and have been distinguished by their different sal.

FI responsible for alteration and ore formation were Na-Ca-Cl brines. Speciation calculations suggest that the hydrothermal F responsible for the formation of unconformity-type uranium deposits were distinguished by their high oxygen fugacity and relatively low pH. Uranium was transported mainly as uranyl chloride complexes.

The calculations show that the observed paragenesis is a function not only of the F chemistry but also of the host-rock lithologies. The modeling indicates that although an orebody can be produced with or without graphite as a reactant, its presence leads to a better agreement with the observed alteration paragenesis. (From authors' abstract by E.R.)

KONTAK, D.J., 1996, A multidisciplinary approach to detect multiple source reservoirs and processes in the formation of turbidite-hosted gold mineralization: an example from the Meguma Terrane of Nova Scotia: From Cape Chidley to Cape Race: Exciting new developments in mineral and petroleum exploration: Geological Association of Canada Newfoundland Section 1996 Annual Meeting, published in Atlantic Geol., v. 32, p. 76-77 [176-177?]. Author at Nova Scotia Dept. of Natural Resources, P.O. Box 698, Halifax, Nova Scotia, Canada.

FI studies indicate the vein F were low-sal H_2O-CO_2-NaCl type, record a large range in P_{fluid} (1 to 6.5 kbars), suggest over-pressuring was common, and that F unmixing was rare (West Gore Tangier). All vein types have similar I types and chemistry (thermometric and G chemistry). Isotopic data (C, S) record interaction of the vein F with Meguma Group lithologies and local derivation of reduced carbon and sulphur. Isotopes of O ($\delta^{18}O_{fluid}$ = 8-120) and D (-40 to -60) are most consistent with a metamorphic origin, with some overlap into the magmatic field. Strontium isotopes for vein carbonates and tourmaline indicate a mixed reservoir, one of which must be a non-Meguma Group (i.e., SrI < 0.712 at 370 Ma). However, when the Sr isotope data are combined with Pb isotope data for vein galena the Liscomb Gneisses can be fingerprinted as the sole reservoir. These data are consistent with REE data for vein carbonates that show a wide range in SREE and fractionation, again suggesting multiple reservoirs.

This multidisciplinary study indicates that the F which formed the Meguma gold deposits are generally not unique geochemically, but instead owe their origin to a variety of processes from the time they were generated deep within the crust until they precipitated as vein material within brittle/ductile shear zones. Interaction of the F with wall rocks during their passage through the crust has resulted in the inheritance of many geochemical signatures, all of which bear witness to this interaction. Recognition of such camouflaging is important when discussing sources of F or metals, and genetic models. (From author's abstract by H.E.B.)

KONTAK, D.J. and **BOYCE, A.J.,** 1996, A comparison of the Carboniferous carbonate-hosted Zn-Pb-Ba-Fe-Ag deposits of southern Nova Scotia and the Irish midlands (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract v. 21, p. A51. First author at Nova Scotia Dept. of Natural Resources, P.O. Box 698, Halifax, Nova Scotia, Canada B3J 2T9.

The Carboniferous of Ireland (Tournaisian) and southern Nova Scotia (Visean) host Zn-Pb-Ba-Fe-Ag deposits of variable tonnage (few Mt to tens of Mt) which contain features suggestive of syngenetic to epigenetic origins. Comparison of the two areas indicates that whereas there are many similarities (metal endowment, mineral textures, overall stratigraphy, some geochemical parameters), notable differences occur including thickness of the carbonate stratigraphy, timing of mineralization, evidence for F mixing, and biogenic sulphur in the Irish deposits. The latter features are considered to be critical and may account for generation of the larger tonnage Irish deposits. In southern Nova Scotia, Visean carbonates (10-20 m) of the Visean Windsor Group record a marine transgression over the terrestial red beds of the Horton Group and metaturbidites of the Lower Paleozoic Meguma Group (MG). The carbonates are overlain by thick evaporitic sequences. Significant mineralization occurs at the Gays Rivers (GR; 2.5 Mt, 15% Zn + Pb) and Walton (past production 5 Mt barite, 0.5 Mt Pb-Zn-Cu-Ag ore) where dolomitized and sideritized carbonate, respectively, host replacement-type mineralization which post-dates diagenesis, e.g., at Gays River it is some 30 Ma later (Ar-Ar, paleomagnetic dating). FI indicate mineralizing F were ≤250°C and highly saline (20-28 wt.%) Na-Ca-Cl brines. Methane, L petroleum and isochoric projections indicate mineralization at ambient P of ca. 400-500 bars. Isotopic data indicate mineralizing F equilibrated with MG rocks or their clastic derivative, and that S, of evaporitic origin, was reduced by TSR due to the presence of methane at GR and L petroleum at Walton. In Ireland, thick carbonates (100's m), deposited over the basal Old Red Sandstone (Famennian), represent deposition on a stable carbonate platform with facies controlled by synsedimentary faults. Minor amounts of alkaline magmatism suggest an elevated geotherm (?) and evaporites are minor or absent. Mineralization (to 70 Mt of 7-15% Zn + Pb) is variable (replacement, veining, breccia, exhalative), but is clearly related to synmineralizing faults and was synsedimentary to early diagenetic. Mineralization is variably related to several stages of hydrothermal dolomitization. FI indicate mineralizing F were a mixture of high-T (250°C) moderately-saline (10 wt.%) F and lower T (<100°C), highly saline (25 wt.%) F. As in Nova Scotia, isotopes indicate a basement source for metals, but sulphur is of mixed basement and marine origin (Carboniferous seawater) with sulphate reduction due to bacteriogenic processes. (Authors' abstract)

KONTAK, D.J. and **CLARK, A.H.**, 1995, The role of hypersaline, high-temperature magmatic fluids and meteoric fluids in the formation of a high-grade lode Sn deposit: the San Rafael Sn-Cu deposit, SE Peru (abst.): Geol. Assoc. Can/Min. Assoc. Can. 1995 Annual Meeting Abstracts, p. XXX

Indexed under FI (E.R.)

KONTAK, D.J., HORNE, R.J. and **SMITH, P.K.**, 1996, Hydrothermal characterization of the West Gore Sb-Au deposit, Meguma Terrane, Nova Scotia, Canada: Econ. Geol., v. 91, p. 1239-1262.

The West Gore Sb-Au deposit is anomalous in the Meguma Terrane of Nova Scotia because of its enrichment in Sb, a metal that is essentially absent from other Meguma gold deposits. The deposit is hosted by graphitic and sulfide-bearing slates that were metamorphosed to the greenschist facies. Mineralization occurs as stibnite, native antimony, aurostibite, Au-Sb alloys, and Au-Sb-O phases in vein quartz with associated Fe, As, Pb, Zn, Cu sulfides and chlorite-carbonate gangue; wall-rock alteration is variably developed as narrow zones peripheral to veins enriched in sericite, calcite, sulfides, tourmaline, and chlorite. Early stages of mineralization are constrained to maximum T of 495°C from arsenopyrite geothermometry, but lower T are recorded by chlorite geothermometry (350-390°C). Textures of vein quartz include comb and plumose varieties with bimodal grain size and also a coarser, anhe-dral quartz. FI studies indicate that the F was a mixed H_2O-NaCl-$CaCl_2$- CO_2-CH_4 type and that F unmixing occurred, albeit in minor amounts. Thermometric measure-ments reveal maximum Th of 375°C and a range of sal (0.4-28.1 wt.% NaCl eq.). The volumetric properties of FI reflect cycling of F P with supralithostatic P (to 4-5 kbars P_{fluid}) recorded by the presence of H_2O-CO_2 I (to 20 mole % CO_2) which are interpreted to have resulted from F-rock interaction. Subsequent reduction in F P (to ca. 2 kbars) resulted in decreasing amounts of CO_2 (<1-2 mole %) and F unmixing that generated higher and lower sal trends observed in Th-sal plots.

Vein forming F are characterized by $\delta^{13}C$, $\delta^{18}O$, δD, $\delta^{34}S$, and $^{87}Sr/^{86}Sr$ measured data consistent with a metamorphic origin for the F with local inheritance of C and S isotope signatures from interaction of the ore F with graphite and sulfide wall-rock slates of the Halifax Formation. (From authors' abstract by E.R.)

KONTAK, D.J. and **SANGSTER, D.F.**, 1996, A study of aqueous and petroleum fluid inclusions in barite from the Walton Ba-Pb-Zn-Cu-Ag deposit, southern Nova Scotia, Canada (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual Meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A51. First author at Nova Scotia Dept. of Natural Resources, P.O. Box 698, Halifax, Nova Scotia, Canada, B3J 2T9.

The Walton deposit, a past producer of barite-Pb-Zn-Cu-Ag (4.5 Mt $BaSO_4$, 0.5 Mt sulphide ore), is located within the basal Carboniferous Windsor Group of southern Nova Scotia. The deposit occurs within finely laminated, sideritized limestone (Macumber Formation) that overlies Lower Carboniferous (Tournaisian) clastics of the Cheverie Formation and black, organic-rich and sulphidic shales of the Horton Bluff Formation. The deposit is overlain by anhydrite and dolostone of the White Quarry Formation. Mineralization occurs as discordant and concordant massive barite and sulphide ore that replaces siderite and also infills fractures. Barite types include: (1) massive, fine-grained, equigranular, (2) coarse bladed with a radial texture, (3) euhedra intergrown with massive sulphide, (4) veinlets cutting massive sulphide, and (5) tabular, transparent crystals (≤6-8 mm) overgrowing sulphide ore and coated with bitumen. All barite types contain abundant, two-phase (L-V), aq FI; L-V-halite types are rare. In barite types 2 to 5, petroleum I (P-type) occur uniformly disseminated within barite or along crosscutting fracture planes. The P-type I have a variable assemblage: (1) L, (2) L-V (3) L-V-bitumen (B), (4) L-B; unidentified solids (sulphate?) occur. The presence of L petroleum and saline F in some I indicate heterogeneous trapping. Under UV microscopy, the L petroleum is whitish-blue to blue. Thermometric measurements for aq I indicate: (1) Th = 100-320°C with no discrimination of barite type, (2) sal of 8-28 wt.% eq. NaCl for types 1 to 4 barite, and 0-6 wt.% (meteoric water?) and 10-26 wt.% eq. NaCl for type 5 barite, (3) low Te values (to –70°C, mostly –35 to –50°C) indicate a NaCl-$FeCl_2$-$CaCl_2$-H_2O brine and hydrohalite-ice melting indicates NaCl/(NaCl + $CaCl_2$) ratios of 0.1 to 1. Two phase P-type I have Te values of 70-320°C, but narrower T ranges (10-20°C) are defined for groups of I. I similar in terms of type (aq, P-type) and thermometric data occur in barite from mineralized sites in the Macumber Formation along strike from Walton. Given the high Th values for the petroleum I, well above the oil window, it is suggested that petroleum generation was facilitated by the passage of heated brines (+300°C) through organic-rich sediments; both the Macumber and Horton Bluff formations are possible source rocks. The P-type I indicate the area cooled rapidly after petroleum formation (i.e., <0.5 Ma) and has not since been heated to ca. 150°C. A modern day analogue for generation of petroleum under similar conditions is the Guaymas Basin off California. (Authors' abstract)

KORMUSHIN, V.A., 1996a, The feeler for the thermal influence on fluid inclusions (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 488. Author at Scientific Society "Termobarogeochemist" (Kazakstan).

It is well known that the themal influence causes to move gas bubbles in FI (1). The nature of this motion is not studied yet. [not true - E.R.] The feeler (2) [i.e., Patent] had been contrived for the thermal pointed influence on microobjects within the eyeshot of microscope. The feeler is applied for study of FI in thin polished plates, petrographic and immersed preparations with no destruction. It has T register and may influence on fluid inclusions in the regime of regulated heating as well as create the gradient thermal flow of variable intensity at any horizontal direction. The device is of a little size and convenient in work. The application of the described above device will promote the additional information about physico-chemical features of ore forming F. [sic]

1. Roedder E. (1987). Fluid inclusions in minerals. / Russian translation by D.N. Khitarov / Moscow, Mir, v. 2, 560p.

2. Kormushin V.A. (1992). Author Certificate (USSR), No 1774240. [i.e., patent] (Author's abstract.)

KORMUSHIN, V.A., 1996b, The feeler for the thermal influence on fluid inclusions, (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 38. Author at Scientific Soc. of Ore-Forming Fluid Research in Inclusions of Minerals of Uzbekistan.

See previous item (E.R.)

KORMUSHIN, V.A., 1996c, The feeler for the thermal influence on fluid inclusions (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/ Shortcourse, Aug. 10-11, p. 2. (Note: this abstract was distributed at the I.G.C. Workshop/Shortcourse, but was not printed in the official 30th I.G.C. Abstracts volumes. E.R.) Author at Scientific Soc. "Termobarogeochemist" (Kazakstan).

See previous item (E.R.)

KORMUSHIN, V.A., 1996d, Precrystallization stage of ore deposit development in intrusive-overintrusive zone (IOZ) (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 2. (Note: this abstract was distributed at the I.G.C. Workshop/Shortcourse, but was not printed in the official 30th I.G.C. Abstracts volumes. E.R.) Author at Scientific Soc. "Termobarogeochemist" (Kazakstan).

The cooling of hardened granitic intrusives is accompanied by the decrease of granite volume and the rise of free space (pores, emptiness, cracks) in them. The estimation of this decrease is about 2% (Osipov, 1974), and 7-8% for the granites of ore deposits (Shcherba, 1961); Laumumulin, 1976).

The contractive nature of filling cracks and increased volume of the veins of ore deposits suppose the decreased density of initial magmatic M within the limits of ore vein development as compared with density of magma out of ore deposits.

This and other facts permit to conclude that an isolated magmatic F-saturated chamber (MFSC) existed in ledges of granitic massifs on places of future greisen- and quartz-vein ore deposits. A magma in MFSC crystallizes in hard framework of hardened intrusive with no influence of external P.

The configuration and dimensions of MFSC are defined by form of ledge, vertical thermal gradient of cooling intrusive and by a difference in T of "dry" and F-saturated magmas. A vertical span of MFSC exceeds several times the depth of vein spread. The granites below MFSC are not changes. A process of development is elucidated in report from the start of hardening of intrusive to complete formation of ore deposit. [sic] (Author's abstract.)

KORMUSHIN, V.A., 1996e, Precrystallization stage of ore deposit development in intrusive-overintrusive zone (IOZ), (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 43. Author at Scientific Soc. of Ore-forming Fluid Research in Inclusions of Minerals of Kazakhstan.

See previous item. (E.R.)

KORMUSHIN, V.A., 1996f, Fluid inclusions as instrument of exploration for endogenic mineralisation (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 50. Author at The Scientific Soc. of Ore Forming Fluid Research in Inclusions of Minerals of Kazakstan Thermobarogeochemist Soc.

A review of the activities of the Society. (E.R.)

KOTELNIKOVA, Zoya, 1996a, Reequilibration of synthetic fluid inclusions under hydrothermal conditions (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 568. Author at Inst. of Litosphere RAS, Russia.

Reequilibration of the FI under outer condition alteration may provide vagueness of PTX parameters estimation. Posttrapping processes study was carried out on brine and H_2O-CO_2 synthetic FIs (SFI) in quartz. Crystal with SFI was disposed into Pt-capsule with NaCl solutions and holded out 14-60 days at 300-700°C and 300-1500 bars. The SFI were studied before and after runs by microthermometry. The dislocational structure of the host crystal were studied carefully by the chemical decoration, selective etching and TEM-methods. SFI reequilibration after runs were detected: (1) stretch of SFI in crystals with high density of dislocation (up to 10^7-10^8/cm^2); (2) partially loss of density by leakage without daughters FI formation; (3) appearing of the fractures with daughters FI, the density of dislocation was 10^4/cm^2. Experimental data confirmed that dislocational channels take part in mass transport at T > 350°C. Compositions of FI may change by this way. The new-healing fractures with SFI have raw and unfinished dislocation structure. These structures was altered early during reequilibration runs. So, the results of the SFI reequilibration can not used directly to natural FI investigation. The correction procedure becomes necessary. (Author's abstract.)

See also adjacent item (E.R.)

KOTELNIKOVA, Zoya, 1996b, Synchronous synthesis of primary and secondary inclusions in quartz: Geokhimiya, 1996, no. 2, p. 128-133 (in Russian; Engl. abst.; translated in Geochem. Int'l., v. 34, p. 112-xxx).

P and S FI are characterized by different formation mechanisms, which some researchers believe has bearing on the consistency of I properties with that of the parent solution. Synthethic I modeling natural P and S I were produced in experiments under identical physicochemical conditions. Growth of quartz crystals on a seed and concurrent fracture healing were carried out in an autoclave under the conditions of a T gradient. The synthetic I in the zones of new-formed quartz (P) and in healed fractures (S) were investigated by microthermometric methods. The composition of all I correspond to that of experimental solutions. The Th of P and S I differed insignificantly. The experimental results obtained confirm the conformity of the properties of P I to those of parent solution. (Author's abstract)

KOTOV, N.V., MASLENIKOV, A.V, and **PORITSKAYA, L.G.,** 1996, The systems Au-Ag-Te-H_2O, Au-Ag-Bi-Te-H_2O and Au-Ag-Pt-Pd-Pb-Se-H_2O in isothermal and thermogradient conditions under elevated P-T-parameters (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 724. Authors at Dept. of Geol., State Univ., St. Petersburg, Russia.

KOTOV, N.V., PORITSKIY, M.S., PORITSKAYA, L.G., PUSHKAREV, Yu.D. and **CHEBOTARIOVA, N.V.,** 1996, Petrological and mineralogical features of a new copper-porphyry (with Au, Mo) deposit Borgulikan (Amur region, Russia) (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 617. First author at Sankt-Petersburg State Univ., Russia.

The Th of the FI of three generations in amethyst-like quartz is 400°C and more, and P=2200-500 bar. (From authors' abstract by E.R.)

KOVALENKER, V.A., MYZNIKOV, I.K., KOCHETKOV, A.Y. and **NAUMOV, V.B.,** 1996, PGE-bearing gold-sulfide mineralization in the Ryabinovyi alkaline massif, central Aldan, Russia: Geol. Ore Deposits, v. 38, p. 307-317. First author at Russian Acad. Sci., Inst. Ore Deposit Geol., Petrog. Mineral & Geochem., Staromonetnyi per, Russia.

This paper contains new data on the mineral composition of gold-sulfide veinlet disseminated mineralization associated with the Ryabinovyi multiphase ring-type alkaline massif in the Aldan region of southern Yakutia. The following minerals of platinum-group elements (PGE) were discovered and studied comprehensively: moncheite (platinum ditelluride) and erlichmanite (iridium- and ruthenium-bearing osmium disulfide). They are associated with three bornite varieties distinct in optical properties and in Me/S and (Cu+Ag)/Fe ratios, djurleite and anilite-digenite (silver-bearing minerals of the chalcocite group), carrollite (cobalt thiospinel), and tetrahedrite. PGE concentrations in igneous rocks, alkaline metasomatites, and gold-sulfide ores of different types were analyzed by neutron activation and spectrochemical methods. The study of FI shows that the gold-sulfide mineralization was formed at T of 400-160°C with the involvement of two types of F: (a) a high-P (4.0-7.3 kbar) CO_2-H_2O F with high sal and (b) an H_2O-rich F with low sal. Both F and metals participated in the formation of the PGE-rich gold-sulfide mineralization and derived from a deep source. (Authors' abstract by E.R.)

KOVALENKO, V.I., RYZHENKO, B.N. and **BARSUKOV, V.L.,** 1996, Experimental and computer modeling of greisenization in the system granite-SnO_2-H_2O-HCl: Geokhimiya, 1996, no. 6, p. 538-550 (in Russian, Engl. abst., translated in Geoch. Int'l., v. 34, no. 6, p. 483-XXX).

Equilibrium in the system granite-SnO_2-H_2O-HCl was modeled experimentally and on a computer. Three main factors were shown to control the formation of commercial tin concentrations: the chemical properties of aq F (HCl content and pH), the dynamics of F filtration through rock (ensuring that the weight ratio of reacting rock and F is above 0.1), and the presence of accessory cassiterite in the rock. (Authors' abstract)

KOVALENKO, V.I., TSARYEVA, G.M., NAUMOV, V.B., HERVIG, R.L. and **NEWMAN, S.,** 1996, Magma of pegmatites from Volhynia: composition of crystallization parameters determined by magmatic inclusion studies: Petrologiya, v. 4, no. 3, p. 295-309 [228-239?] (in Russian, translated in Petrol., v. 4, no. 3, p. 209-220). First author at Inst. of Geol. of Ore Deposits, Petrog., Mineral., and Geochem., Russian Acad. of Sci., Staromonetnyi per. 35, Moscow, 109017 Russia.

Recrystallized MI (relics of the pegmatitic magma) were studied in topaz from the chamber pegmatites of Volhynia, Ukraine. The MI homogenize into silicate M, which form glasses upon quenching. The composition of pegmatitic magma was determined by means of an electron and ion microprobe, along with the technique of local infrared spectroscopy. The major-element composition of this magma is close to that of a strongly fractionated ongonitic M poor in SiO_2 and rich in Al_2O_3 and F. The first direct data on the trace element contents of the homogenized MI indicate that the pegmatitic magma was rich in Li, Rb, Be, Sn, Nb, Cs, U, and Th, and poor in Ree, Zr, Sr, Ba, and Ti. These geochemical features, typical of ongonites, are intrinsic to the pegmatitic magma rather than caused by overprinted processes. The physicochemical parameters of the pegmatitic magma are as follows: liquidus T 650-700°C, solidus T 530°C, P of the water-dominated F 2.6 to 3.0 kbar, magma was composed of M, crystals, and F. The direct determination gave the following contents: 7 wt.% H_2O, 157 ppm CO_2, 5.1 wt.% F, 0.3 wt.% Cl. Judging by the dm and I textures, the MI are an approximate model of the chamber pegmatites. The assemblage of the dm association of the I is essentially the same as the rock-forming and accessory minerals of the pegmatite, a fact indicative of their crystallization from the pegmatitic M. Grains of the dm increase toward the contact with the F phase, and this provides evidence for the influence of F on the origin of the coarse-grained pegmatitic textures. The occurrence of syngenetic M, crystal, and FI suggest the boiling of the pegmatitic magma, from which all main and accessory pegmatite minerals crystallized. The magma was saturated in some minerals of Nb (columbite), Sn (cassiterite), W (wolframite), Be and U. The partitioning coefficient of Cl between the F and M was 33. The crystallization of pegmatitic magma can be approximated by the model for ongonitic magma, and the increase in Li, Rb, Cs, Sn, Nb, U, Th, H_2O, F, and Cl, and decrease in Ti, Zr, REE, Sr, and Ba contents were caused by fractional differentiation. (Authors' abstract)

KOWALSKI, B.S. and **KISSIN, S.A.,** 1996, Fluid inclusion studies of the Metalore-Golden Highway gold deposits, Geraldton-Beardmore district, northwestern Ontario (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 66-67. First author at 690 Dog Lake Rd., Thunder Bay, Ontario P7B 5E5 Canada.

The adjoining Metalore and Golden Highway deposits are hosted by rocks of Archean age.

Three stages of hydrothermal mineralization are distinguishable on the basis of mineralogy and cross-cutting relationships in both deposits. Stage 1 (Pre-ore) precipitated quartz and ankerite accompanied by hematite, pyrite, and chalcopyrite in small amounts. Stage 2 (Ore stage) alteration is characterized by silica flooding accompanied by clinochlore, ankerite, potassium feldspar, and minor tourmaline and sericite. Native gold, argentite, pyrite, and chalcopyrite were deposited at this stage. Stage 3 (Post-ore) alteration is in the form of quartz-calcite and muscovite-sericite veinlets.

FI in quartz and carbonate are of five types:

1) aqueous (L + V);
2) aqueous (L + V + S);
3) H_2O (L + V) + CO_2 (L);
4) H_2O (L+V) + CO_2 (L) + S; and
5) CO_2 (L+V)

Stage 1 mineralization at both deposits contains type 1 and type 3 FI. All I are of low sal with freezing point depression of °C or less, consistent with observed clathrate melting T of +10.4 to +10.6°C. Th = 221-230°C. These data suggest that a NaCl-H_2O F evolved to a NaCl-$CaCl_2$-H_2O F or that the –22°C eutectic T is observed only because of the small amount of L formed at the eutectic for NaCl-$CaCl_2$-H_2O.

Stage 2 (Ore-stage) FI are of type 3 and 4 at both deposits, where the solid (S) in type 4 is probably a poorly crystallized silicate and is unreactive. Te = –35°C; Tm ice = –0.1 to –8.9°C; Th = 266°C.

These data suggest that a low sal, $MgCl_2$-H_2O F accompanied gold deposition.

Stage 3 FI were of two populations at Golden Highway (Te = –56°C and ~ –15°C) but only one at Metalore: Tm ice = –0.9 to –8.3; Th 30 to 70°C.

The –56° C eutectic T are characteristic of the CO_2-H_2O system with negligible sal. [sic] The Th above +31.1°C indicate the effect of low T, H_2O-rich I. The aq I with Te clustering around –15°C at Golden Highway are difficult to explain, but Raman spectra of some of these reveal the presence of N_2, which may account for the variable eutectic T observed.

Estimates of densities of FI from the two deposits indicate that they were trapped on alternate sides of the locus of critical end-points. Thus, the FI record the onset of the breakdown of supercritical F in the CO_2-H_2O system, whereupon CO_2-rich V effervesced from H_2O-rich L.

The P as determined from P-V-T relations in the CO_2-H_2O system cluster around 1200 bars. The relatively low P together with change in style of mineralization from shear zone at Metalore to fissure vein at Golden Highway are suggestive of a transition from mesothermal to epithermal conditions. Moreover, the decomposition of supercritical F at the site of gold deposition may have been an important factor in its deposition as well as also marking the mesothermal-epithermal transition. (From authors' abstract by E.R.)

KOZLOV, A.V., LOKHOV, K.I., TOKAREV, I.V. and LEVSKY, L.K., 1996, Methodical aspects in analysis of gas composition in fluid inclusions within quartz crystals: Proceedings of the Russian Mineralogical Soc., v. 75, no. 3, p. 113-129 (in Russian; Engl. abst.).

The paper is focused upon peculiarities of interpretation for data on the G composition in FI within quartz crystals--the data obtained by the mass-spectroscopy method with thermic technique to release the G phase. The new way of analysis assumes to use, as specimens, that monolithic quartz samples with genetically homogeneous series of FI. A good agreement between calculated results and the real contents of G components has been proved on the base of the synthethic quartz analysis. The whole way of interpretation is demonstrated on the materials of mass-spectrograms for natural quartz crystal. (Authors' abstract)

KOZLOV, V.V., SMIRNOVA, S.K., SYROMJATNIKOV, N.G. and LEVIN, V.L., 1996 (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 68-70. First author at Inst. of Geol. and Geophys., Tashkent, Uzbekistan; e-mail (kozlov@rubin.gov.uz)

A small group of volcanic-hosted low-sulfidation gold deposits have an anomalous F evolution, e.g. high T jumps after the main stage of epithermal ore deposition. As a result, calc-silicate, skarn-like assemblages are developed after carbonate in quartz-carbonate-adularia gold bearing veins. Among these deposits are the Chadak, Kyzylcheku, Shkol'noe, and Bichanzor gold deposits. As a rule, not all veins contain high T calc-silicates (wollastonite, garnet, epidote), but only those located in the most heated parts of deposits, e.g. near an intrusion cupola (Chadak) and/or intramineralization granitoid dikes (Shkol'noe). Few FI and related stable isotope studies have examined the details of mineral-forming processes in the deposits.

The mineralogy of the vein systems is very complex. 156 ore and gangue minerals, including 12 new unnamed minerals, have been identified. However, volumetrically, quartz is the most abundant mineral in the veins. Other common vein minerals are calcite, adularia, wollastonite, andradite, actinolite, hematite, and ankerite. The most important Au- and Ag-bearing phases are electrum of highly variable fineness, acanthite and Ag-Cu sulfides (jalpaite, mckinstryite etc.).

The Chadak vein systems developed during four major mineralization events, which represent different fluid pulses of different T and composition:

I. The oldest mineralization, comprises Au-Ag ore bearing quartz-calcite-adularia veins surrounded by a quartz-sericitic alteration halo.

Microthermometry gave 272-364°C (av. 339°C) for P FI in early stage quartz. Boiling has been recognized in two samples. P have been estimated in the interval 75-115 bar. For the late stage quartz, the Th interval is 151-339°C (av. 263°C). Both types of homogenization, to L and to V phase, have been recognized. Liquid CO_2-bearing I (secondary?) also occur in the late stage quartz.

The mineral equilibria T range from 263 to 349°C (av. 306°C (24 tests)) for the first stage assemblages and from 192 to 292°C (av. 221°C (n=16)) for the second.

Atomic-absorption spectrometry, G chromatography and ion-selective electrodes were used for bulk FI analyses in 11 quartz samples, recalculated using water content in the samples. It was determined that F were the chloride-bicarbonate Ca>Na >K>Mg solutions of low sal (<5% NaCl eq.). They contain CO_2 (1.7-5.0mol.%), CH_4 (up to 0.2 mol%) and N_2 (0.02-0.04 mol%); H_2, C_2H_4 and O_2 have not been detected.

The oxygen isotope data combined with thermometry data show that ore-forming F had inputs of magmatic and meteoric components.

II. Skarn-like calc-silicate, Ag-Bi-Pb-Zn-Cu-bearing mineralization replaced most of the older gold-bearing quartz-calcite-adularia veins in the Pirmyrab and Aktash vein systems and also occurs in the northern part of the Guzaksai and Akbulak-Karakutan vein systems. Skarn occurrences in the vein systems. The skarn is composed of two major stage of formation: (1) an early wollastonite + garnet prograde stage and (2) a late quartz+actinolite+andradite+epidote+Fe-oxides+sulfides retrograde stage. Formation of the first stage minerals, notably wollastonite, is extensive at the quartz-calcite contacts. Calcite bands, blades, and lenses are usually replaced by wollastonite. Extensive recrystallization and partial redeposition of the older Au-Ag ores took place during both prograde and retrograde stages.

Primary FI in the prograde stage minerals have not been found. Small S polyphase (liquid(L)+vapor(v)+1-2 anisotropic dm) usually occur in early quartz near thin veinlets of wollastonite.

Six types of P FI occur in quartz and epidote of the retrograde stage:

(1) 5-phase FI: L+gas+NaCl+2 anisotropic crystals (up to 40 vol.%), Th = 372-470°C, Td = 410-531°C;

(2) 3-phase FI: L+gas+1 small anisotropic crystal, Th = 370-411°C;

(3) 3-phase CO_2-bearing FI: $L+CO_2(l)+CO_2(g)$, 10-15 mol.% CO_2, Th = 283-323°C;

(4) CO_2-rich low density FI: $CO_2(l)+CO_2(g)$ with a small L rim, CO_2 density 0.27-0.34 g/cm^3; Th = 277-312°C;

(5) NaCl-bearing FI: L+v+NaCl, 29-38 wt.% NaCl, Th = 201-245°C;

(6) two phase FI: L+gas, Th = 204-339°C.

The P, estimated from CO_2-bearing I, ranges from 250 to 450 bar.

III. Quartz-hematite-ankerite Cu-Bi-bearing mineralization comprise numerous quartz- hematite veins in the same vein systems. Only two-phase (L+v) P I occur in quartz crystals. The Th cluster between 150 and 272°C.

IV. Quartz-barite-fluorite Pb-Zn-bearing mineralization comprise the small veins and veinlets cross-cutting all previously deposited mineralizations as well as latest alkaline basaltoid dikes. FI Th ranges from 90 to 210°C.

Thus, the mineralogical and FI evidences suggest the invasion of high-T magmatic F into the buried mesoepithermal vein system and their progressive mixing with meteoric water and cooling. (From authors' abstract by E.R.)

KOZLOWSKI, Andrzej, LEACH, D.L. and **VIETS, J.G.,** 1996, Genetic characteristics of fluid inclusions in sphalerite from the Silesia-Cracow ores, Poland, *in* Prace Panstwowego Instytutu Geologicznego, Carbonate-hosted zinc-lead deposits in the Silesian-Cracow area, Poland, v. 154, p. 73-84. First author at Inst. of Geochem., Mineral. and Petrog., Faculty of Geol., Warsaw Univ., al. Zwirki I Wigury 93, 02-089 Warszawa, Poland.

FI studies in sphalerite from early-stage Zn-Pb mineralization in the Silesian-Cracow region (southern Poland), yielded Th from 80 to 158°C. 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 water-dominated medium, position of the I in crystals, features of SI, the I refilling phenomena, their formation on recrystallization of ores, and Th distribution in single fissure fillings were considered. The ore-forming F were L-hydrocarbon-bearing aq 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 sal from nul to about 23 wt.% NaCl eq. Three types of F were recognized, that mixed during ore precipitation: a) ascending F of low-to-moderate sal and high, b) formation brines of high sal and moderate Th, and c) descending waters of low sal and low-to-moderate Th. (Authors' abstract)

KREISBERG, V.A., 1996, Water transport in natural quartz at high temperatures (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 22. Author at Chem. Dept., Moscow State Univ., Moscow 119899, Russia.

The study of regularities of molecular transport in quartz opens new opportunities to model and reconstruct geological processes. Water diffusion coefficients have been determined by mass spectrometry from isothermal kinetic regularities of the intensities of ion current for the evolution of water impurities at T range 800-1400°C. (From author's abstract by E.R.)

KRIEGER, F.W., EADINGTON, P.J. and **EISENBERG, L.I.,** 1996, Rw [water resistivity], reserves and timing of oil charge in the Papuan Fold Belt: Proceedings of the Third PNG Petroleum Convention, Port Moresby, 9th-11th September, 1996, Buchanan, P.G., p. 407-416.

Mapping of palaeo formation water sal and oil charge history in the Toro and Iagifu sandstones, using newly deveoped techniques, supports a model of significant sal changes in Cretaceious and Jurassic aquifers throughout the evolution of the Papuan Basin.

Oil zone samples containing FI that simultaneously trapped both oil and water have sal exceeding 50,000 ppm, which is significantly higher than sal of 6,000-15,000 ppm for extant ground waters that reflect hydrodynamically-driven meteoric water recharge. This suggests high oil saturation immobilised and isolated irreducible water, shielding it from the introduction of present day low sal waters.

Aq FI in samples from the water zone also have sal exceeding 50,000 ppm, but in addition have sal as low as 2,000 ppm consistent with FI having trapped current formation water. Sal data indicate that the oil and water zones shared a similar hydrologic history until oil charge and that irrerducible water is a fossil water with sal higher than current formation water. This is consistent with oil charge having occurred before the current hydrodynamic flow of formation waters in the Toro sandstone and recharge with low sal meteoric water.

Tilted oil-water contacts, induced by hydrodynamic flow of ground waters are a feature of the Iagifu oil field in the Papuan Fold Belt. At Iagifu-7X three separate oil-water contacts have been delineated in the Toro sandstone. However, oil saturation data derived from oil-bearing FI suggest that oil was originally emplaced as one continuous column. This supports a model of oil charge preceding the establishment of hydrodynamic flow and is consistent with FI sal data.

Accurate determination of oil field reserves is a critical component of any development proposal. An important outcome of oil charge before the introduction of meteoric waters, and one supported by these new data, is that irreducible water within the oil column could be different to that below the oil-water contact. The sal data presented here identify a potentially significant error to reserves estimates that can be inadvertently introduced if the Rw of 0.4 ohm/m (at 50°C) for present day waters is used for irreducible water. In this investigation, samples of pristine irreducible water from oil-water I, and therefore linked to oil charge, have Rw values of about 0.08 ohm/m at 50°C. This results in significantly higher calculated oil saturation and oil reserves. (Authors' abstract)

KRIEGER, F.W., EADINGTON, P.J. and **LISK, Mark,** 1996, Calculation of resistivity of irreducible water for reserves estimation (abst.): AAPG Annual Meeting Abstracts, v. 5, p. 79. Authors at CSIRO, Div. of Petroleum Resources, Sydney, Australia.

A new FI technique that allows determination of the resistivity of irreducible water trapped during oil accumulation has been developed. The technique is directly applicable to problems associated with the evaluation of oil accumulations which arise when the sal and thus the resistivity of present day formation waters differ from those of the irreducible water trapped during oil accumulation.

It is possible by measuring the ice melting T of samples of formation water trapped during creation of three phase, oil-water-V I to calculate a sal for the irreducible water and thus calculate a resistivity to be used in reserves calculations. Sal of 71,000 to 85,000 ppm have been measured on three phase I in oil zone samples from the Papuan Foldbelt. Present day sal in the Papuan Foldbelt are about 10,000-12,000 ppm indicating that oil charge occurred before the present day hydrologic system was emplaced. Using sal data from three-phase I results in resistivity values of about 0.05 ohm/m for irreducible water while present day formation waters have a resistivity of about 0.3 ohm/m at formation T of 60°C.

Using the water saturation calculated from three phase FI sal data compared with using the water saturation from present day formation water results in an estimated 25% increase in reserves for oil fields studies in the Papuan Foldbelt. (Authors' abstract)

KRIVOVICHEV, V.G., BRUSNITSYN, A.I. and **ZAYTSEV, A.N.**, 1996, Absolute age and geochemical characteristics of granites from Verkhneurmiysk Massif, Amur Basin, Russian Far East: Geokhimiya, 1996, no. 2, p. 106-111 (in Russian; Engl. abst.)

Indexed under FI (E.R.)

KRZEMNICKI, M.S., HÄNNI, H.A., GUGGENHEIM, R. and **MATHYS, D.**, 1996, Investigations on sapphires from an alkali basalt, South West Rwanda: J. Gemm., v. 25, no. 2, p. 90-106.

A new deposit of sapphires in the Cyangugu district of SW Rwanda has been investigated. The sapphires are believed to have originated from a specific alkali basalt lava flow, extruded during the Tertiary extensional regime along the East African Rift. They exhibit mainly a deep blue colour, often showing so-called silk (I of hematite or rutile) or a slight milkiness possibly due to submicroscopic exsolution of these minerals. Studies of the I reveal the presence of Ti and Fe oxides, silicates, spinel, zircon and a complex Th-REE phosphate as solid I; the presence of CO_2 in FI was determined by microthermometric methods. (From authors' abstract by E.R.)

KUMAR, Ravindra, and **CESS, G.R.**, 1996, The role of fluid pathways and dehydration melting reactions in gneiss-charnockite transformations in the Kerala Khondalite belt of south India (abst.): 30th Int'l. Geol. Congress Abstracts, v. 2, p. 555.

Recent field and petrological studies in south India granulite belt have shown that F play a decisive role in the lower crustal processes and granulite growth. The change of F composition from H_2O-rich in amphiboloite-facies condition to CO_2-rich in granulite-facies condition has been well documented. F channelled mineral-F reactions [were] determinants in changing the metamorphic aspects of the rock within the lower crustal conditions (~20-30 km corresponding to P of 5-7 kbar and T of 750-850°C). This has emphatically suggested further that F were the powerful transient source of heat and pathways were the immediate zones of dehydration, partial melting and LILE depletion.

In this paper, movements, controls and effects of F related to dehydration of the host rock and the phenomena of dehydration melting noted in KKB are discussed. The study reiterates that various types of gneiss-charnockite transitions in rocks of broadly similar bulk compositions are due to varying types of F pathways and conduits, and between different bulk compositions due to varying aspect of F-rock interaction. The discreet patches of charnockites developed independent of any visible pathways are argued as cases of dehydration melting pockets. Spatio-temporal relations judged based on field and petrologic data document that granulite formation in south India was largely limited by the F transport mechanism and not to fundamentally different processes. (From authors' abstract by E.R.)

KURZ, M.D. and **KENNA, T.C.**, 1995, Helium isotopic evolution of Mauna Kea volcano: first results from the 1 km drill core: J. Geol. Research, v. xx, p. xx.

KUSÄU, Mustafa, 1995, Geological characteristics of Gölbasi (Isparta) epithermal arsenic mineralization: Geological Bulletin of Turkey, v. 38, no. 2, p. 31-xx.

Arsenic mineralization takes place within the Eocene aged Isparta formation which is flyschoid in character. The mineralization occurs as a main vein that is 38 m in length, 1-2 m in thickness with 1-50 cm thick stockwork veinlets developed around the main vein. It is found along a normal fault zone trending approximately N-S.

Realgar-bearing calcite veins have a simple mineral paragenesis which consists of coarse-grained calcite, realgar, barite, pyrite, and oripment.

Realgar-bearing calcite veins are product of epithermal (50-120°C) mineralization [FI data] related to Pliocene trachyandesitic-latitic Gölcük volcanism. (Author's abstract)

KYLE, J.R., JAMES, E.W. and **RUBIN, J.N.**, 1996, Magmatic-hydrothermal–epithermal transition in the Ertsberg (Gunung Bijih) district, Irian Jaya, Indonesia (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A333.

The world class Ertsberg District contains a wide range of deposit types including the supergiant Grasberg porphyry Cu-Au, an associated Au-enriched 'banded clay' zone in altered volcanic rocks, the Lembah Tembaga porphyry Cu, Cu-Au replacement zones in mixed carbonate-clastic wall rocks, and vertically zoned Cu (± Au) skarns near the Ertsberg pluton. FI studies indicate a change from high T, high sal F of 'magmatic' origin with characteristic Cu- and Fe-bearing dm in the porphyry deposits to lower T and sal F in distal deposits and late-stage minerals. Pb isotope data for sulfide minerals are similar to those of local igneous rocks but differ substantially from sedimentary wall rocks, confirming metal supply from magmatic sources. Pb isotope composition of Ertsberg skarn-hosted sulfides are less radiogenic than Ertsberg igneous rocks or sedimentary wall rocks, suggesting a deeper magmatic source. Pb isotope ratios of Big Gossan skarn-hosted sulfides suggest only minor addition of metals from sedimentary sources.

Synchrotron XRF analysis of FI in Grasberg stockwork quartz reveals high concentrations of Cu and Fe, as well as metals (Zn, Pb, Mn) that generally occur peripheral and paragenetically late with respect to Cu. Sphalerite and galena occur along the perimeter of the Grasberg contact zone, as well as in limestone-hosted veins. Mn occurs as pore-filling Mn-rich calcite and as Mn enrichments, with precious metals, in solution zones in limestones around the Grasberg perimeter. Precious metal distribution is particularly relevant to the epithermal connection. High fineness native Au occurs with bornite and chalcopyrite from both skarn- and intrusion-hosted deposits. Fineness of native Au hosted by a variety of sulfide minerals and quartz correlates positively with elevation in the Big Gossan skarn, suggesting greater epithermal character than other district skarns. Ag-rich alluvial Au grains in district drainages suggest epithermal sources, perhaps from the eroded Grasberg volcanic cover. (Authors' abstract)

LAJACK, D.J., McCANDLESS, T.E., RUIZ, J. and **GHAZI, A.M.**, 1996, Trace element determination in natural fluid inclusions by laser ablation ICP-MS: The Santa Eulalia Pb-Zn-Ag District, Sonora, Mexico(abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F788-F789, November 12, 1996. First author at Dept. of Geosci., Univ. of Arizona, Tucson, AZ 85721; e-mail (diamonds@ccit.arizona.edu)

FI in minerals preserve the composition of F responsible for hydrothermal ore deposition. The low detection limit of ICP-MS and the ability of UV lasers to ablate IR-transparent host minerals such as quartz makes laser ablation ICP-MS (LA-ICPMS) an ideal means of obtaining compositional information from FI. However, the very small size of FI (10-100 microns diameter) makes it difficult to obtain reproducible data by LA-ICPMS.

We selected quartz from the Santa Eulalia Pb-Zn-Ag carbonate replacement deposit for trace element analysis of entrained F. The P V-L I are several millimeters in diameter, allowing for multiple analyses of individual I. Elemental concentrations in the FI were determined using external standard solutions sealed in microcapillary tubes after the method of Ghazi et al (J. Anal. Mass. Spect. 9, in press). Data were obtained with the Finnigan-MAT SOLA and System 266 Nd:YAG laser that operates in the UV. Standards give reproducibilities (%RSD) of 5-13% and single natural I give RSD's of ~13% for Rb and 15-30% for Sr.

Preliminary data indicate Rb and Sr concentrations of ~1.5 ppm and ~0.5 ppm, respectively. In contrast, Zn and Ag concentrations are below detection limits (<10 ppb). The results suggest that, by the time hydrothermal F precipitate gangue minerals, nearly all Zn and Ag have been removed, whereas incompatible elements such as Rb and Sr are at relatively high levels in the last available F. This agrees with observations that quartz occurs late in the paragenetic sequence at Santa Eulalia. (Authors' abstract)

LAMB, J.B., 1995, A petrographic and fluid inclusion study of the Purple Vein and Post-Betze ore bodies, Carlin, Nevada: Unpub. M.S. Thesis, Univ. of Nevada, Las Vegas, 16 pp.

Referenced in Leonardson & Rahn, 1996, this volume. (E.R.)

LAMB, William, 1996, Carbonate - silicate equilibria in granulites: Implications for the formation of CO_2 rich fluid inclusions (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 71-73. Author at Dept. of Geol. and Geophys., Texas A&M Univ., College Station, TX 77843-3115, U.S.A.; e-mail (lamb@geopsun.tamu.edu)

Rocks metamorphosed to granulite facies P and T often differ from lower grade metamorphic rocks of similar bulk composition as peak metamorphic H_2O activities are much <1, and LILE contents are generally low. Various mechanisms have been proposed to explain the stabilization the granulite facies mineral assemblages, and they fall into one of three categories. (1) During partial melting granulites are generated as H_2O is partitioned preferentially into the M phase (Fyfe, 1973). Thus, melting can result in a F phase enriched in components with low solubilities in M relative to H_2O (e.g., CO_2), or the rock may contain no free F phase. (2) Metamorphism of "dry" rocks, such as certain igneous lithologies or rocks previously metamorphosed to high grades, may also produce granulites (Lamb and Valley, 1988). (3) Pervasive infiltration of large amounts of CO_2 (Newton et al., 1980; Touret, 1992), which dilutes H_2O produced by dehydration reactions, could stabilize granulite facies mineral assemblages. The presence of CO_2-rich FI in many granulites may be evidence of a CO_2-rich peak metamorphic F, and may support the CO_2-infiltration hypothesis. However, this assumes that the FI were formed at the peak of metamorphism, and that they have not undergone compositional changes during retrograde cooling and uplift.

Calculations are summarized indicating that carbonates are part of the peak granulite facies equilibrium mineral assemblage. In some cases, it may be possible that small amounts of carbonates were included within minerals (e.g., garnet) as they grew prior to attainment of peak P-T conditions, and that the carbonates were then armored against further reaction with other phases. In most cases, however, it is likely that the carbonates were formed after the peak of metamorphism. These carbonate grains are often intimately associated with CO_2-rich FI, and so these FI are also not part of the peak assemblage and, in many cases, were probably formed after the peak of metamorphism, perhaps during retrograde cooling and depressurization. (From author's abstract by E.R.)

LAMB, W.M., POPP, R.K. and BOOCKOFF, L.A., 1996, The determination of phase relations in the CH_4 - H_2O - NaCl system at 1 kbar, 400 to 600°C using synthetic fluid inclusions: Geoch. Cosm. Acta, v. 60, no. 11 (1996) p. 1885-1897. First author at Dept. of Geology and Geophysics, Texas A&M Univ., College Station, Texas 77843-3115.

Synthesis of FI in the CH_4-H_2O-NaCl system was accomplished by subjecting fractured quartz, along with known quantities of CH_4, H_2O, and NaCl, to a P of 1 kbar and T of 400, 500, or 600°C in sealed Au capsules. Under the elevated P-T conditions some of the fractures healed, trapping F as I. Microthermometric measurements conducted on the FI show that at 1 kbar and 400 to 600°C, there are very broad regions of F unmixing in the CH_4-H_2O-NaCl system. For those bulk F compositions that lie in the two-phase (i.e., immiscible F) field, the high density phase is enriched in NaCl, whereas the low density phase is enriched in CH_4. For any given bulk composition, the degree of NaCl enrichment in the high density phase increases, whereas the degree of CH_4 enrichment in the low density phase decreases, as T increases from 400 to 600°C. (Authors' abstract)

LARESE, R.E. and HALL, D.L., 1996, Studying petroleum migration with fluid inclusions: Results from hydrothermal burial simulation experiments (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 74-75. Authors at Amoco Tulsa Tech. Center, P.O. Box 3385, Tulsa, Oklahoma 74102-3385.

The documentation of hydrocarbon FI in rock samples is a powerful tool for tracking petroleum migration and evaluating the relationship between porosity evolution and hydrocarbon emplacement. However, in applying FI technologies to the understanding of petroleum systems, it is necessary to 1) insure that oil I document hydrocarbon migration rather than *in-situ* generation or inheritance of I to recycled clastic material; 2) correctly interpret textural relationships among I and diagenetic/microstructural features, and 3) understand the controls on petroleum I formation. We have combined observations from natural systems with the results of hydrothermal compaction and cementation experiments to begin addressing these problems. Several of these experiments are described below.

Sieved, angular Brazilian quartz grains were compacted at 360° or 150°C for 288 hr. with an effective stress (confining P - pore P) of 690 bars in the presence of a pore F consisting of 100% natural crude oil. The post-compactional sample displayed negligible P solution or quartz cementation but prominent physical compaction effects, notably an abundance of open microfractures and crushed quartz grains. In spite of the lack of intergranular cementation, and low total water content of the system, many microfractures generated during the experiment healed in the presence of the oil pore F, and these are decorated with oil I. The water content of the oil was determined prior to experimentation to be about 0.1 wt%; hence, even adding the adsorbed, atmospheric-derived water which inevitably coats the interior of the capsule and quartz grains, the total quantity of water within the system was small–far below that expected in virtually all natural systems. In addition to oil I along healed microfractures, other oil I appear to have exploited pre-existing aq I, apparently through breaching, flushing and refilling of old I cavities. This "exploitation" process appears to be energetically favored at lower T as compared to fracture healing.

Cementation experiments were conducted at 325°C and 690 bars of hydrostatic P using a combination of angular Brazilian quartz, rounded quartz sands and chlorite- or hematite-coated quartz sands, along with a variety of pore F ranging from 100% aq to 100% oil. Texturally P FI were rare within overgrowths and along dust rims, and no preference was noted for I formation along coated or uncoated grains. Exploitive oil I, however, were common within detrital portions of quartz grains. Some of the rare dust-rim I were incompletely sealed during the experiments, resulting in porous, permeable interfaces which were accessible to later pore F in spite of significant overgrowth formation. We were able to introduce oil into these dust-rim pores, thereby producing a false texture of P oil I along quartz overgrowth boundaries.

Brazilian quartz and Phosphoria shale (containing 20% total organic carbon) were mixed in a 9:1 ratio (giving a 2% total organic carbon bulk sample) and compacted in an aq pore F at 360°C with an effective stress of 690 bars for 336 hr. Generation of oil and G *in-situ*, and entrapment of this petroleum along healed microfractures resulted in oil and G I in quartz, most of which were not spatially related to the shale grains. The results of this and other experiments described above imply the following conclusions for interpreting petroleum I textures and distributions in natural rocks:

1) Oil I can form in the burial environment from oil-dominated pore F even in the absence of intergranular cementation and intense compaction, either by diffusive crack healing, or exploitation of old I cavities. The documentation of petroleum I formation mechanisms which do not rely on active cementation suggests that paleo-migration events are easier to document in the FI record than previously believed.

2) Textural criteria can be misleading. Exploitive I with no visible F entry points may be mistakenly identified as inherited or pre-overgrowth I. Infiltration and entrapment of oil along weak boundaries between detrital grains and overgrowths can cause deceptive timing relationships and inaccurate interpretations of reservoir quality at the time of migration.

3) Oil and G I can be formed through *in-situ* generation/entrapment processes in nominally non-source intervals if high TOC shale fragments are present. The resulting textures may not be distinguishable from migrated hydrocarbons; hence, thermal maturity must be taken into consideration when interpreting petroleum inclusion distributions. (Authors' abstract)

See also Hall, this issue. (E.R.)

LARROQUE, Christophe, GUILHAUMOU, Nicole, STEPHAN, J.F. and **ROURE, Francois,** 1996, Advection of fluids at the front of the Sicilian Neogene subduction complex: Tectonophysics, v. 254, no. 1-2 (1996) p. 41-55. Authors at Univ. de Nice-Sophia Antipolis, Inst. de Geodynamique, Valbonne, France.

The Sicilian accretionary prism shows a large, southward imbricated system of thrust sheets. Syntectonic dewatering of the sedimentary sections occurred along decollements and thrust faults, involving hydrofracture and mineralized vein development. Inside the deep sole thrusts (rooted in the basal decollement), hydrofractured blocks show different generations of syntectonic quartz and calcite extensional veins, while in the upper decollement only calcite veins have been observed. Both quartz and calcite veins show aq P FI of low sal, with low trapping T for F in the upper decollement (<60°C) and high Tt for F in the deep sole thrusts (up to 235°C in calcite, for a P near 0.8-1.0 kbar). We suggest that the frontal Sicilian prism supported localized transient F flow of deep freshwater sourced from two different origins: a shallow one for F now trapped in the upper decollement, and a deep internal origin (6-10 km minimum depth) for the hot F channelized along the basal decollement and now trapped inside the sole thrust of the Mt. Scalpello duplex area. (From authors' abstract by E.R.)

LAUGHLAND, M.M., 1996, A practical approach to reconstructing burial and temperature histories; an example from the Mobil O'Connell well, Piceance Basin, CO (abst.): American Assoc. of Petroleum Geologists Annual Meeting Abstracts. Author at Mobil New Exploration & Producing Ventures, Dallas, TX, US.

The O'Connell well was drilled about five years ago as part of a deep basin, tight G play. The well penetrates a Devonian through Paleocene age section of carbonate and clastic lithologies. Fifty-five m.y. old strap of the Wasatch Formation are exposed at the surface. Corrected measurements of bottom-hole T are as high as 240°C (464°F), and the present-day geothermal gradient is differs from 40°C/km (2.20°F/100') [sic]. Measurements of %RO increase semi-continuously from differs from 0.5% at 0.9 km subsurface depth (2,950') to differs from 6.0% at a total well depth of 5.6 km (18,422'). A multidisciplinary empirical approach was used to determine the magnitude and timing of maximum T and paleogeothermal gradient, as well as uplift and erosion, independent of numerical basin modeling. Apatite fission track analysis (AFTA) indicates that 1.36 km (4.460') of section were eroded beginning at differs from 5 Ma, which was synchronous with the timing of uplift of the Colorado Plateau. The timing of maximum T at differs from 27 Ma was determined using $^{40}Ar/^{39}Ar$ thermochronology and was synchronous with the timing of local igneous activity and mineralization of the Colorado Mineral Belt. Maximum paleotemperatures based on %RO and P corrected Th from FI in quartz veins are as high as 340°C (644°F), or about 100°C higher than present-day maximum T. Calculations of maximum paleogeothermal gradient equal differs from 52°C/km (3.03°C.100'). This multiple thermal indicator approach to the analysis of cuttings and core limits the number of possible burial and thermal history scenarios, thereby reducing much of the uncertainty in basin history reconstructions. Entering the empirically determined values for the magnitude and timing of maximum paleogeothermal gradient, as well as uplift and erosion, into numerical basin models yields a match between model predictions of %RO, and measured values, giving the reconstruction of burial and T history a stronger degree of confidence than a reconstruction based solely on the traditional industry approach of matching model fits of %RO to measured values. (Author's abstract)

LEACH, D.L., APODACA, L.E., KOZLOWSKI, Andrzej, LANDIS, G.P. and **HOFSTRA, A.H.,** 1996, Fluid-inclusion gases in sphalerite, galena, and dolomite from the Silesia-Cracow Zn-Pb district, Poland, in Prace Panstwowego Instytutu Geologicznego, Carbonate-hosted zinc-lead deposits in the Silesian-Cracow area, Poland, v. 154, p. 105-112 [?]. First author at U.S. Geological Survey, Box 25046, MS 973, Denver Federal Center, Denver, CO 80225 USA.

The G in FI from samples of sphalerite, galena, and sparry dolomite from ore deposits in the Silesian-Cracow zinc-lead district were determined by mass spectrometry. The results show that CO_2 is the major G in the FI with lesser amounts of CH_4. Samples of galena and sphalerite also commonly contain H_2S and short-chain hydrocarbon G. G in sphalerite and galena appear to contain two end-member compositions, CO_2-CH_2 and CO_2-H_2S bearing FIs. The apparent end member compositions could represent chemically distinct generations of FI trapped at different times or at least two distinct F present during ore formation. The presence of distinct FI G compositions is consistent with previous FI studies that show the presence of multiple F during ore deposition. The presence of multiple F in the ore-forming environment could lead to ore precipitation through processes of F mixing. (Authors' abstract)

LEACH, D.L., VIETS, J.G. and **GENT, C.A.,** 1996, Sulfur isotope geochemistry of ore and gangue minerals from the Silesian-Cracow Mississippi-Valley-type ore district, Poland, in Prace Panstwowego Instytutu Geologicznego, Carbonate-hosted zinc-lead deposits in the Silesian-Cracow area, Poland, v. 154, p. 105-112 [?]. First author at U.S. Geological Survey, Box 25046, MS 973, Denver Federal Center, Denver, CO 80225 USA.

Studies of the sulfur isotopic composition of ore and gangue minerals from the Silesian-Cracow Zn-Pb district were conducted to gain insights into processes that controlled the location and distribution of the ore deposits. Results of this study show that minerals from the Silesian-Cracow ore district have the largest range of sulfur isotope compositions in sulfides observed from any Mississippi Valley-type ore district in the world. The δ34S values for sulfide minerals range from +36 to –32‰ for the entire paragenetic sequence but individual stages exhibit smaller ranges. There is a well-developed correlation between the sulfur isotope composition and paragenetic stage of ore deposition. The sulfur isotopic data, ore mineral textures, and FI data are consistent with the hypothesis that F mixing was the dominant ore-forming mechanism. (From authors' abstract by H.E.B.)

LECUYER, Christophe, 1996, Effects of heating on the geochemistry of biogenic carbonates: Chemical Geol., v. 129, no. 3-4, p. 173-183. Author at Ecole Normale Superieure, Laboratoire des Sciences de la Terre, Lyons, France.

Heating and leaching experiments were performed on biogenic carbonates to investigate the behavior of trace elements during diagenetic and metamorphic processes. Samples were treated with H_2O_2 to remove organic compounds and heated in vacuum in the range 100-500°C. The effects of heating on the geochemistry of these shells were studied by measuring: (1) Cl-, SO_4^{2-}, Na^+, Ca^{2+}, Mg^{2+} and Sr^{2+} concentrations in leachates; and (2) the amount of CO2 released by the carbonate during heating experiments. No significant increase in Mg2+ and Sr2+ was observed in the leachates for heated samples relative to the blank reference which corresponds to the leaching of unheated samples. An enrichment in Ca^{2+} from 100 to 700 ppm is only detectable at high T (>400°C) as a consequence of a decarbonation process. The effects of heating on the chemistry are especially sensitive for the aragonite shells. Leachates were obtained on aragonites heated above 200°C and enrichment factors up to 100, 200 and 500 were measured for Cl^-, SO_4^{2-} and Na^+, respectively. Na^+ contents display a positive correlation with T whereas Cl- ion contents are rather constant. The source of Cl- is probably the FI which represent differs from 1 wt.% of the shell. Na contents in samples treated with H_2O_2 are lower than those untreated, this result suggests that a fraction of Na+ is linked to the organic matrix of the shells. On the basis of increasing Na^+ and SO_4^{2-} contents with peak T, another fraction of Na^+ and SO_4^{2-} ions is considered associated with defects in the crystal lattice. These ions are thus expelled during the heating of samples which is responsible for the annealing of defects and the observed progressive aragonite-calcite inversion. Mass-balance calculations using the chemistry of shell fragments reveal that heating and leaching of aragonites above 200°C are responsible for reductions by up to 70%, 55%, and 25% of initial Cl-, SO_4^{2-} and Na^+ contents, respectively. Sr^{2+} and Mg^{2+} ions are more stable in the crystal structure of the biogenic carbonates and are probably more reliable indicators of paleoenvironment than SO_4^{2-}, Cl^- and Na^+ ions. In skeletal carbonates, especially aragonites, the abundance of the latter elements can be strongly modified when they are exposed to T of only 200°C and leached by low-sal F. (Author's abstract)

LEDESERT, Beatrice, JOFFRE, Janie, AMBLES, Andre, SARDINI, Paul, GENTER, Albert, and **MEUNIER, Alain,** 1996, Organic matter in the Soultz HDR granitic thermal exchanger (France); natural tracer of fluid circulations between the basement and its sedimentary cover: J. of Volcanol. and Geothermal Research, v. 70, no. 3-4 (1996) p. 235-253. Authors at Univ. de Poitiers, Poitiers, France.

Organic matter has been observed in cores of the Soultz-sous-Forets granite (Alsace, France) at depths between 2158 and 2160 m, in a highly fractured and altered zone. The soluble organic matter analyzed by GC-MS is composed of aliphatic acids, n-alkanes with a bimodal C18 and C24-C25 centered distribution, alkylbenzenes and aromatic acids. Organic compounds in the granite would either originate from a single source (immature sediments) or from two sources (immature sediments and migration of the Pechelbronn oil). No real evidence was found to prove which hypothesis is the best one. The presence of organic matter in the granite shows the importance of F flows between the sedimentary cover and the granitic basement through major fractures. (Authors' abstract by E.R.)

LEE, Der-Chuen, HALLIDAY, A.N., DAVIES, G.R., ESSENE, E.J., FITTON, J.G. and **TEMDJIM, Robert,** 1996, Melt enrichment of shallow depleted mantle: a detailed petrological, trace element and isotopic study of mantle-derived xenoliths and megacrysts from the Cameroon Line: J of Petrol., v. 37, no. 2, p. 415-441. First author at Dept. of Geol. Sci., Univ. of Michigan, 2534 C.C. Little Bldg., Ann Arbor, MI 48109-1063, USA.

Major element, trace element and Sr-Nd-Pb isotopic compositions of ultramafic xenoliths and megacrysts from the continental Cameroon line provide evidence for metasomatism of the upper-most lithospheric mantle by enriched M during the Mesozoic. Mass balance calculations suggest that the M responsible for the most recent enrichment of the lithosphere were probably the product of small degrees of partial melting associated with the earliest stages of the breakup of Pangea. (From authors' abstract by E.R.)

LEE, Mingchou, 1996, K/Ar dating of illite in understanding fault-related diagenesis (abst.): American Assoc. of Petroleum Geologists 1996 Annual Meeting Abstracts, v. 5, p. 81. Author at Mobil Exploration and Producing Technical Center, Dallas, TX, US.

K/Ar dating of diagenetic illite provides quantitative information regarding the timing of major geological events within sedimentary basins. K/Ar data, however, have to be evaluated in the framework of sedimentological, mineralogical and structural configuration. Stable oxygen isotopes of illite and hand-picked quartz cements and FI show hot, high sal (>20 wt.%), $CaCl_2$-rich F were involved in these diagenetic processes, suggestive of hydrothermal origin. Our data and other published data show that these processes may be very common in rift settings, and significant reservoir heterogeneity could be generated by fault-related diagenesis. (Author's abstract)

LEE, Woh-jer, and **WYLIE, P.J.,** 1996, Liquid immiscibility in the join $NaAlSi_3O_8$–$CaCO_3$ to 2.5 GPa and the origin of calciocarbonatite magmas: J. of Petrol., v.37, no. 5 (1996) p. 1125-1152. Authors at Div. of Geological and Planetary Sci., California Inst. of Technol., Pasadena, California 91125.

Field evidence from intrusive and effusive carbonatites supports the existence of calciocarbonatite magmas. Published experimental evidence in the model system Na_2O–CaO–Al_2O_3–SiO_2–CO_2 indicated the formation of nearly pure (99%) $CaCO_3$ immiscible L from a carbonated silicate L. There is no experimental evidence for immiscible calciocarbonatite magmas with >80% $CaCO_3$, and calcite lapilli cannot be formed from 99% $CaCO_3$ magmas. Sovites are surely cumulates. (From authors' abstract by E.R.)

LEI, Liangqi, 1996, The physicochemical condition of mineralization of Hesan Pb–An [Ag] deposit, Guangxi: J. of Guilin Inst. of Tech., v. 16, no. 3 (1996) p. 272-276. (in Chinese with Engl. abst.) Author at Dept. of Resource Engineering, Guilin Inst. of Tech.

I in minerals and galena–sphalerite geothermometer shows that the minerogenetic condition of Hesan ore deposit is both middle-high T (203-420°C) and middle-low P. And with the mineralization proceeding, the T and P dropped, while the hydrothermal density rose, the moderate sal (5.7-11.5% NaCl) was almost unchanged. At the main minerogenic stage, it might be that the hydrothermal solution boiled and the volatile component was lost, therefore the minerogenic materials were concentrated and formed ore deposit. It may be the main reason why Hesan ore deposit is large and concentrated, but the alteration of surrounding rock is weak, and the quantity of gangue minerals is small. (Author's abstract)

LEITCH, C.H.B., 1996, Preliminary petrographic, geo-chemical and fluid inclusion studies of the Fors deposit, southeastern British Columbia (82G/5W): British Columbia Min.Resources Div., Geological Fieldwork 1995, Paper 1996-1, p. 95-105.

LEONARDSON, R.W. and **RAHN, J.E.,** 1996, Geology of the Betze-Post gold deposits, Eureka County, Nevada, in Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 61-94. Authors at Mine Geol. Dept., Barrick Goldstrike Mines, Inc., P.O. Box 29, Elko, NV 89803.

The Betze-Post gold deposits on the Carlin Trend in northeastern Nevada constitute one of the largest concentrations of gold mineralization currently recognized in the western hemisphere.

Betze-Post mine rocks were subjected to four periods of pre-gold mineralization stress and three periods of post-mineralization stress.

P high-angle faults in the Betze-Post pit area strike north-northwest and dip both east and west. Secondary faults strike east to east-northeast with north dips. Gold mineralization occurs where S and P faults intersect, and both fault sets allowed hydrothermal F to flow long distances from major feeders. Secondary access was developed at fault intersections with and along anticlines, in favorable decalcified horizons like the sedimentary breccia unit of the lower Popovich limestone, and in zones of collapse breccia.

Mineralization in the Betze and Deep Post deposits occurs in vertically stacked ore zones that are separated by impermeable barriers within the Betze and Post anticlines. Dissolution of limestone between barriers formed stacked stratified collapse breccias forming conduits for hydrothermal F permitting widespread decalcification of limestone and subsequent gold mineralization.

Five stages of pyrite have been identified at the Betze-Post deposits. Early stages were barren. Early hydrothermal pyrite of the third pyrite stage is commonly coated with micron-sized gold-bearing hydrothermal pyrite of the fourth pyrite generation. Post-ore pyrite, possibly related to hydrothermal system contraction, is barren.

During hydrothermal activity, the rock column in and around the deposits was decalcified and lost about 100 feet of thickness. Compression following collapse of the hydrothermal system caused extensive deformation that impacted the upper 150 feet of the Popovich limestone in the ore deposits.

We believe that 40-Ma mineralization at Goldstrike occurred at a depth of about 3 km. The mineralization is spatially related to small porphyry intrusions that we speculate were apophyses above a main magma mass that intruded to a depth of 5-6 km below the paleosurface. (From authors' abstract by E.R.)

Work on FI from Meikle (Lamb, 1995) and Carlin (Kuehn and Rose, 1995) indicates deposition of pre-ore quartz and pyrobitumen from F with sal of 11-20 wt.% NaCl eq. and average Tt of 230-240°C (Lamb, 1995) and 155°C (Kuehn and Rose, 1995). The organic material and some of the F was probably derived from the host limestones that contain 0.2-0.45% organic matter and thin bioclastic interbeds (Kuehn and Rose, 1995). Honey yellow to amber sphalerite (Lamb, 1995) and barite that are slightly older than pyrobitumen veinlets were precipitated from F with sal of 9-20 wt.% NaCl eq. and Tt of 200-230°C (Kuehn and Rose, 1995). These F may represent basin brines that were driven away from Jurassic intrusives like the Goldstrike intrusive complex prior to gold mineralization (Kuehn and Rose, 1995).

FI from the Deep Post deposit indicate the presence of main gold stage F with minimum Tt of 140-275°C with modes at 150-180°C and 200-210°C (Lamb, 1995). Two sal modes of 2-4 and 6-7 wt.% NaCl eq. from possible ore-related F combined with two T modes and both H_2O-rich and CO_2-rich F argue for the mixing of two F as a mechanism for ore precipitation as proposed by Kuehn and Rose (1995) at Carlin. Following this interpretation, hotter, deep-seated CO_2-rich and possibly gold-bearing F from a probable magmatic source rose into the Post anticline from an over-pressured environment to mix with normally pressured unevolved meteoric F in permeable lower Popovich limestone debris flows and fossil hash beds above the Roberts Mountains Formation. (From text, p. 93 by E.R.)

LEPEZIN, G.G. and **OSORGIN, N.Y.**, 1994, Natural cordierite outgassing kinetics: determination of H_2O diffusion coefficients under isothermal conditions: Doklady Ross. Akad. Nauk, v. 339, no. 5, p. 658-661 (in Russian translated in Trans, Russian Acad. Sci., Earth Sci. Sect., v. 342, p. 176-182,1996. Authors at Inst. for Mineral. and Petrog., Siberian Div., Russian Acad. of Sci., Novosibirsk.

See FIR, v. 28, p. 84 (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, 1995, v. 342, no. 1, p. 92-94 (in Russian, translated in Trans. (Doklady) Russian Acad. Sci., Earth Sci. sect., v. 344, p. 171-181, 1996). Authors at Inst. for Mineral. and Peterog., Siberian Div., Russian Acad. of Sci., Novosibirsk.

LEROUX, Hugues and **DOUKHAN, J.C.**, 1996, A transmission electron microscope study of shocked quartz from the Manson impact structure: Geol. Soc. of America Special Paper, v. 302, p. 267-274.

Indexed under FI (E.R.)

LEUNG, I.S., TAYLOR, L.A., TSAO, C.S. and **HAN, Zhuguo**, 1996, SiC in diamond and kimberlites: implications for nucleation and growth of diamond: Int'l. Geol. Review, v. 38, p. 595-606. First author at Dept. of Geol. and Geog., Lehman College, The City Univ. of New York, Bronx, NY 10468.

LEVASSEUR, R. and **SAMSON, I.M.**, 1996, Fluid inclusion characteristics of REE-Y-Nb pegmatites, South Platte district, Colorado (abst.): Geol. Soc. Canada/ Mineral Assoc. Canada Joint Annual Meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A56. First author at Dept. of Earth Sci., Univ. of Windsor, Windsor, ON, N9B 3P4.

The South Platte district, located in the northern granitic portion of the 1.01 Ga Pikes Peak batholith, contains over 50 pegmatites, many of which contain significant enrichments of fluorite, REE, Y and Nb. Many of the pegmatites have a well-developed concentric zonation, in which rare-element minerals occur in fluorite-albite-rich units, typically at the contact between the intermediate and core zones. The fluorite-rich assemblages occur as massive pods and as veins and patches in intermediate zone feldspar. In the samples studied, these S assemblages are dominated by green, white and purple fluorite (including yttrofluorite), albite and quartz with lesser, variable amounts of hematite, samarskite, allanite, bastnaesite, monazite, and muscovite. Laser-induced fluorescence of REE in fluorite indicate that REE contents of fluorite decreased through time from green to white to purple. This is consistent with principal association of rare-element minerals with purple fluorite.

PI in fluorite and quartz from the hydrothermal units are low sal (<4 eq. wt.% NaCl) L-V and L-V-solid I. The latter contain variable amounts of trapped, birefringent solids. Similar solid I in the host fluorite include bastnaesite and synchysite, indicating that these F were responsible for REE transport and deposition. These I have a wide range of Th from 137 to 363°C. Secondary LV I in hydrothermal minerals include higher sal LV I and halite-bearing I (8-30 wt.%). LV and LVH I occur as SI in core quartz. Sal and densities of these I are similar to the SI in fluorite indicating that the formation of the quartz core post-dated fluorite deposition. Rare, halite-sylvite bearing PI occur in core quartz. Aq-carbonic I are present in some samples, particularly in the Luster 1 1/2 pegmatite, which does not contain any fluorite or REE minerals. These data indicate that the fluorite and REE minerals were deposited from low sal, CO_2-poor F, possibly prior to crystallization of the quartz core. Subsequent crystallization of the residual M resulted in the evolution of F with higher salt and possibly CO_2 contents. (Authors' abstract)

LEVIN, V.Y., ANTONOVA, L.G., ZOLOEV, K.K., KATKALOV, A.V., MORMIL, S.I. and **SAMSONOV, A.V.**, 1995, Geology and ore formation at the Yuzhno-Shameiskoe molybdenum deposit, Middle Urals, Russia: Geol. Ore Deposits, v. 37, p. 464-472. First author at AO Uralskaya Geol. Emochnaya Expeditsiya, Ul Vainera 55, Sverdlovsk 620219, Russia.

The Yuzhno-Shameiskoe molybdenum deposit belongs to the tungsten-molybdenum type and is associated with the Malyshevsk granite massif of Early Mesozoic age (240-220 Ma). The deposit is a steeply dipping linear fluorite-quartz veinlet stockwork (1.2 × 0.2 × 0.26 km), which is situated at the eastern exo- and endocontacts of the granite massif and located along a buried additional crest of the contact surface. Around the crest, the host apovolcanogenic amphibole schists of Early Ordovician are heavily biotitized (+ epidote + calcite) and cut by numerous granite apophyses. Ore-bearing granites are altered with feldspar granulation and poor muscovitization. Ore-bearing granites with quartz veinlets and ore-free homogeneous granites have similar concentrations of silica and total alkalies. Two ore types are distinguished in the deposit: (a) apogranitic and (b) complex apogranitic-metasomatic in the exocontact of granites. The ore mineralization is veined and, less commonly, disseminated. The ore veinlets are composed of quartz, fluorite, pyrite, and molybdenite. Molybdenite contains 1.26% W, 40-60 ppm RE, and 15 ppm Bi. Rare grains of scheelite occur in ores of the exocontact. Several discrete thin ore bodies with scheelite mineralization are revealed at the southeastern flank of the deposit. The specific features of the molybdenum mineralization and composition of ore-bearing granites can best be described in the context of the model of liquation of granitic M that is rich in F and favorable for molybdenum concentration. (Authors' abstract)

LEWIS, Stephanie and **HOLNESS, Marian**, 1996, Equilibrium halite-H_2O dihedral angles: high rock-salt permeability in the shallow crust?: Geology, v. 24, no. 5 (1996) p. 431-434. Authors at Dept. of Geol. and Geophys., Univ. of Edinburgh, West Mains Rd., Edinburgh EH9 3JW, UK.

Shallow deposits of halite are well known to be impermeable to brines and hydrocarbons, yet recent studies of deeply buried salt point toward considerable water-halite interaction. We have resolved this apparent paradox via experimental determinations of the dihedral angle for the (static) halite-H_2O system at T of 20 to 300°C and pressures from atmospheric to 2 kbar. The halite-brine dihedral angle, which controls pore-F connectivity and hence permeability, is found to be a sensitive function of both T and P. In sedimentary basins with normal geothermal gradients, halite bodies at depths exceeding 3 km will contain a stable interconnected brine-filled porosity, resulting in permeabilities comparable to those of sandstones. Our results explain recent observations of major salt-F interactions at depth, and suggest that deep-rooted salt diapirs may act as conduits for basinal formation water. They also have important implications for the flow of brines around heat-producing canisters of high-level nuclear waste buried in natural rock salt. (Authors' abstract)

LI, Chunxi, LI, Yigui, and **ZHANG, Ronghua,** 1996, A new equation of state to predict densities of aqueous NaCl at high temperature and pressure by perturbation theory (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 34. First author at Dept. of Chemical Engineering, Tsinghua Univ., Beijing, P.R. China, 100084.

LI, Cunyou and **SHI, Lida,** 1996a, The application of α-β peak and other parameters produced by the decrepitation of quartz in deciding the stripped degree of gold vein and searching new deposits, (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 1. (Note: this abstract was distributed at the IGC Workshop/Shortcourse, but was not printed in the official 30th IGC Abstracts volumes.) Author at Shenyang Inst. of Geol. and Mineral Resources, CAGS, P.R., China.

The test for quartz from a gold deposit in Hebei Province of China by an improved decrepitation instrument gives much information for mineralization and exploration. The results of test are as follow: when quartz heated to 573°C, α quartz will be transformed into β quartz some samples may produce α-β peaks whose characters and appearance rates are related to the minerogenetic location, which can be used to decide the stripped [sic] degree of veins. A parameter-depth model of α-β peak has been built for the mined veins, thus the stripped degree and gold resources of unknown similar veins are evaluated. The Td of the head peaks is related to the gold content. The lower the Td value is, the higher the gold content is, which is useful in evaluating the gold content of quartz vein. The results have been verified in some large gold deposits in Shandong Province of China. Decrepitation activity (h) is related to the structural stress, the gold content of vein and the origin of quartz. The h-values of quartz that was rich in gold and suffered multiple structural movements and was formed mainly by replacement are lower. The chief ore bodies are dispersed mostly in the negative abnormal of evaporation halo formed in h-values. The Carlin-type gold deposits in Guangxi of China are also with such characters. The form and type of the decrepitation curve, the height and ratio of the main decrepitation peak, and derived hydrothermal activity frequency coefficient (PC) and intensity coefficient (Qd) can all be used to predict mineral deposits. Some veins have been found based on the above-mentioned information in the forecast area. (Authors' abstract)

LI, Cunyou and **SHI, Lida,** 1996b, The application of α-β peak and other parameters produced by the decrepitation of quartz in deciding the stripped degree of gold vein and searching new deposits, (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 42. First author at Shenyang Inst. of Geol. and Mineral Resources, CAGS, China.

See previous abstract (E.R.)

LI, Hui, WANG, Zhinong, YUAN, Yuexiao, LI, Deliang, LOU, Yuansheng, JIANG, Renyi, WANG, Zhengyang, ZHANG, Xiuhong, WANG, Liguan and **FANG, Nan.** 1996, Models of gas haloes, ion haloes and their superimposed haloes of inclusions in gold deposits (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 53-55. First author at Inst. of Geophys. and Geochem. Exploration, Geophys. Exploration Bureau, MMI, Booding, 071051;2 Beijing Inst. of Geol. for Mineral Resources, CNNC, Beijing, 100012.

There are obvious haloes around the following gold deposits: Denggezhuang and Sanjia gold-bearing quartz veins in Mu-Ru gold ore belt, Xincheng gold deposit of altered rocks type and Linglong quartz vein type gold deposit in Zhao-Ye gold ore belt. Complex models of the various types of haloes are useful in prospection for gold deposits.

Ore bodies have been found in one of three prospecting target regions presented by us. (From authors' abstract by E.R.)

LI, Jianren, 1996, 100 kyr paleoclimate record from salt cores, Death Valley, California: Doctoral thesis at SUNY at Binghamton, Binghamton, NY, US. 239 pp.

Indexed under FI (E.R.)

LI, Jingyun, NIE, Weiqing, and **ZHANG, Weigen** 1996, Geological characteristics of the Baoziwan gold deposit, Shanxi Province: Mineral Deposits (Kuangchuang Dizhi), v. 15, no. 3 (1996) p. 216 (in Chinese; Engl. abst.). First author at No. 3 Geological Exploration Bureau, Ministry of Metallurgical Industry, Taiyuan 030002.

The Baoziwan gold deposit is a cryptoexplosion breccia pipe type hydrothermal gold deposit genetically related to Late Hercynian intermediate-acid subvolcanic rocks, with the parent rock being adamellite porphyry. During the activity of adamellite magma, intense cryptoexplosion took place, forming a steeply southward dipping breccia pipe 1000 m in length, 100 m in width, and over 400 m in downward extension. Gold orebodies occur in the contact zone between the breccia pipe and its wall rocks. Metallogenic T [FI data] are mainly 320~230°C, sal of ore-forming F are 9.2~13.2 wt% NaCl, pH values of ore F are 4.25~4.91, Eh values are -0.459~-0.598, and R (reduction parameters) are 0.045~0.132. G components of I consist mainly of H_2O and CO_2, and also contain H_2, N_2, CH_4 and CO, with CO_2 / H_2O ratios averaging 0.039; in L phase, cations are mainly Na^+ and K^+, whereas anions are mainly SO_4^{2-} and Cl^-. As for hydrogen and oxygen isotopic compositions, $\delta^{18}O$ and δD are 10.0‰~14.9‰ and -64‰~-90‰ respectively. $\delta^{34}S$ values of sulfide minerals are -3.2‰~+1.2‰, with the maximum difference being 4.4‰. Up until now, scores of similar breccia pipes have been discovered in northern Shanxi as well as along the border area between Shanxi and Inner Mongolia. These pipes almost unexceptionally contain gold-silver mineralizations, among which some have proved to be large-sized silver deposits, and some have turned out to be medium-sized gold or gold-silver deposits. It is worth noticing that breccia pipes along the Shanxi-Inner Mongolia border area and north of this area are mainly related to Hercynian intermediate-acid subvolcanic rocks, whereas those in northern Shanxi to the south of this area are merely associated with intermediate-acid subvolcanic rocks. (Authors' abstract)

LI, Jun, 1996, On genetic mechanism of celestite deposits in Triassic salt-bearing series of Hechuan, Sichuan (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 681. Author at National Geological Exploration Center of Building Materials Industry, China.

Most deposits are bedded or quasi-bedded, and roughly concordant with stratification, others are in the form of vein-type (or net work) traversing the wall rocks. S- and Sr-isotopic analyses of celestite and gypsum confirmed that the possible source of the Sr and S would be sea water of Early Triassic. Th and Td of LI in celestite, their chemical compositions and paragenetic association of minerals were measured. Compositions of L I in celestite suggested that: Na^+/Cl^- ratio of hot brine ranged from 0.17 to 0.67, the Na^+/K^+ ratio ranged from 0.67 to 0.93. The Ca^{2+}/Mg^{2+} ratio ranged from 4.85 to 8.00. Most of celestites were formed by replacing dolomites. The main changes are as follows: (1) Aragonite transformed into calcite. (2) Dolomitization. (3) Degypsification. (4) Replacement ore of celestite and dedolomitisation. Dedolomitisation is the key of formation of these deposits. The author considers that the deposit would be "sedimentary-reworked" celestite deposit, and suggests the further exploration targets in this and other provinces. (From author's abstract by E.R.)

LI, Li, 1996, The study on fluid inclusions of Jinya gold deposit in north-western Guangxi, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 742. Author at Shenyang Inst. of Gold Tech., China.

Jinya, the micro-fine grain disseminate type of gold deposit, is mainly distributed in the middle of west-northern district of Fengshan county, Guangxi, China. There are lots of FI in quartz, calcite and dolomite. They are tiny and clear. Generally, the size of the I are less than 8 µm, most are 2~5 µm and few less than 1 µm. The I appear white, transparent, irregular, some I distributed along quartz edge of crystal and calcite crystal face.

The forming T of FI in the deposit lies in 130~310°C. The first T peak located in 200°C~280°C, the second peak located in 160°C~180°C. Besides the water, K^+, Na^+, Ca^{2+}, Mg^{2+} and some cations and F^-, Cl^-,HCO_3^-, SO_4^{2-} as well as some anions are found in the F. Because of $Na^+>K^+$, $Ca^{2+}+Mg^{2+}>Na^++K^+$, HCO_3^-/Cl^- is more than 2, SO_4^{2-}/Cl^- less than 0.5, the minerogenitic F is mainly from underground water. There are lots of CO_2 and CH_4 in the G. (From author's abstract by E.R.)

LI, Ning and **KYLE, J. R.,** 1996a, Alluvial fan/fan delta facies controls and genesis of the Jinding Zn-Pb-Sr deposit, Yunnan, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 736. Authors at Dept. of Geological Sci., The Univ. of Texas at Austin, Austin, TX, U.S.A.

The Jinding deposit consists of two types of orebodies: the upper sandstone-hosted concordant orebodies and the lower carbonate-hosted discordant orebodies. The concordant upper ore zone is in the fan delta sandstones, whereas the irregular-shaped lower discordant ore zone is in alluvial fan breccia. Fine-grained sphalerite, galena, pyrite, and marcasite are the major sulfide minerals within the fan delta sandstones; a substantial amount of massive pyrite and celestite occurs in the alluvial fan breccia.

A preliminary FI study indicates that ore-forming solutions were basinal brines that contained hydrocarbons. A substantial amount of bitumen also occurs in both types of orebodies. P oil I and bitumen in the Jinding deposit suggest a genetic link between maturity of the Lanping-Simao basin and Zn-Pb mineralization. FI data indicates that F responsible for calcite cementation were similar to the ore-forming solutions. Furthermore, drill core logging shows a positive correlation between degree of sandstone cementation and mineralization in the boundary area of mineralized and unmineralized sandstones, demonstrating that F for calcite cementation were moving F fronts of ore-forming solutions.

The working genetic model for the Jinding deposit proposes that the ore-forming brines migrated from depth along the Pijiang fault conduit during burial diagenesis of the Yunlong Formation. The mineralizing F partially replaced carbonate blocks and matrix within the alluvial fan facies near the fault and replaced calcite cement within the fan delta sandstones, accounting for the two orebody types. (From authors' abstract by E.R.)

LI, Ning and **KYLE, J.R.,** 1996b, Depositional controls of Tertiary sandstone-hosted Zn-Pb-Sr mineralization at Jinding, Yunnan Province, China (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A211. First author at Dept. of Geological Sci., Univ. of Texas at Austin, Austin, TX 78712.

The Jinding deposit is probably the world's youngest major sediment-hosted Zn-Pb deposit and is hosted in coarse continental clastics, an environment commonly regarded as unproductive for metal resources. Furthermore, in contrast to 'sandstone-type Pb deposits', Jinding is dominated by Zn and contains appreciable Sr. Approximately 60% of the reserves are hosted by sandstones, with the remainder in brecciated carbonates.

Sphalerite, galena, pyrite, and marcasite are the major sulfides within Eyc sandstones, massive pyrite and celestite occur with colloform sphalerite and galena in Eyb limestone breccia. FI in celestite and ore-state calcite indicate ore-forming solutions were brines with 15-22 NaCl eq. wt.% and Th V from 90-130°C. Oil I and bitumen in ore suggest a genetic link between maturity of the basin and mineralization. The working genetic model proposes that basinal brines migrated up the Pijiang fault and replaced carbonate blocks and matrix near the fault and calcite cement within sandstones. (From authors' abstract by H.E.B.)

LI, Qiangzhi, 1996, Mineral paragenetic sequence and hydrothermal alteration of gold-bearing vein in Hadamengou pegmatite type gold deposit, Inner Mongolia, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 765. Author at China Univ. of Geosci., Beijing.

Hadamengou gold deposit consists of more than one hundred gold-bearing veins in Archaean high grade metamorphic formation. The veins are closely related to pegmatite both in time, space, and genesis. The wall-rock alteration related to gold mineralization is K-feldspathization.

According to characteristics of pyrite and FI of quartz, the deposit occurs at depth of 2.0 to 3.0 km, and T of 250°C to 310°C in the crust. Potassium-rich F are characterized of high alkaline components, high oxygen fugacity and high K^+/H^+ ratio. The pH value of the F is of over 7. Gold was precipitated as gold-bearing chloride with K-feldspathization.

Wallrock alterations include K-feldspathization, carbonatization, chloritization, magnetization, sericitization, silicification, rutilization and albitization, of which, K-feldspathization is the most. (From author's abstract by E.R.)

LI, Shengrong, 1996, Gold ore deposit series of Qiyugou area, eastern Qinling of China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 636. Author at China Univ. of Geosci., Beijing, China.

1. The porphyry-breccia molybdenium (gold) ores, the gold-silver-polymetal-bearing cryto-explosive breccias, the structurally fractured metasomatites and quartz veins found in Qiyugou and its neighbouring area of east Qinling ore zone were all developed from the calc-alkaline granitic magma of Mid-Late Yanshan Epoch.

The $\delta^{34}S\Sigma s$ values for the forming fluid of breccia and vein gold is obtained to be about ± 1.[?]5‰, showing that the sulfur here is of magmatic origin. For breccia, vein and metasomatitic gold, their major ore-forming period gives $\delta^{18}O_Q$ = +10.5~12.5‰, T=330~280°C, and their late mineralization period gives $\delta^{18}O_Q$ = +10.1~11.9‰, $\delta^{18}O_{CO}$ = +6.2~9.93‰, T=196~150°C. A calculation makes it clear that the water in major ore-forming period of all deposits belongs to re-balanced magmatic water, and that in late period is meteoric in nature. In late period, $\delta^{13}C_{\Sigma c}$ values for breccia and metasomatite gold range about -2.6 ~ -6.2‰, showing that the carbon was from related magma. The FI compositions for different deposits are all belong to CO_2-H_2O-NaCl system with high sulfur concentration. (From author's abstract by E.R.)

LI, Weiyuan, 1996, The basic facts and advances on the studies of crustal fluids in countries of the European Union: Earth Sci. Frontiers, v. 3, no. 3/4--Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 313-323. Author at Inst. of General and Applied Geol., Univ. of Munich, Germany, D-80333.

The author reviews the basic facts and advances in the study of crustal F in three areas: (1) geothermal F in geothermal field in Tuscany, Italy; (2) paleofluid in Variscan basement and Mesozoic-Cenozoic sedimentary cover in central Europe; (3) recent and paleofluid in continental deep drilling (KTB), Germany. (From author's abstract by E.R.)

LI, Wenliang, XU, Yanfu and LEI, Shibin, 1996, Study on characteristics of ore-forming fluid in gold-polymetallic deposit, Gongtong–Gadagou area, Liaoning: Gold Geol., v. 2, p. 57-60. Authors at Gold Geol. Inst. of MMI, Langfang, Hebei, 102800.

Gold-polymetallic deposits in Gongtong–Gadagou area mostly occur in early Yanshanian granite. FI in quartz are well-developed, and are mainly G-LI. From the study of FI, it is concluded: ore-forming F belongs to Na^+ - Ca^{2+} - Cl^- - $[SO_4]^{2-}$ type with low-to-moderate sal (5.7% ~ 8.5%), the metallogenic T is 225 ~ 275°C, the P 75.1 ~ 115.8 MPa, pH 5.23 ~ 6.05, Eh–0.57 ~ -0.62 V, and the possible transported form of gold is deduced to be [AuCl2]-. Therefore, gold-polymetallic deposits in this area belong to moderate (or low) T postmagmatic hydrothermal ores. (Authors' abstract)

LI, Zhaolin, 1996a, Study on the silicate melt inclusions in accessory minerals of various igneous rocks in China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 480. Author at Dept. of Geo., Zhongshan Univ., Guangzhou, 510275, China.

Th and M composition of the I from many (unspecified) igneous rocks vary widely. (E.R.)

LI, Zhaolin, 1996b, The experimental research into mineralization of intergranular solution (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 555. Author at Dept. of Geol., Zhongshan Univ., Quangzhou, 510275, P.R. China.

In order to prove the existence of intergranular solution in nature, the authors made experimental studies on its formation in some ore deposits, such as the gold deposits in Jiaodong and the copper-iron deposits in Chuandu granite mass of Dabaoshan, Guandong Province. The experimental method was as follows: crush the ore-bearing granite [or] granodiorite to powder, seal in gold or silver tube, put the tube with sample into P vessel and under 2-3 x 105 KPa, 800-850°C for 144-720 hr. to complete melting, then cool at 20-50°C/day. The purpose of the experiments is to imitate the mechanism of formation of intergranular solution caused by differentiation during slowly cooling of magma in nature.

The experiments showed local magmatic differentiation during slow cooling, and higher contents of Cu and Pb in the upper parts of the charges. (E.R.)

LI, Zhaolin, and **YANG, Zhongfang,** 1996, Rock-forming and ore-forming temperatures of Lianhuashan tungsten deposit, Guangdong Province: Chinese J. of Geochem., v. 15, no. 3 (1996) p. 239-248 (in Engl.) First author at Dept. of Geology, Zhongshan Univ., Guangzhou, 510275.

The Lianhuashan tungsten deposit occurs in the volcanic terrain in the coastal area of southeast China, where rhyolite, quartz porphyry and granite constitute a complete magmatic series. The orebodies are located in the endo- and exo-contacts between the quartz porphyry and the metasandstone of the Xiaoping coal measures. Th of M I 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, demonstrating that the rock-forming T dropped successively from the eruptive to the intrusive rocks and that the Th of M I in zircon are 50-180°C higher than those in quartz. Th of G-L I in quartz are 230-520°C (mostly 230-270°C) for quartz porphyry, 200-240°C (mostly 200-360°C) for ore-bearing quartz veins, 150-210°C for granite and 170-200°C for the vein quartz in it. Quartz from the quartz porphyry and from the ore-bearing quartz veins show similar characteristics in I type and Th, indicating that intergranular solutions must have been formed upon cooling of magma and that ore-forming solutions for the tungsten mineralization were evolved mainly from ore-bearing intergranular solutions in the quartz porphyry. (Authors' abstract)

LI, Zhaolin, YANG, Rongyong, SUN, Xiaoming and **LI, Yuansheng,** 1996, Formation, evolution and mineralization of fluid during geological process: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 237-244.

A review. (E.R.)

LI, Zhiping and **PETERS, S.G.,** 1996, Geology and geochemistry of Chinese sediment-hosted (Carlin-type) gold deposits (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A153. First author at Dept. of Geological Sci., Mackay School of Mines, Univ. of Nevada, Reno, NV 89557; e-mail (lzp@dws014.cs.unr.edu)

Chinese Carlin-type deposits are along the margin of the Precambrian Yangtz [sic] craton. Their distribution is controlled by regional rifts, while secondary structures, such as short-axial anticlines, high-angle faults and fault-parallel breccia bodies are favorable structures. They are found in the sedimentary formations of Paleozoic to Cenozoic age. Impure limestone, siltstone, and mudstone are the hostrocks for ore. Alteration types are silicification, decarbonatization and argillization. Igneous intrusions are not present in most of Chinese deposits, except for local lamprophyre and silicic dikes.

Gold is disseminated in all deposits. Main ore minerals include gold, electrum, pyrite, arsenopyrite, stibnite, orpiment, realgar and cinnabar, and gangue minerals are quartz, albite, barite, organic carbon, carbonate and clay minerals. As, Sb, and Hg are closely associated with these deposits as they are in Nevada, but uranium forms independent deposits associated with some Chinese deposits. Low sal FI (3-9 wt.%) and limited stable isotope data show multiple sources of metallogenic F. Tt vary from 165 to 290°C, and P from 52 to 560 bars, indicate that Chinese Carlin-type gold deposits may have formed below the epithermal environment. (From authors' abstract by H.E.B.)

LIAGHAT, S., MOORE, F. and JAMI, M., 1996, Genesis of the Kuh-e-Surmeh carbonate-hosted Pb-Zn deposit, a unique MVT mineralization in the simply folded belt of Zagros Mountains, S.W. of Iran (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 640. Authors at Dept. of Geol., College of Sci., Shiraz Univ., Shiraz, Iran.

The Kuh-e-Surmeh Pb-Zn deposit represents a unique and hitherto unreported Mississippi Valley type (MVT) mineralization in the area.

T and sal of the ore F were determined from FI studies on transparent gangue minerals. Th typically range between 50 and 200°C, and sal generally exceed 15 wt% salts. The salts being dominated by sodium-calcium chloride. (From authors' abstract by E.R.)

LIKHOYDOV, G.G. and NEKRASOV, I.Y., 1995, The solubility of gold in the Na-Fe-S-Cl-H_2O-O_2 system at 300 to 500°C and Ptot = 1 kbar in the presence of the pyrite-magnetite-pyrrhotite buffer assemblage: Dokl. Ross. Akad. Nauk, 1995, v. 341, no. 6, p. 804-806 (in Russian, translated in Trans. (Doklady) Russian Acad. Sci., Earth Sci. Sect., v. 344, p. 272-275, 1996).

LIMA, A., 1996, CO_2 fluid inclusion in a gabbroic xenolith from Panarea (Aeolian Islands): A contribution to the understanding of pressure evolution of the subvolcanic magmatic system: Acta Vulcanologica, v. 8, no. 2, p. 139-146. Author at Dipartimento di Geofisica e Vulcanologia, Via Mezzocannone 8, 80134 Napoli, Italy.

This paper presents the results of a FI study from two mafic xenoliths sampled from dacite lava at Panarea (PA) and Lisca Bianca (LB) (Aeolian archipelago). CO_2 I have been analyzed in order to characterize the P-T history of xenoliths during their ascent to the surface. Additionally detailed electron microbe analyses have been used to characterize the host phases. The results obtained from S CO_2 FI data and from feldspar composition indicate a low P evolution of the subvolcanic magmatic system at Panarea. This is consistent with the data obtained at Lipari, Stromboli, Vulcano and Ventotene. The ascent to the surface of the xenoliths was not straightforward; the bimodal P distribution derived from CO_2 density values, assuming a trapping T of 800°C, indicates that two main trapping events occurred mostly around 350 bars in plagioclase and 850 bars, mostly in pyroxene (assuming a higher trapping T, i.e. 1000°C, the two main trapping events fall at 400 bars and 1100 bars, respectively, in plagioclase and pyroxene). The maximum trapping P (i.e. ~950 bars) obtained from CO_2 I has to be considered the minimum crystallizing P of the pyroxene and plagioclase. Detailed microprobe analyses of the constituent phases reveal a dissimilar mineralogical composition compatible with the interpretation that the studied xenoliths could have a different origin. PA clinopyroxene compositions fall in the diopside field, closely approaching the generalized trend in "KHS"-type lavas from the Roman Comagmatic Region, LB clinopyroxene compositions are more salitic; LB plagioclases show a different composition and a different crystallization history compared with PA plagioclases. (Author's abstract)

LIN, Jingqian, TAN, Dongjuan, YU, Xuefeng, XU, Wenliang, LI, Bingren, and **LI, Ying,** 1996, Genesis and metallogenic model of Guilaizhuang gold deposit, western Shandong, China: J. of Changchun, Univ. of Earth Sci., v. 26, Special Issue 1996 (dedicated to the 30th International Geological Congress, but not in the IGC Abstracts volumes), p. 76-86 (in Engl.).

Several forms of gold mineralization located in and around the Tongshi subvolcanic complex [are] characterized by potassic alkalic affinity [and] the framework of metallogenic model is contributed. The gold deposits in Guilaizhuang belong to a type of precious-metal rich, quartz-fluorite-adularia, hypabyssal and low to moderate T hydrothermal deposit. (Authors' abstract.)

Th(?) data for quartz and fluorite from Tongshi and Guilaizhuang deposits are shown (Fig 5). (ER)

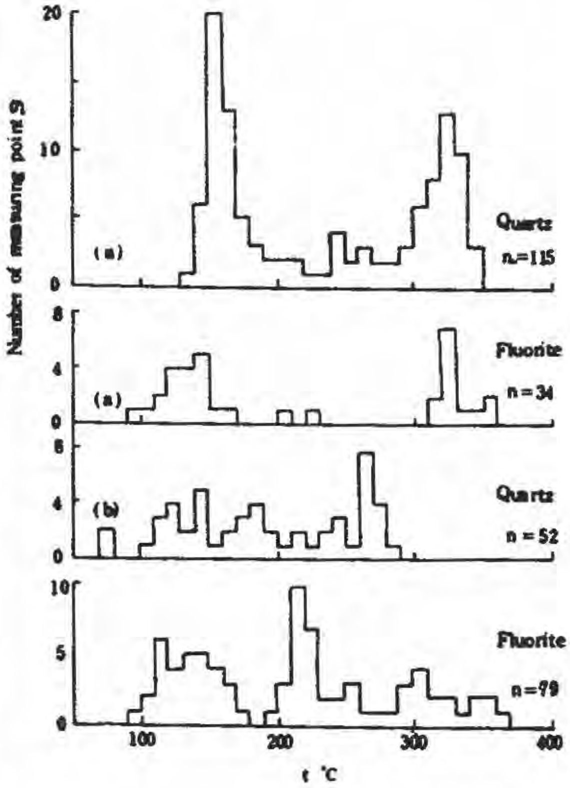


Fig. 5 The histograms of fluid inclusion heterogenization [homogenization?] Tongshi complex (a) and Guilaizhuang gold deposit (b)

LINDBLOM, S., BROMAN, C., and **MARTINSSON, O.,** 1996, Magmatic-hydrothermal fluids in the Pahtohavare Cu-Au deposit in greenstone at Kiruna, Sweden: Mineral. Deposita, v. 31 (1996) p. 307-318. First author at Dept. of Geol. and Geochem., Stockholm Univ., S-106 91 Stockholm, Sweden.

FI indicate an early formation of quartz and pyrite at T initially near 500°C and a P of 2-2.4 kbar from a supersaturated aq solution of magmatic origin. In addition to halite cubes, dm of sylvite, calcite, hematite, graphite and two unknown phases are found. The main stage of chalcopyrite and gold deposition is characterized by aq F of variable sal (up to 30 eq. wt.% NaCl including $CaCl_2$), at T below 350°C and P between 1 and 2 kbar. A minor CO_2 phase with some N_2 accompanies this stage. Gold was transported as a chloride complex which destabilized due to an increase in pH (as a consequence of the CO_2 loss) as well as cooling and dilution of the solution. The ore deposition occurred as a result of mixing with a low sal aq solution during tectonic fracturing with P fluctuations and CO_2 unmixing. Late oxidation of ores was caused by low to moderately sal (3 to 13 eq. wt.% NaCl) low T aq solutions. (From authors' abstract by E.R.)

LINGADEVARU, M., MAHABALESWAR, B., SHADAKSHARA SWAMY, N., and SRIKANTAPPA, C., 1996, Metamorphic conditions of charnockites of Kollegal-Hanur area, southern India (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 555. First author at Dept. of Geol., Bangalore Univ., Bangalore-560 056, India.

The Kollegal-Hanur area exhibits structurally controlled breaking and making of charnockite. CO_2 I are dominant both in foliated charnockite (FC) and incipient charnockite (IC), Th data of CO_2 I in FC exhibits bimodal frequency distribution one peak at –50 to –45°C and the other at –30 to –25°C with CO_2 densities of 1.18 to 1.16 and 1.11 to 1.09 g/cc respectively. CO_2 I in incipient charnockite show a single peak at –30 to –25°C with CO_2 densities of 1.12 to 1.09 g/cc. The high density CO_2 isochores of FC pass through the mineral P-T box of M1 and M2 indicating syn-metamorphic nature of CO_2, the late low density CO_2 I of FC and IC indicate their entrapment at lower P-T conditions which is related to M3 metamorphic event.

Textural, mineral P-T and FI data indicate an isobaric cooling path followed by isothermal decompression path for the granulites of Kollegal-Hanur area. (From authors' abstract by E.R.)

LINGADEVARU, M., SHADAKSHARA SWAMY, N., MAHABALESWAR, B., and SRIKANTAPPA, C., 1996, Metamorphic conditions and role of CO_2 fluids in foliated and incipient charnockite of Kollegal-Hanur area, Karnataka, south India (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 435. First author at Dept. of Geol., Bangalore Univ., Bangalore-560 056, India.

CO_2 I are dominant both in foliated charnockite (FC) and incipient charnockite (IC). The data of CO_2 I in FC exhibits bimodal frequency distribution one peak at -50 to -45°C and the other at -30 to -25°C with CO_2 densities of 1.18 to 1.16 and 1.11 to 1.09 g/cc respectively. CO_2 I in incipient charnockite (IC) show a single peak -30 to -25°C with CO_2 densities of 1.12 to 1.09 g/cc. The high density CO_2 isochores of FC pass through the mineral P-T box of M1 and M2 indicating syn-metamorphic nature of CO_2. The late low density CO_2 I of FC and IC indicate their entrapment at lower P-T conditions which is related to M3 metamorphic event. Textural, mineral P-T and FI data indicate an isobaric cooling path followed by isothermal decompression path for the granulites of Kollegal-Hanur area. (From authors' abstract by E.R.)

LINNEN, R.L., KEPPLER, H., and STERNER, S.M., 1996, High temperature in situ FTIR measurements of synthetic H_2O-CO_2 fluid inclusions (abst.): Sixth International Symposium on Experimental Mineral., Petrol. and Geochem., Abstract Supplement No.1 to TERRA Nova, v. 8, Supp. 1, p. 39-40. First author at Bayrisches Geoinstitut, Universität Bayreuth, 95440 Bayreuth, Germany.

Although H_2O-CO_2 FIs are one of the most common I types in the earth's crust, there is no direct means of measuring compositions and molar volumes. We have therefore developed a new technique to analyze FI by mid infrared Fourier transform spectroscopy at a T in the one-phase field (300°C). The variation of the H_2O/CO_2 peak area ratio as a function of composition provides a calibration curve that can then be used to determine the composition of an unknown I (and from microthermometry the molar volume). This curve has been established using synthetic H_2O-CO_2 FI of known composition and density hosted in quartz.

The data were collected on a Bruker IFS 120 HR spectrometer equipped with a Bruker IR microscope, Globar source, CaF_2 beamsplitter and a MCT detector with a resolution of 4 cm^{-1}. An adjustable rectangular aperture in the rear focal plane of a 15x Cassegranian objective (working distance 32 mm) was used to isolate the selected FI from the surrounding quartz and the minimum inclusion size is approximately 15 µm in length. The inclusions are heated in a modified U.S.G.S.-type heating-stage with CaF_2 windows.

To date H_2O/CO_2 compositions ranging from 0.6 to 7.0 have been examined. The H_2O/CO_2 peak area ratio varies continuously with composition and is only weakly dependent on molar volume. The technique is not only promising for the analysis of natural FI of unknown composition, but can also has the potential of replacing classic cells in some spectroscopic studied. (Authors' abstract.)

LINNEN, R.L., PICHAVANT, Michel and HOLTZ, Francois, 1996, The combined effects of fO_2 and melt composition on SnO_2 solubility and tin diffusivity in haplogranitic melts: Geoch. Cosm. Acta v. 60, no. 24 (1996) p. 4965-4976. First author at Bayerisches Geoinstitut, Univ. Bayreuth, 95440 Bayreuth, Germany.

LIRA, Raul, RIPLEY, E.M. and ESPAÑÓN, A.I., 1996, Meteoric water induced selvage-style greisen alteration in the Achala Batholith, central Argentina: Chemical Geol., v. 133, p. 261-277. First author at Consejo Nacional de Investigaciones Científicas y Técnicas de la R. Argentina, Universidad Nacional de Córdoba, Velez Sarsfield 299, 5000-Córdoba, Argentina.

Zoned, selvage-style greisen alteration is common along fracture zones in the ~350 Ma Achala Batholith of central Argentina. Zonation proceeds from only slightly altered monzogranite, through zones of biotite alteration (Zone 1), partial alteration of feldspar (Zone 2), and intensely altered zones characterized by the complete destruction of feldspar, formation of S muscovite, and crystallization of S quartz in veins and vugs (Zone 3). FI studies indicate that F involved in the formation of S quartz were dilute (ave. = 1.5 eq. wt.% NaCl), and were trapped at T < ~350°C.

Oxygen and hydrogen isotopic data collected from P quartz, feldspar, and muscovite, and S muscovite and quartz indicate a complex history of isotopic exchange and mineral precipitation. Isotopic data suggest that P minerals initially exchanged with a F of δD ~ -175 to -135‰ and $\delta^{18}O$ ~ -23 to -18‰. However, S muscovite and quartz are characterized by $\delta^{18}O$ values of -11.6 to -5.0‰ and -16.0 to -7.1‰, respectively. S muscovite δD values (-117 to -83‰) are generally higher than those of exchanged, P muscovite in Zones 2 and 3. FI extracted from late-stage quartz have δD values of -55 to -54‰, consistent with computed values for F in equilibrium with S muscovite. Meteoric water with this hydrogen isotopic composition would be characterized by a $\delta^{18}O$ value of ~ -8‰, again consistent with $\delta^{18}O$H2O computed from late-stage S muscovite. The data suggest that early isotopic exchange was initiated by reaction with a low-D, low-^{18}O meteoric water, but that F composition changed through time. Increases in F $\delta^{18}O$ and δD values may be related to changes in climate and geographic location or elevation of the area, or may in part be related to interaction with evolved F that exchanged isotopes in other portions of the flow system. Exchange durations computed from feldspar and quartz $\delta^{18}O$ values are <65,000 yr., and indicate that F introduction into the fracture system was episodic in nature. Such a pattern of changes with time in the isotopic composition of meteoric water may be characteristic of hydrothermal alteration of back-arc granitoid rocks of the Eastern Sierras Pampeanas. (From authors' abstract by E.R.)

LISK, M., GEORGE, S.C., SUMMONS, R.E., QUEZADA, R.A. and **O'BRIEN, G.W.,** 1996, Mapping hydrocarbon charge histories: detailed characterisation of the South Pepper oil field, Carnarvon Basin: Appea J., (1996). part 1, p. 445-464. First author at CSIRO Div. of Petroleum Resources and Australian Petroleum Coop. Research Centre, P.O. Box 136, N. Ryde, NSW, 2113.

This study combines FI, micro and conventional GC-MS, stable isotope, mineralogical and petrological data, to allow the accurate reconstruction of the charge history of this field. The micro GC-MS work on oil-bearing FI in the reservoir section allows, for the first time, a comparison to be made between the geochemical characteristics of the presently reservoired oil with samples of the palaeo-reservoired oils, as preserved within the FI.

Oil I abundances (OIA) recorded within the reservoir section in South Pepper-1 show two distinct abundance peaks, which are interpreted to correspond to zones of high oil saturation. The first occurs near the top of the reservoir, in sands that are presently gas saturated and represents a palaeo-oil column. The oil I occur primarily within pre-existing ankerite cement that crystallised from highly sal F, probably derived from Palaeozoic evaporites. Carbon isotope compositions measured on the ankerite are isotopically depleted, consistent with the derivation of CO_2 from the maturation of organic matter. Geochemical characterisation of the oil contained within these I shows the presence of biomarkers such as 30-norhopanes and methylhopanes which are indicative of a calcareous source rock. Subsequent uplift and sub-aerial exposure of the basin margin during the Middle Miocene allowed fresh waters to dilute formation waters in the Barrow Group and biodegrade this early oil charge. However, the abundance of highly water-soluble compounds in the FI oil suggests that biodegradation occurred subsequent to initial oil emplacement.

The second oil I abundance peak corresponds to the present-day oil zone and, although absolute oil I abundances are similar to those recorded in the upper zone, the fluorescence colours are significantly different, suggesting a different source for the second oil charge. (From authors' abstract by E.R.)

LIST, Mark, O'BRIEN, G.W., EADINGTON, P.J. and **KRIEGER, F.W.,** 1996, Quantitative evaluation of oil-leg potential in gas reservoirs (abst.): American Assoc. of Petrol. Geologists Annual Meeting Abstracts, v. 5, p. 84. First author at CSIRO Div. of Petrol. Resources, Sydney, NSW, Australia.

Oil-bearing FI in sandstone represent hidden oil shows. The frequency of quartz grains containing these I (GOI number) reflects maximum palaeo-oil saturation irrespective of the present F phase. In this way, FI data can be used to both identify palaeo-oil columns and to map original oil water contacts (OWC) in wells where oil has been displaced by later G charge. Studies conducted on G fields from the north west shelf of Australia have shown that substantial oil columns were once present. Moreover, detailed GOI mapping has been used to define the location of the original OWC in these reservoirs allowing the height of the palaeo-column to be determined and an estimate to be made of original oil in place (OOIP). At Oliver-1 in the Timor Sea, the reservoir is presently filled to spill with a 164 m G, and 14.5 m oil, column. GOI mapping has, however, delineated a 96 m thick palaeo-oil column within the G leg. This is almost seven times thicker than the present oil leg which suggests that perhaps 170-190 million barrels of oil were displaced from this structure. In the Pepper G field in the Carnarvon Basin GOI mapping has demonstrated the presence of a gross palaeo-oil column between 15 and 30 m thick, suggesting that between about 50 and 70 million barrels of oil has been displaced. This is more oil than that reservoired in any of the surrounding oil discoveries, which emphasizes the importance, from an exploration standpoint, of defining these remigration pathways. (Authors' abstract)

LIU, Bin, 1996, The mineralization geology of Maojiadian gold deposit in Liaoning (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 632. Author at Shenyang Inst. of Geol. and Mineral Resources, China.

Maojiadian gold deposit belongs to auriferous sulfide quartz vein type. The major mineralization element composition of Maojiadian gold deposit is Au, Ag, Cu, Pb and Zn. The decrepitation characteristics of quartz I in auriferous sulfide quartz veins indicates that the decrepigraphs are mainly bimodal and secondly unimodal, multimodal and α-, ß-modal curves. The samples with higher gold content are mainly in bimodal curves. The detonation T is 250-290°C and tendents higher from shallow to deep, indicating that the mineralized hydrothermal is possible deep-source. (From author's abstract by E.R.)

LIU, Changshi, SHEN, Weizhou, and **WANG, Dezi,** 1996, The characteristics and genetic mechanism of igneous topazites in South China: Acta Geologica Sinica (Engl. Edition) v. 9, no. 1 (1996) p. 33-45. Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing, Jiangsu.

Igneous topazites found recently in South China are closely associated with F-rich granites in time and space. The phenocrysts are topaz and quartz, while the ground mass consists mainly of prismatic or acicular topaz microlites and anhedral quartz. Compared with granites, topazites are rich in SiO_2 (65.06% - 81.12%) and Al_2O_3 (13.01% - 18.09%) but poor in MgO and Na_2O and strongly peraluminous with A/NKC = 3.204-37.313. Geochemically, the rocks are evidently depleted in Sr and Ba, but enriched in Sn, W, Nb and F. The concentrations of Sn and partial W in the topazites are 1-2 orders of magnitude higher than the average of acid rocks. Hydroxylated silicate M I, consisting of several grains of quartz and aq F, have been found in the quartz phenocrysts. The entrapment T of these I is about 520°C. (From authors' abstract by E.R.)

LIU, Cong and **CHENG, Shangda,** 1996, Volcanogenetic gold mineralization in Tongjing, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 651. Authors at Jiangsu Bureau of Geol. and Minerals, China.

The Tongjing gold-copper deposit is a volcano-genetic gold-copper deposit hosted by alkaline volcanic rocks intruded by aegirine-augite syenite in the early Cretaceous.

Gold-bearing quartz vein is composed of quartz, calcite, maganocalcite, barite etc. Sulfur isotope values of pyrite are in range of $\partial^{34}S$=3.24 to 8.18 per mil, that interprets the sulfur comes from mantle and upper crust, so is the lead. The $\partial^{18}O$ values of L range from 0.36 to 4.84 per mil and ∂D values range from -66.1 - -73 per mil. The data show that F are the mixture of meteoric water and magmatic water. Data of F and G I show that the gold-copper mineralization was deposited from a L with 11.95 to 15.4 wt% (NaCl) at T between 219 and 250°C, the fO_2 between $10^{-32.6}$ to $10^{-37.85}$, the pH between 4.73 to 5.14. (From authors' abstract by E.R.)

LIU, Dongsheng, TAN, Yunjin, and WANG, Jianye, 1996, The geological and geochemical characteristics of Carlin-type gold deposits in China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 773. Authors at Research Inst. of Geol. for Mineral Resource, Guilin, China.

The Chinese Carlin-type gold deposits often occur in the contact part between two different geotectonic elements. The mineralized host rocks are fine clastic rocks, clay rocks and impure carbonate rocks. They are different in lithological features, with different geochemical types of gold deposits. The organic matter and sedimental pyrite-rich is the important feature of the mineralized host rock. Thus suggest that these rocks were deposited in a reduction environment.

Metallogenetic T was defined about 100°C~300°C, the T of gold mineralization is 170°C ~ 250°C, the ore-formed F was defined as Na^+ - Ca^{2+} - Cl^- - SO_4^{2-} type, its density is 10.7 [sic] ~ 0.97 g/cm^3 and sal is 1.15%~11.7% (wt. NaCl). In the ore-formed process the oxygen- and sulfur-fugacity are -33.3 ~ -48 and -16.5 ~ -21.47 respectively and pH value is 3.2 ~ 6.7.

The Chinese Carlin-type gold deposits can be geochemically classified into three types, the gold-antimony type, the gold-mercury-(thallium) type and the gold-arsenic-(antimony) type. (From authors' abstract by E.R.)

LIU, Gang, 1996, Study on mineralizing physical-chemical conditions of gold deposits in Chifeng-Ghaoyang District, China: Gold Geol., v. 2, no. 4, p. 43-49. Author at Gold Geol. Inst. of MMI, Langfang, Hebei, 065000

A systematic discussion of mineralization T and P, fugacities of various G, pH values, activities of gold ion and complex compounds, and transport form of gold in main gold deposits in this district. The mechanism of gold precipitation in different types of ore F is inferred. (Author's abstract)

LIU, Guanliang, ZHAI, Lina, WANG, Xiongwu, MIAO, Qing, CHE, Feng, LU, Qi and ZHENG, Shu, 1996, Magma melt inclusions in diamonds (abst.): 30th Int'l. Geol. Cong. Abstracts, v. 2, p. 397. First author at Yichang Inst. Geol. Min. Res., CAGS, China.

The occurrence of magma M materials as I in diamonds has been found from the Fuxian, Mengyin mines and Dingjiagang diamond placer mine, China.

The magma MI in diamonds are of 30-85 µm in size, with black to deep brown in colour and with weak metallic luster. The I materials in diamonds consist of some microspheres and groundmass (M), which are uncommon in diamonds.

The microspheres are of ferroball, silico-ferroball and mafelsic ball [sic], and the groundmass (M) are high in SiO_2, Al_2O_3, K_2O; SiO_2, FeO, CaO and SiO_2, FeO, MgO in different diamonds respectively (Table 1).

The authors conclude that a certain material of a quenched or T unequilibrated M were present as I in diamond.

These I represented in part magma as a L immiscibility phase of the M from which diamonds formed, and suggest that the formation of diamonds might be related with volcanic eruption [sic]. (Authors' abstract)

Table 1. Chemical compositions of magma melt inclusions in diamonds by electron microprobe analyses

	Ln−18						SD−05			T−90−08			
	sphere			groundmass			sphere	groundmass		spheres		groundmass	
	1	2	3	4	5	6	7	8	9	10	11	12	13
SiO_2	13.84	0.15	0.02	60.85	58.82	65.40	5.54	28.05	42.08	62.85	63.87	60.306	0.69
TiO_2	0.71	0.07	0.04	0.79	0.63	0.67	2.31	0.48	0.03	0.04	0.07	0.12	0.09
Al_2O_3	0.54	0.00	0.00	29.15	31.82	26.02	1.85	2.64	7.71	1.03	1.20	27.57	27.56
FeO	107.46	110.80	106.93	1.66	3.70	1.37	69.18	45.66	33.02	25.96	25.79	0.23	0.35
MnO	0.03	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.07	0.00	0.00	0.98	0.83	1.02	20.93	4.17	15.65	2.47	2.29	3.30	3.25
CaO	0.03	0.00	0.00	0.10	0.07	0.11	0.30	18.93	0.23	4.84	0.17	0.15	0.34
Na_2O	0.24	0.00	0.00	0.34	0.15	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K_2O	0.16	0.01	0.01	5.83	3.92	5.35	0.08	0.05	0.24	0.77	0.78	7.93	6.91
Sum.	123.47	111.08	107.00	99.31	99.97	98.60	99.99	99.98	98.96	97.95	99.97	99.50	99.69

1−6, Fuxian, Liaoning; 7−9, Mengyin, Shandong; 10−13, Dingjiagang, Hunan.

LIU, Huaibo, FORGOTSON, James M., and BLATT, Harvey, 1996, Diagenesis and paleokarstification of the Brown zone of Ordovician Arbuckle Group in the Healdton Field, Carter County, Oklahoma (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 858. First author at Jianghan Petroleum Inst., Jingsha, Hubei, PRC.

Petrographic evidence indicates complex paragenetic sequence which involved fourteen diagenetic events. The diagenetic sequence has been further proved by FI and geochemical data. The FI data from the saddle dolomite cement suggest that this dolomite formed in a deep burial (1800-2500 m) and high T (>80°C) environment. The hydrocarbon and brine I in the phase (2) calcite cement and their thermometry data indicate that this calcite precipitated from a brine water at a high T, 90-110°C, when the migrated hydrocarbon from a source rock had reached the Brown zone reservoir. The $SrCO_3$ (800 ppm) in the phase (2) calcite is much higher than in the Permian cave calcite cement (200 ppm), which also suggests that the former may be formed in a brine water.

Based on the geology of unconformities, geochemical data and FIs, the diagenetic dolomitization (2) took place during Silurian to early Devonian time when the Brown zone was buried about 1200-1400 m at T ranging from 50° to 60° C; the saddle dolomite cementation occurred probably during latest Mississippian when the burial depth reached 2000-2300 m and the T had increased to 75-85°C. (From authors' abstract by E.R.)

LIU, Jun, BOHLEN, S.R., and ERNST, W.G., 1996, Stability of hydrous phases in subducting oceanic crust: Earth and Planet. Sci. Lett. v. 143, no. 1-4 (1996) p. 161-171. First author at Dept. of Geological and Environmental Sci., Stanford Univ., Stanford, California 94305.

Experiments in the basalt-H_2O system at 600-950°C and 0.8-3.0 GPa, demonstrate that breakdown of amphibole represents the final dehydration of subducting oceanic tholeite at T≥650°C; the dehydration H_2O occurs as a free F or in silicate M co-existing with an anhydrous eclogite assemblage. In contrast, about 0.5 wt. of H_2O is stored in lawsonite at 600°C, 3.0 GPa. Our results suggest that slab melting occurs at depths shallower than 60 km for subducting young oceanic crust; along a subduction zone with an average thermal gradient higher than 7°C/km, H_2O stored in hydrated low-postassium, metabasaltic layers cannot be subducted to depths greater than 100 km, then released to generate arc magma. (Authors' abstract)

LIU, Shuwen, 1996, Fluid evolution during high-grade metamorphism in east Hebei: Acta Petrologica Sinica, v.

12, no. 1 (1996) p. 48-58. Author at Dept. of Geology, Peking Univ., Beijing, 100871.

Texture, mineral associations and metamorphic reactions of the Archean high-grade metamorphic rocks in East Hebei reflect that their metamorphic evolution has experienced four stages: prepeak, peak, postpeak and retrograde metamorphisms. *P-T* conditions and F nature in every metamorphic stage are found after study of F inclusions and calculating of thermodynamic equilibrium. T and P conditions in prepeak stage are about 650°C~735°C and 0.5~0.7 GPa, and XH_2O is 0.49~0.95 in equilibrium metamorphic F. I trapped in this stage have H_2O and CO_2 L phases, in which the ratio $H_2O/(H_2O+CO_2)$ is about 0.23~0.44 and logüO_2 is about -16.5--17.5. Comparing to peak metamorphism, the temperature in postpeak metamorphism drops about 100°C, P does not clearly change, and XH_2O reduces to 0.09~0.32. FI trapped in this stage have high-density CO_2 and small amount of CH_4, H_2O, H_2, etc., with ratio H2O/(H2O+CO2) less than 0.02 and logüO_2 down to -19--24. In last stage of metamorphism, the conditions are 677°C~775°C and 0.64~0.74 GPa, XH2O is 0~0.64 and XCO2 is 0.42~0.78, in which the ratio and oxygen fugacity are close to those in post-peak metamorphism. Last type of I have salt solution component and oxygen in their G component, indicating that oxygen fugacity largely increased. XH2O is obviously reduced from pre-peak, through peak, to post-peak stage and increased in CO2, which in F changed into nearly pure CO_2 in postpeak stage. During late metamorphism rocks are hydrated again. The evolution of metamorphic F from pre-peak to peak metamorphism is controlled by buffering of equilibrium mineral associations. While mantle F in dispersion are presented in peak stage, post-peak metamorphic F are mainly controlled by CO_2-rich F from deep resource. The circulation and infiltration of shallow F with lower sal is one of the most important factors that influence the evolution of F in retrograde metamorphism and uplifting process. During evolution of metamorphism, F system changes from closing or semi-closing in peak stage into opening in postpeak and then into retrograde metamorphism. (Author's abstract)

LIU, Xiaodong, 1996a, Characteristics of fluid inclusions and the relation to Au-Cu mineralization in Bitian deposit, Fujian province, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 553. Author at East China Geological Inst., P.O. Box 71, Fuzhou, Jiangxi, P.R. China.

The Au-Cu mineralization of Bitian deposit is dominated by ore-bearing quartz veins locally with significant adularization in stratoid breccia volcanic rocks and granite. Systematic studies of FI in ore-bearing quartz veins indicate that the FI related to Au-Cu mineralization can be classified into three types: type 1, mono-aq phases, type 2, polysaline aq phase and V phase with the volume percent of V phase 10 to 70, and type 3, dm (NaCl and KCl?) bearing I. The Th for type 2 and type 3 inclusions mainly ranges from 190 to 220°C with a little bit higher in the east portion of the deposit, and the sal ranges from 6 to 28 wt% NaCl eq. Similar to most of the quartz vein type gold deposits in China, the bulk G composition of FI in Bitian is also rich in CO_2. The FI evidences and the bulk composition suggest that the ore-forming F are close to H_2O-NaCl(KCl)-CO_2 system.

The ore-bearing quartz veins hosted in stratoid breccia rocks and the geological occurrence of ore body in the field indicate that the ore veins formed at relatively lower P open environment, while the characteristics of type 3 and type 2 inclusions with different volume percentage of V phase and similar Ths occurring in close space suggest the boiling of ore-forming solution during the mineralization stage. Therefore, the T for Au-Cu mineralization in Bitian could be represented by the measured Th 190 to 220°C. The boiling of ore-forming solution could cause the phase separation and further could have caused the precipitation of Au-Cu. (Author's abstract.)

LIU, Xiaodong, 1996b, Characteristics of fluid inclusions and the relation to Au-Cu mineralization in Bitian deposit, Fujian Province, China, (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 37-38. Author at East China Geol. Inst., P.O. Box 71, Fuzhou, Jiangxi, P.R. China.

See previous item (E.R.)

LIU, Xuemei, and LIU, Benli, 1996, Infrared spectroscopic feature at deep-seated thinning-out and recurrence parts of ore vein I in Dongping Au deposit: Geol. and Prospecting, v. 32, no. 1 (1996) p. 13-16 (Chinese)

LIU, Yimao, WANG, Changlie, XU, Youzhi and LU, Huanzhang, 1995, Metallization and metallogenetic conditions of Shizhuyuan ultra-large tungsten deposit: Hunan Geol., v. 14, no. 4, p. 211-220 (in Chinese; Engl. abst.). First author at Inst. of Geol. and Exploration of South Hanan, HBGMR.

Shizhuyuan ultra-large tungsten deposit formed from melting of Proterozoic basement. The metallization includes differentiation of crust molten magma, separation of the immiscible phases and the compositing process of metallization of leaching - distillation - convection of strata materials. With regard to the metallogenetic conditions there are as follows 1) element assemblage very rich in fluorine, Cl and B and magma - hydrothermal solution, that is, the M - F system containing metallogenetic elements; 2) full supply of metallogenetic materials and volatile components with multi-sources; 3) Jurassic water-storing basin providing water source for infiltration and convection, and giving partly the motive power for metallization; 4) the border of two big massives and the intersections of fault groups at which occur the heat columns in the zone of magmatic metallization, all these places being favourable tectonic setting for deposit-forming; 5) geochemical field extremely rich in fluorine, W, Sn, Mo, Bi, Pb and Zn; 6) high volatile components carrying and transporting metallogenetic materials in very suitable condition of Al and Si media; 7) and the metasomatism and filling and emplacement of metallogenetic materials in upper carbonate rocks. (From authors' abstract by E.R.)

LIU, Yuqiang, 1996, Geology and origin of the Maodeng tin-copper deposit, Inner Mongolia: Mineral Deposits (Kuangchuang Dizhi), v. 15, no. 2 (1996) p. 133-143 (In Chinese; Engl. abst.). Author at Inner Mongolia Bureau of Geology and Mineral Resources, Hohhot 010020.

The Maodeng tin-copper deposit is located 50 km northeast of Xilin Hot City, Inner Mongolia. On its outskirts there are well-developed Late Jurassic bimodal volcanic rocks, suggesting that this ore deposit might have been related to Yanshanian intracontinental rifting on the western slope of Da Hinggan Mountains. Within the ore deposit, acid volcanic rocks, porphyritoid granite and granite porphyry were successively formed and superimposed upon each other to produce a volcanic-intrusive complex. Detailed petrological, mineralogical and element geochemical data show that there existed the evolutionary trend of fractional crystallization among these three sorts of rocks, and that fractional crystallization of magma must have played the dominant role in the enrichment of tin in granitic M and the subsequent formation of stanniferous granite-granite porphyry in the ore deposit.

Controlled by a fracture-fissure system, tin-copper orebodies are distributed exclusively from wall rocks west of the contact zone of the granite porphyry to fractures and fissures in Jurassic conglomerate and sandstone. Nearly one hundred ore veins are in echelon arrangement, forming three ore vein groups. Potassic alteration, greisenization and silicification are mainly developed within or around ore veins.

Th of FI fall into three ranges, i.e., 510~560°C, 310~450°C and 200~350°C, corresponding respectively to three alteration-mineralization stages, namely potassic alteration (magnetite), greisenization (cassiterite) and silicification (sulfides). $\delta^{18}O$ and δD values of F gradually decreased from potassic alteration stage through greisenization stage to silicification stage, suggesting that the gradual increase in meteoric water proceeded synchronously with the cooling of F. The above evidence reveals that, being a hydrothermal vein type tin-copper deposit related to granite porphyry, the Maodeng deposit was formed at medium depth (1.6~2.0 km) and moderate temperatures (450~200°C). (From author's abstract by E.R.)

LOCKWOOD, M.S., 1990, Controls on precious-metal mineralization, Easton-Pacific vein, Virginia City mining district, Madison County, Montana: unpublished M.S. thesis, New Mexico Inst. of Mining and Tech., 136 pp.

The deposits bridge the artificial boundary between epithermal and mesothermal deposits. FI (ore-forming stage) show 275°, 3-6% NaCl eq. to 175°C + 10-12% NaCl, presumably from mining of fluids. (As quoted by Ermin, 1997, SEG Newsletter v. 28, p. 110-114)

LOKHOV, K.I., and LEVSKIY, L.K., 1995, Carbon and heavy-noble-gas isotopes in metamorphic fluids: Geokhimiya, no. 6, p. 829-842, 1995 (in Russian, translated in Geoch. Int'l., v. 33, no. 3, p. 23-38, 1996). First author at Inst. for Precambrian Geol. and Geochronology, Russian Acad. of Sci., St. Petersburg.

Abstract in FIR, v. 28, p. 88 (E.R.)

LONDON, David, 1996, Granitic pegmatites: Transactions of the Royal Soc. of Edinburgh: Earth Sci., v. 87, p. 305-319 (also in: The Third Hutton Symposium, Geol. Soc. Amer. Special Paper 315).

The P focus of this review is on P–T conditions, mineralogical indicators of M or F composition and textural evolution; lesser treatment is given to pegmatite sources or to pegmatite-wallrock interactions. Investigations of stable and radiogenic isotopes have revealed that the source materials for pegmatites are likely to be more heterogeneous or varied than previously thought, especially for peraluminous pegmatites, but that overall pegmatites bear a clear intrusive relationship with their hosts, as opposed to an origin in situ. The P–T conditions of crystallisation of some lithium-rich pegmatites have been constrained by lithium aluminosilicate stability relations in combination with stable isotope or FI methods. Experimental studies have elucidated the effects of components such as Li, B, P and F, which are common in some classes of pegmatites, to liquidus relations in the hydrous haplogranite system. Experimentation has also provided corroboration of an old concept of pegmatite crystallisation–that pegmatites owe their distinctive textures and mineral/chemical zonation to relatively rapid crystallisation of M from the margins inwards at conditions far from the equilibrium (i.e. from supercooled L). The origin of aplites, whether alone, layered, or paired with pegmatites, remains an active area of research. Studies of FI, crystal-V equilibria and wallrock alteration have helped to define the timing and compositions of V phases in pegmatites and to aid in the economic evaluation of deposits. (Author's abstract)

LOSADA-CALDERÓN, A.J. and McPHAIL, D.C., 1996, Porphyry and high-sulfidation epithermal mineralization in the Nevados del Famatina Mining District, Argentina: in " Andean copper deposits: new discoveries, mineralization, styles and metallogeny," Soc. Econ. Geologists Special Publication No. 5, Camus, F., Sillitoe, R.H. and Petersen, R., eds., 1996, p. 91-118. First author at M.I.M. Exploration Pty. Ltd, P.O. Box 1121, West Perth, Western Australia 6872 Australia.

This paper discusses the possible genetic relationship between two ore deposits in the Nevados del Famatina mining district, Argentina: Nevados del Famatina Cu-Mo-Au porphyry deposit and La Mejicana Cu-Au high-sulfidation epithermal deposit. The porphyry system crops out in three open annular areas dominated by porphyritic rocks at elevations between 4000 and 4800 m; the epithermal vein system is peripheral to the porphyry and crops out on adjacent ridges at elevations above 4500 m. The spatial, geologic, petrographic and geochronologic parameters suggest that there is a genetic relationship between the two deposits, and detailed mineralogic, FI, and stable isotope studies and preliminary thermodynamic modeling provide additional support. The hydrothermal F, from which the ore, gangue, and alteration minerals were deposited, were dominated by magmatic volatiles, with admixture of groundwaters during the later vein stages in both the porphyry and epithermal deposits. Representative P, T, and sal decreased over the paragenetic stages of the porphyry and with increasing elevation in the late vein stages of the porphyry and epithermal systems. The F also became progressively more oxidized, more acidic, and lower in sulfur G activity over the same stages and elevations. The T, P, and F composition (sal, redox state, sulfur G, acidity) inferred for the epithermal system are similar to those calculated for the last stage of the porphyry deposit. There are striking similarities in detailed mineralogy between the last porphyry vein stage and the epithermal veins. All available data support the hypothesis that the porphyry and high-sulfidation deposits are transitional and genetically related. (Authors' abstract)

LOTT, D.A. and COVENEY, R.M., Jr., 1996a, Fluid-inclusion evidence for the origins of organic-rich Chinese nickel-molybdenum ores (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 713. Authors at Dept. of Geosci., Univ. of Missouri, Kansas City, MO, U.S.A.

Cambrian black shales contain extraordinarily enriched ores in which both Ni and Mo occur in percent concentrations in what appears to be a single, discontinuous thin organic-rich, phosphatic iron sulfide bed that can be traced sporadically across south China. Previous results from U-Pb dating and Re-Os systematics are consistent with formation of the ores during the Cambrian Period and point towards a possible hydrothermal source of metals for the deposits. Bacterial fossils and the abundant organic matter suggest a possible role for biogenesis. The present study is focused on FI evidence regarding genesis.

Our efforts were concentrated on quartz crystals derived from what may be penecontemporaneous veinlets cutting the ores and from isolated occurrences and stockworks in Proterozoic dolomites that underlie the deposit. At the present state of our research (late 1995), Th for P FI contained by quartz crystals range at least from 99 to 263°C and eq. NaCl contents vary from below sea water values to near saturation. There is evidence for phase separation in the form of coexisting L-rich and V-rich I. Thus the results of FI studies seem to be in accord with the concept of venting F to the early Paleozoic seas during the time of ore formation. Given that rich biotic communities surround numerous modern undersea vents, their presence in the Cambrian seas seems likely. An active role for biological agents in accumulating metals, if only by generating reduced sulfur species (Murowchick et al., GCA, 1994) is also probable. (Authors' abstract.)

See also adjacent item. (E.R.)

LOTT, D.A. and **COVENEY, R.M., Jr.,** 1996b, Fluid-inclusion evidence for the origins of Chinese nickel-molybdenum ores: The Geological Society of American, 30th Annual North-Central Section, 1996 Abstracts with Programs, v. 28, no. 6, p. 52, May 1996. Authors at Dept. of Geosci., Univ. of Missouri, Kansas City, MO 64110-2499.

Cambrian black shales of south China contain extraordinarily enriched ores in which both Ni and Mo occur in percent concentrations in what appears to be a single, discontinuous thin organic-rich, phosphatic, iron sulfide bed that can be traced sporadically across numerous provinces. Although analytical errors are considerable, previous results from U-Pb dating and Re-Os systematics are consistent with formation of the ores during the Cambrian Period. Previous studies have pointed toward a possible hydrothermal source of metals for the deposits. Bacterial fossils suggest a possible role for biogenesis. The present study is focussed on FI evidence regarding genesis.

Our efforts were concentrated on quartz crystals derived from what may be penecontemporaneous veinlets cutting the ores and from isolated occurrences and stockworks found in the Proterozoic dolomites that underlie the deposit. At the present state of our research, Th for P FI contained by quartz crystals range at least from 99 to 263°C and eq. NaCl contents vary from 2.3 to 23%. There is evidence for phase separation in the form of coexisting L-rich and V-rich I. Thus the results of FI studies seem to be in accord with the concept of venting of F to the early Paleozoic seas during the time of ore formation. Judging from the ubiquity of organisms around modern undersea vents, an active role for biological agents seems likely. (Authors' abstract)

LOUCKS, R.R. and **HIBBERSON, William,** 1996, Experimental solubility of gold in sulphidic brine to 625°C and 4 kbar measured in synthetic fluid inclusions by ICPMS-ULTEMA: Geol. Soc. of Australia Abstracts, v. 41, p. 258. First author at Australian Nat'l. Univ., Research School of Earth Sci., Canberra, Australia.

See also adjacent items (E.R.)

LOUCKS, R.R., MAVROGENES, J.A., and **HIBBERSON, W.,** 1996, Experimental solubility of gold in sulphidic brine to 625°C and 4 kbar measured in synthetic fluid inclusions by LA-ICPMS (abst.): Sixth International Symposium on Experimental Mineral., Petrol. and Geochem., Abstract Supplement No. 1 to TERRA Nova, v. 8, Supp. 1, p. 40-41. Authors at Research School of Earth Sci., Australian National Univ, Canberra, ACT, Australia.

The fS_2, fH_2, and pH buffer assemblages pyrrhotite + pyrite + magnetite + water (Py-Po-Mt-W) and muscovite + orthoclase + quartz (Mu-Or-Qz) were loaded in a gold foil capsule, together with ~0.06 ml of 1-molal KCl solution spiked with 7.5 ppm Th and 44 ppm U. The sealed capsule was run in a cold-seal vessel 10 days at 625 ± 3°C and 3.7 ± 0.2 kbar. During the run, a quartz rind containing primary FI up to 20 µm in diameter was precipitated upon the starting quartz pieces. Those synthetic FIs were opened individually by a 193-nm wavelength excimer laser microbeam for quantitative analysis of their dissolved Au content as 540 ± 200 ppm by inductively-coupled-plasma mass spec-trometry (ICPMS), employing the U and Th as internal standards, and using a synthetic glass standard to calibrate the relative ionization efficiencies of Au, U, and Th in the ICPMS. These data may be used to evaluate gold solubility as $HAu(HS)_2$ cover the range of T and P relevant to genesis of porphyry Au-Cu and slate-belt and greenstone gold lodes. (From authors' abstract by E.R.)

See also adjacent items. (E.R.)

LOUCKS, R.R., PALIN, J.M., SHELLEY, J.M.G., and **MAVROGENES, J.A.,** 1996a, Infrared laser extraction of gaseous components from selected individual melt or fluid inclusions in minerals for analysis by quadrupole mass spectrometry (abst.): Sixth International Symposium on Experimental Mineral., Petrol. and Geochem., Abstract Supplement No. 1 to TERRA Nova, v. 8, Supp. 1, p. 40. Authors at Research School of Earth Sci., Australian National Univ., Canberra, ACT, Australia.

The Research School of Earth Sci. has engineered unique instrumentation for in situ sampling and chemical analysis of gaseous components (H_2O, CO_2, CH_4, H_2S, SO_2, N_2, NH_3, H_2, etc) of single glass or FI in minerals. For G release, the SIGMA (Selected Inclusions Gas Micro-Analyzer) uses a 25-watt Nd-YAG laser that supplies a continuous-wave, infrared beam focussable to -10 µm diameter by a microscope objective. Most coloured minerals and glasses absorb sufficiently at the laser's 1064-nm wavelength to melt in response to the absorption. Quartz, feldspars and most other colourless minerals do not absorb significantly at that wavelength, but water absorbs the beam energy as heat, which permits a targeted, single aq FI to be gradually heated until it thermally decrepitates, releasing its volatile components into the high-vacuum sample chamber that is mounted to a microscope stage. The G released from melted minerals or glass or from a decrepitated FI are transmitted to a fast-scanning quadrupole mass spectrometer to precisely measure molar proportions of the gaseous species. Calibration is relative to pure G standards and certified G mixtures, as well as relative to our custom-made F or M I synthesized with known G concentrations.

The SIGMA permits precise analysis of synthetic FI that trapped samples of F experimentally equilibrated with mineral assemblages at high T and P, for the purpose of thermodynamically characterizing mineral-F equilibria. We also use it for analysis of F released by piercing experimental capsules containing F that have been equilibrated with minerals and/or melts at high T and P, and for analysis of volatiles experimentally dissolved in the glass itself. The SIGMA is also proving useful for measuring proportions of volatile components in natural FI for determinations of palaeo-F P and F-P gradients in V-saturated hydrothermal F columns. Applications of such high-precision FI geobarometry include barometric evaluation of post-entrapment vertical displacement on faults, or of post-entrapment erosion of the overlying rock column, or evaluation of regional tilting or relative uplift. (Authors' abstract.)

See also adjacent items (E.R.)

LOUCKS, R.R., PALIN, J.M., SHELLEY, J.M. and MAVROGENES, J.A., 1996b, Applications of the new SIGMA technique for mineral exploration in epithermal- and porphyry-type hydrothermal systems: Geol. Soc. of Australia Abstracts, v. 41, p. 259. First author at Australian Nat'l. Univ., Research School of Earth Sci., Canberra, Australia.

See also adjacent items (E.R.)

LOWENSTERN, J.C. and **SINCLAIR, W.D.,** 1996, Exsolved magmatic fluid and its role in the formation of comb-layered quartz at the Cretaceous Logtung W-Mo deposit, Yukon Territory, Canada: Earth Sci., v. 87, p. 294-303)also in: The Third Hutton Symposium, Geol. Soc. Amer. Special Paper 315).

Comb-layered quartz is a type of unidirectional solidification texture found at the roofs of shallow silicic intrusions that are often associated spatially with Mo and W mineralisation. The texture consists of multiple layers of euhedral, prismatic quartz crystals (Type I) that have grown on subplanar aplite substrates. The layers are separated by porphyritic aplite containing equant phenocrysts of quartz (Type II), which resemble quartz typical of volcanic rocks and porphyry intrusions. At Logtung, Type I quartz within comb layers is zoned with respect to a number of trace elements, including Al and K. Concentrations of these elements as well as Mn, Ti, Ge, Rb and H are anomalous and much higher than found in Type II quartz from Logtung or in igneous quartz reported elsewhere. The two populations appear to have formed under different conditions. The Type II quartz phenocrysts almost certainly grew from a high-silica M between 600 and 800°C (as β-quartz); in contrast, the morphology of Type I quartz is consistent with precipitation from a hydrothermal solution, possibly as α-quartz grown below 600°C. The bulk compositions of comb-layered rocks, as well as the aplite interlayers, are consistent with the hypothesis that these textures did not precipitate solely from a crystallizing silicate M. Instead, Type I quartz may have grown from pockets of exsolved magmatic F located between the magma and its crystallized border. The Type II quartz represents pre-existing phenocrysts in the underlying magma; this magma was quenched to aplite during fracturing/degassing events. Renewed and repeated formation and disruption of the pockets of exsolved aq F accounts for the rhythmic banding of the rocks. (Authors' abstract)

LU, Dengrong, 1996, Feature of volcanic rocks in Yamansu iron ore (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 655. Author at Xi'an College of Geology, Xi'an, China.

The iron ore and skarn occurs in volcanic rocks and relict texture of basalt and andesite is recognized in the skarn. Quartz $\delta D = -80.60 \sim -94.37‰$, $\delta^{18}O_{solid} = 6.15 \sim 14.80‰$, and $\delta^{18}O_{H_2O} = 6.00 \sim 12.18‰$, which shows that the hydrothermal source is mixed by ground-water (sea water). The Th of FI in calcite varies from 320°C or more to 50°C, and sal from 2.72 to 12.88%. The main compositions of FI in andradite are Ca^{2+}, Cl^-, Mg^{2+}, Na^+, K^+ and H_2O, CO_2, CO, etc. (From author's abstract by E.R.)

LU, Fengxiang, 1996, Deep mantle and its fluids: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 181-186. Author at China Univ. of Geosci., Wuhan, 430074.

This paper deals with the advance in study of the composition, geochemistry and deep-seated F of lower mantle, [and particularly] preserved in diamonds. The main components of deep F [from diamond studies?] are C, H, O, N, S, and they also contain Fe, Si, Cu, Pb, Zn, Sn, Ag, Au, W alkali metals and halogen elements. The study on deep F will contribute to the understanding of plume activity, generation of mantle magma, the global geodynamic processes and metallogenesis. (From author's abstract by E.R.)

LU, Fenxiang and ZHENG, Jianping, 1996, Fluid inclusion of diamond in Liaoning, China, implication for composition of mantle fluid (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 486. Authors at China Univ. of Geosci., Wuhan, P.R., China

Mantle F is the main object on study of metasomatic processes. Recently, FI are discovered in diamonds implying that there is closed relationship between diamond forming and mantle F.

Several diamonds sampled from kimberlite pipe No. 50 in Fuxian, Liaoning province. Most of the diamonds with FI [show?] developed growth. All diamonds are type I except two are type II. Solid I are graphite, phlogopite, olivine, rutile, calsite, apatite, chromite, zircon. The diamonds were determined in each with Infrared (IR) spectroscope at first, then with a Ramnor U 1000 Laser Raman microprobe.

FI contain CO_2, which is the main component of F. All samples contain H_2O. Almost all samples contain CH_2, [sic] H_2S, N_2, H_2. Furthermore, the FI without H_2S contain SO_2. It indicates the oxygen fugacity constant in F. N_2, H_2, and NH_3^- do not coexist in a single I, and implies the reaction $N_2 + 3H_2 = 2NH_3$ may [occur]. There are detail research on nebulous I of diamonds, and the results show tht H (may be H_2O) is the most important. They contain N_2, CO_2, CO, CH_4, also. In C-H-O system, there are several kinds of coexist relationship show below: $H_2 + CO_2 + CH_4 + H_2O$, $H_2 + H_2O + CO + CO_2$, $CH_4 + H_2O + CO + CO_2$. Based on the principle of facies, they present three reactions as following: $CO_2 + 4H_2 = CH_4 + 2H_2O$, $CO_2 + H_2 = CO + H_2O$, and $CH_4 + CO_2 = CO + 2H_2O$. It is said that every diamond probably represents a self-catalytic reaction system. HACONSP mantle juice (H - hydrogen, A = potassic, C - carbon, O - oxygen, N - nitrogen, S = sulfur, P = phosphorus) is the basic form of mantle F. The FI coming from different mantle samples represent divided segments of mantle F [sic]. (From authors' abstract by E.R.)

LU, Guxian, KONG, Qingcun, DENG, Jun, and **LI, Xiaobo,** 1996, Study and estimate of depths of the formation of the Linglong and Jiaojia gold deposits, Shandong: Geological Review (Dizhi Lunping), v. 42, no. 6 (1996) p. 550-559 [in Chinese; Engl. abst.] First author at Chinese Acad. of Geological Sci. CAGS, Beijing.

PVTX FI data are presented and discussed in relation to depth estimates. (HEB)

LU, Huanzhang, 1996, Magmatic fluid-magmatic and fluid inclusions studies on granites, South China: J. of Guilin Inst. of Tech., v. 16, no. 1 (1996) p. 1-13. [in Chinese, Engl. abst.) Author at Univ. du QuÇbec a Chicoutimi and Inst. of Geochem., Chinese Acad. of Sci.

The magmatic (M), magmatic-F and FI in granites of south China have been examined. The results show that the magmatic I in granites can be classified into three types: crystalline M; crystalline–glass M and glass. The Th of these range from 650 to 1100°C with optimum value from 850 to 925°C. Chemical and electron microprobe analysis of the composition of magmatic I indicates that they are similar to the bulk composition of the granite but richer in volatiles. Magmatic-FI represent the process of a transition from magma to hydrothermal F have been found. They consist of silicate M and F in one or a group inclusions and are usually found in rare elements bearing granites with optimum H temperatures of 750°C. The results explain that the granite driven from a partial melting of crustal or of crustal-mantle origin has difference in Th and composition. (Author's abstract)

LU, Huanzhang and CHI, Guoxiang, 1996, Geochemical characteristics of ore forming fluids in shear zone hosted Archean gold deposits: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 19-38. Authors at Univ. du Quebec a Chicoutimi, Chicoutimi, Quebec, G7H 2B1, Canada.

In terms of the composition, stable isotopes and trace element characteristics of ore-forming hydrothermal F in shear zone-hosted gold deposits, the authors consider that it is hard to draw a decisive conclusion on the source of ore-forming F. There are four possible sources of ore-forming F: metamorphic, magmatic, mantle degassing and 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 fourth source has not yet been accepted by most scientific researchers because it is in conflict [with evidence] that shear zone F are low in sal and high in P. There is a possibility of mixing of ore-forming F of various sources. Isotopic homogenization of ore-forming F in the same deposit or the same region suggests homogenization [before] entrance of ore F into a 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-forming F in a shear zone, which can reflect the control of the shear zone over gold mineralization.

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 in the study of geochemical characteristics of shear zone F. (From authors' abstract by E.R.)

LU, Huan-Zhang and WANG, Zhonggang, 1996, Electron microscope studies on fluid-melt inclusions of No. 3 pegmatite, Keketuohai, Xinjiang province, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 482. First author at Inst. of Geochem., Academia [Sinica], Guiyang, 550002, P.R. China.

The No.2 pegmatite of Keketuohai, the largest one in China, is located in the Fuyun country, Xinjiang province. It is being mined for Li, Be, Nb and Ta in abundant spodumene, beryl, and pollucite. The pegmatite occurs in a gabbro which is on the top of a biotite granite. It consists of 10 zones (in the probably sequence of formation): graphic zone (I) with a assemblage of quartz, feldspar and beryl; coarse grained albite zone (II), Be ore body; massive microcline zone (III), with beryl; muscovite and quartz zone (IV), with Be, Nb, and Ta mineralization; cleavelandite and spodumene zone (V) with Li, Nb and Ta mineralization; quartz-spodumene zone (VI) rich in Li, Nb, and Ta; muscovite and albite zone (VII) with Ta and Cs mineralization; albite-lepidolite zone (VIII) Li, Ta, Rb, Cs ore body; quartz-pollucite zone (IX) with Cs mineralization; and massive microcline and quartz zone (X, core) rich in Rb and Cs.

F, F-M and MI studies in spodumene, beryl, petalite and coexisting quartz from different zones show four types of I: M, F-M, H_2O-CO_2, and aq. MI are found in zone I, and M-FI (consist of M and F, the F are mostly H_2O and CO2, in one I) occur in zones I, III and IV. Aq I occur in all zones except in Zone I. Most H_2O-CO_2 I are found from Zone IV to X, coexisting with aq I. Microthermometric data show that Th of M I range from 700 to 900°C. Th of M-FI range from 570 to 720°C, and that for aq and H_2O-CO_2 I range from 305 to 510°C. The sal in aq I range from 5 to 9 wt.% NaCl eq., which is relatively low. The P calculated from H_2O-CO_2 and CO_2 I is from 800 to 1500 bars.

The composition of dm in F-M I by electron microscope analyses, are beryl, quartz, K-feldspar, spodumene, apatite, albite, etc. which are similar to the mineral assemblage of the pegmatite.

The results indicate that the No.3 pegmatite was formed during the transition from magmatic to subsolidus hydrothermal F conditions, occurring probably in three stages. Stage 1 was magmatic; stage 2 implicated immiscible processes to produce M and F; the final stage was predominantly issuing F. Li, Be, Nb, Ta and Cs mineralization resulted most likely throughout this transition. (Authors' abstract.)

LU, Jianchun, SECCOMBE, P.K. and ELDRIDGE, C.S., 1996, SHRIMP S-isotope evidence for F mixing during gold mineralization in a slate-belt gold deposit (Hill End, New South Wales, Australia): Chemical Geol. (Isotope Geosci. Sect.), v. 127 (1996) p. 229-240. First author at School of Earth Sci., Univ. of Melbourne, Parkville, Vic. 3052, Australia.

Sensitive high-resolution ion microprobe (SHRIMP) sulfur isotope data show that pyrrhotite, pyrite, galena and chalcopyrite in syntectonic auriferous quartz veins at the Hill End goldfield are characterized by two populations, with $\delta^{34}S$ fluid -values of ~ +7 and ~0‰. These two populations are accounted for by F mixing involving two sources of sulfur during evolution of the veins systems. A local sulfur source and reduced fluids derived from trough-fill Siluro-Devonian sedimentary and volcano-sedimentary sequences are responsible for the first two gold-bearing events, whereas a more oxidized F and a sulfur source from turbidites and volcanics in deeper parts of the crustal sequences appear responsible for gold deposition late in the second fold-forming event and are the dominant influences in the final gold-forming stage. For fine-grained mixtures, where mineral separation is difficult, the SHRIMP analyses are particularly useful for tracing detailed $\delta^{34}S$ variations of sulfides precipitated in different paragenetic stages. (Authors' abstract)

LU, J., SECCOMBE, P.K., FOSTER, D., and ANDREW, A.S., 1996, Timing of mineralization and source of fluids in a slate-belt auriferous vein system, Hill End goldfield, NSW, Australia: evidence from ^{40}Ar / ^{39}Ar dating and O- and H-isotopes: Lithos, v. 38 (1996) p. 147-165. First author at School of Earth Sci., Univ. of Melbourne, Parkville, Vic. 3052, Australia.

^{40}Ar / ^{39}Ar dating of metamorphic biotite and alteration muscovite from the auriferous veins and host rocks at the Hill End goldfield, N.S.W., Australia, has distinguished four major geological events, including the timing of gold mineralization. The earliest hydrothermal event occurred during the Middle Devonian Tabberabberan Orogeny (370-380 Ma) and resulted in the formation of quartz veins barren of Au. A second and major episode of vein emplacement occurred in the Early Carboniferous during the principal phase of metamorphism and deformation at 359-363 Ma. This was followed by Au accumulation in two stages: (1)

after the major phases of quartz deposition, and (2) during and after the development of conspicuous internal vein laminations (~357 Ma and ~343 Ma, respectively). Two sources of F are proposed for vein and ore formation. The first is a local metamorphic F characterized by $\delta^{18}O_{H_2O}$ values of 8.9 to 12.5 per mil and δD_{H_2O} values of -87 to -90 per mil. The second is a mixed ore F with $\delta^{18}O$ and δD values in the range of $\delta^{18}O_{H_2O}$ 8.4 to 11 per mil and δD_{H_2O} of -49 to -36 per mil. Progressive entry of this second F, sourced from trough-fill or deeper crustal rocks, is linked closely to cycles of gold precipitation at Hill End. (Authors' abstract)

LU, Jianchun, SECCOMBE, P.K. and **WALSHE, J.L.,** 1996, Conditions of chlorite growth in the Hill End goldfield, New South Wales, Australia: some predictions and evaluations: The Canadian Mineralogist, v. 34 (1996) p. 9-21. Author at School of Earth Sci., Univ. of Melbourne, Parkville, Vic 3052, Australia.

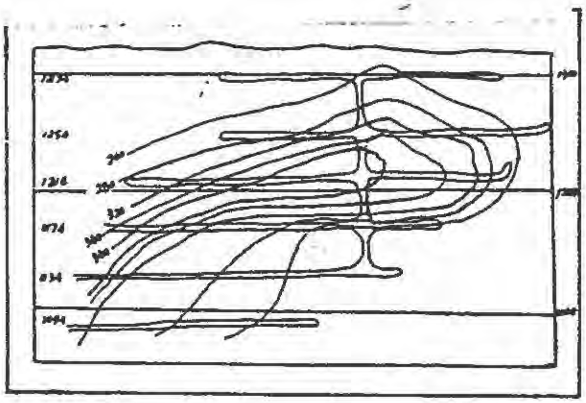
A solid-solution model for the composition of chlorite has been used to calculate the physicochemical conditions of gold deposition for the slate-belt-hosted Hill End goldfield in the Paleozoic Lachlan Fold Belt of New South Wales, Australia. A P-T range of 295-340°C and 1.4-3 kbar, and the redox conditions for three major stages of gold mineralization, are estimated by combining data for T, $f(O_2)$ and $f(S_2)$, calculated from chlorite compositions, with the results obtained from F-I analyses and a knowledge of the mineral paragenesis. Gold deposition occurred in a redox environment where $f(O_2)$ ranged from 10^{-32} to $10^{-36.4}$, tracked by F and mineral species from below the CO_2-CH_4 stability boundary to above the pyrite-pyrrhotite stability boundary, respectively. The T corrections to FI Th data provided by the chlorite model could be as high as 190°C. With careful paragenetic control, the chlorite geothermometer seems to be a powerful tool in deciphering multistage F systems, and offers a solution to some of the ambiguities attending FI studies in metamorphic environments. (Authors' abstract)

LU, Ren and **KEPPLER, Hans,** 1996, Solubility of hydroxyl in pyrope garnet: an infrared spectroscopic study (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 555. Authors at Bayerisches Geoinstitut, Universität Bayreuth, D-95440 Bayreuth, Germany.

Knowledge on the solubility of water in mantle minerals required for understanding the budget and evolution of volatiles in the Earth. Single crystals of natural pyrope were found to contain nearly 100 ppm H_2O. (E.R.)

LU, X.L., ZHANG, I.G. and LI, Q.B., 1996, Application of the method of fluid inclusion burst thermometry to mining geological work (for example Hatu deposit) (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 774. Authors at Nonferrous Metals Corporation, Xinjang, China.

The authors admit that many factors affect "FI burst thermometry" (i.e., decrepitation), but they utilized "statistical principle," and a "lot of data," to draw 260° to 360°C isotherms on a mine section. (E.R.)



Hatu Gold deposit 1.7 vein's vertical vein projection and isotherm map.

LUCZAJ, J.A., 1996, Diagenesis of the Lower Permian Krider dolomite, southwest Kansas: Fluid-inclusion, U-Pb, and fission-track evidence for reflux dolomitization during latest Permian time (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 76-77. Author at Dept. of Earth and Planetary Sci., The Johns Hopkins Univ., 3400 North Charles Street, Baltimore, MD 21218.

Although some aq all-liquid I are present, most FI are aq and two-phase and contain a G under P (4 - 30 bars) assumed to be methane. I are concentrated in the position of CL Zone 1 and are petrographically P to *recrystallization.* They yield reliable Th's from 60 to 95°C (a few as high as ~150°C; mean is 85.4°C), indicating that the rocks were exposed to T of at least 95°C. Th data suggest that some FIA's have undergone different degrees of reequilibration or were entrapped during variable T conditions. Te's of ~-57°C are consistent with a $NaCl$-$CaCl_2$-$MgCl_2$-H_2O model composition for the I F. A brine composition with an elevated Mg^{+2}/Ca^{+2} ratio is consistent with evaporated sea water, however, the effect of a high SO_4^{-2} concentration on the F I eutectic T in a complex system is not well known. The Tm_{ice} values ranged from –22.7 to –17.5°C with a mean of –21.2°C for all wells, which yields sal values from 20.6 to 24.1 wt.% NaCl eq. (ave. 23.2 wt.% NaCl eq.). There were no significant differences for Te or Tm_{ice} values between the all-liquid and the two-phase I. All-liquid I indicate some recrystallization of the dolomite below ~ 50° C. Stretching of all-liquid I may be responsible for the two-phase I in the lower Krider.

A proposed model suggests that during the latest Permian (~ 256 ± 19 Ma), regional reflux of highly saline, Mg^{+2}-bearing brines associated with the regional precipitation of Permian evaporites (Sumner and/or Nippewalla Groups) precipitated U-bearing dolomite and recrystallized earlier dolomite in the lower Krider at low temperatures (< ~50°C). Some I were thermally reequilibrated by stretching after the Permian possibly by either increased burial and a high geothermal gradient during the Cretaceous or by hot, gravity-driven F flow through the Rocky Mountain foreland during the Tertiary. U (and possibly other rare earth elements) may have been leached from various minerals in the Permian redbeds of the Sumner and Nippewalla Groups during brine reflux, or U may have been sourced from evaporated seawater. Local U incorporation in dolomite may have been influenced by local pore F factors. Methane incorporated in the I at this time was generated locally from decay of original organic matter in the rocks. Massive natural G deposits present in the Hugoton today migrated as a free phase since latest Permian time (~256 ± 19 Ma). (From author's abstract by E.R.)

LÜDERS, Volker, 1996, Contribution of infrared microscopy to FI studies in some opaque minerals (wolframite, stibnite, bournonite): Metallogenic implications: Economic Geol., v. 91 (1996), p. 1462-1468. Author at GeoForschungsZentrum Potsdam, PB, 43 Lagerstättenbildung, Telegrafenberg A 50, D-14473 Potsdam, Germany.

Presents Th and sal data on Pangsqueira, Portugal (wolframite and quartz); Erzgebirge, Germany, (wolframite and quartz), and Zinnwald (wolframite). Both quartz samples were much lower sal and mostly lower in Th. Stibnite and late-Varsican quartz from Wolfsberg had <u>much</u> lower sal (~ -2 to -3) accompanying Mesozoic quartz and bournonite (-30 to -35°C). (E.R.)

LÜDERS, Volker and **REUTEL, Christian,** 1996, Possibilities and limits of infrared microscopy applied to studies of fluid inclusions in sulfides and other opaque minerals (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 78-80. First author at GeoForschungsZentrum Potsdam, PB 4.3 Lagerstättenbildung, Telegrafenberg A 50, D - 14473 Potsdam (Germany)

The limitations of the various available IR instruments, and the laboratory technique are discussed. Campbell et al. (1988) were not able to measure Th of FIs in wolframite from the Panasqueira deposit (Portugal) with the Research Devices Model F IR microscope. It turned out that the observed phenomenon of decreasing IR-transparency with progressive heating can be compensated by boosting the sensivity of the IR camera, and measurements of the Th are possible. The data obtained indicate sal of P and pseudosecondary FI between 7-19 wt.% NaCl eq. and mean Th between 300 to 330°C. The data obtained clearly differ from those of I in associated quartz (mean sal 8.5 wt.% NaCl eq., mean Th 280°C) which is assumed to have deposited cogenetically (Kelly & Rye, 1979, Campbell et al., 1988).

The problem of decreasing IR-transparency during heating particularly appears in sulfides. Due to the varying quality of IR-transmittance, many pyrites become opaque upon heating mostly prior to homogenization of contained FIs. Until now, combined measurements of Tm ice (-3.3 to - -2.2°C) and Th (211 - 256.5°C) were only obtained from FIs in pyrite octahedrons from the Murgul Cu deposit (NE Turkey). Pentagondodecahedrons from the same deposit became opaque at T between 250 and 270°C before the Th of two-phase I is reached. Th of these I were obtained by a cyclic technique similar to that described by Goldstein & Reynolds (1994). The precision of the obtained Th (298 to 324°C) lies in a range of ± 2.0°C. (From authors' abstract by E.R.)

LUO, Cairang, 1996, Reformed-type nickel, iron and gold deposits–a new type of ore deposits (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 664. Author at NW Nonfer. Geol. Inst., Xian, China.

Inside and outside of Jin-Ning stage altered ultra-basic rocks exist nickel, iron and gold ore deposits in Jiancha-Ling, Shaanxi province.

$\delta^{34}S$ values of pyrite in rocks and ores (6.30-29.1‰) imply the multisource features of sulfur, $\delta^{34}S$ values, standard deviation increase from granite porphyry (8.30-10.6‰) to nickel ores (8.6-17.4‰) and gold ores (10.9-29.10/00 [sic; 10.9-29.1‰?]).

The Th of quartz enclosure in magnesite is 200-370°C while that in gold ores is 187-275°C, showing that ore-forming F migrates outward from granite porphyry. (From author's abstract by E.R.)

LUO, Xianchang, WANG, Zhengrun, WU, Yanzhi, and **YANG, Mu,** 1996, Mineralization and genesis of Xianghualing nonferrous rare-polymetal ore field, Hunan, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 631. Authors at Central South Univ. of Tech., Changsha, 410083, China.

Xianghualing ore field is related to granitic bodies rich in fluorine and ore-forming trace elements and considered as the main source of ore-forming material. The mineralization T ranges from 149°C to 442°C, and the pressure from 292 x 10^5 Pa to 443 x 10^5 Pa, $\delta^{34}S$, -1.196‰ to +5.56‰. The isotopic Pb in ore is normal Pb and the Pb model age ranges from 66.5 Ma to 125 Ma. (From authors' abstract by E.R.)

LUO, Xuequan, 1996, Typomorphic characteristics and geological implications of minerals from the Chanziping gold deposit, Hunan Province: Acta Petrologica et Mineralogica, v. 15, no. 2 (1996) p. 170-179. [in Chinese; Engl. abst.] Author at No. 407 Geological Party, Hunan Bureau of Geol. and Mineral Resources, Huaihua 418000.

The ore deposit was formed through silicification, sericitization, pyritization and arsenopyritization of shear-tensiletectonite. G-L I are numerous in quartz, being from 1 Ēm to 18 Ēm, with G to L ratios 5% -15% and Th 180-320°C. G phase is dominated by H_2O and CO_2, and deficient in N_2, H_2O, $H_2O >> CO_2$, $Na^+/K^+ = 0.8–4.47$, $Cl^- > F^-$. At the quartz-pyrite-arsenopyrite stage, $\delta^{18}OH_2O$ = 0.79‰–7.14‰, similar to values of Baimashan granite, and δDH_2O = -54.7‰–91.2‰, suggesting character of magmatic water. (From authors' abstract by E.R.)

LÜETTGE, Andreas, METZ, Paul, WALTHER, Johannes, ALTHAUS, Egon and **HEINRICH, Wilhelm,** 1996, CO_2-H_2O fluid inclusions in forsterite; an experimental study: European J. of Mineral., v. 8, no. 5, p. 997-1014.

Full paper for previous abstract (E.R.)

P I (10-20 µm) of CO_2 - H_2O F were produced in crystals of forsterite synthesized n a conventional hydrothermal apparatus by the reaction: 1 tremolite + 11 dolomite ⇔ 8 forsterite + 13 calcite + 9 CO_2 + 1 H_2O . Stoichiometric mixtures of dolomite and tremolite powders (grain size fraction 80-100 µm) were used to form the forsterite and calcite. Experiments were performed at P = 500 MPa, T = 670°C with a CO_2 - H_2O F in the range X_{CO_2} = 0.10-0.16, and at 720°C with an X_{CO_2} of 0.40-0.44. Petrographic microscopy reveals that many of the synthesized forsterite crystals contain FI. The reults of microthermometric analysis show that these forsterite hosts formed at 670°C trap three different types of I: 1) I representing the bulk composition of the F phase present during the runs (X_{CO_2} = 0.10-0.16); 2) I having slightly smaller amounts of CO_2 (X_{CO_2} = 0.08) than the starting composition, and 3) I having a significantly higher amount of CO_2 (X_{CO_2} = 0.26) than the bulk composition at the end of the run. FI in forsterite hosts produced at 720°C always contain a significantly higher CO_2 concentration (X_{CO_2} = 0.47-0.60) than the bulk composition of the F (X_{CO_2} = 0.40-0.44).

The different sites of forsterite nucleation and growth combined with weak convection of the F can explain the different F trapped in forsterite. The deviation of the trapped F from the bulk composition demonstrate that the F phase was inhomogeneous over distances of millimeters or tenths of millimeters, indicating that microsystems with F of different composition existed within the mineral powders of the experiments at least during the period of formation of the single FI. Microsystems with F of different composition probably account for the different neighboring microstructures seen in natural rocks.

LYAKHOVSKY, V., HURWITZ, S. and **NAVON, O.**, 1996, Bubble growth in rhyolitic melts: experimental and numerical investigation: Bull Volcanol, v. 58 (1996) p. 19-32. Authors at Inst. of Earth Sci., Hebrew Univ., 1-91904 Jerusalem, Israel.

Our results indicate that equilibrium degassing is a good approximation for modeling vesiculation in M with high water concentrations (Co > 3 wt%) in the region above the nucleation level. (From authors' abstract by E.R.)

MA, Guoxi, 1996, Geological feature of the zinc-molybdenum deposit of Dawan of Laiyuan County, Hebei province of China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 572. Author at Hebei Bureau of Geol. and Expl., MGMR, China.

Large-size zinc-molybdenum-[Ag] deposit of Dawan has a mineralization process mainly related to rhyolite porphyry, which is Si-rich and K-rich. The analysis of FI show that the ore solution was characterized by boiling, and the ore-forming T is 150 to 450°, the saltation 5-45%, the P $50\text{-}750 \times 10^{-5}$; and sulphur isotopes indicate that the sulphur of the deposit is from multi-sources, primarily deep-source; and the hydrogen-oxygen isotope show that the water in the atmosphere takes part in mineralization process, which has multi-period and multi-stages. (From author's abstract by E.R.)

MA, Xiujuan, 1996, Discovery of organic inclusions and study of mineralization of Jinya gold deposit (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 486. Author at Inst. of Mineral Deposits, Beijing, 100037.

The Jinya gold deposits in Guangxi occur in Triassic sedimentary rocks. The deposits are related to the fine grained-impregnation type of gold deposits.

FI study shows Th of I, formed during mineralization, range from 98 to 326°C, salts and densities of F are 0.06-4.96 wt.% NaCl., and 0.72-1 g/cm^3 respectively.

Boiling is observed in some ore-forming F. Th measured for these FI are 246-247°C and their salts 1.95-3.18 wt.% NaCl. The boiling P is 12.5 MPa, which may be considered as the minimal P of gold mineralization. But the P at main stage of ore deposition can range from 20 to 30 MPa, and the depth of mineralization is about 800-1200 m. Isotopic study of FI gives following data: $\delta D = -30.94 \sim -69.67(‰)$, $\delta^{18}O_{H_2O} = -4.11 - +15.76(‰)$, which shows the F are polygenic, the ore-forming F consist of magmatic, syngenetic, and atmospheric waters.

This study discovered, among FI formed during mineralization, some organic I, including hydrocarbon bearing salt-water I and pure hydrocarbon organic I. The hydrocarbon bearing salt-water FI are formed when hydro-carbon G is trapped. Their Th may be as high as 313°C. Inclusions, formed during middle and late stages of mineralization, are mainly the I bearing L hydrocarbon, their minimal Th is only about 98°C. Pure hydrocarbon I appear yellow-blue coloured under luminescence. Accordingly, hydrocarbon possibly is related to L pitch in com-position.

It can be concluded that the organic material has taken part in process of the formation of Jinya gold deposits. (From author's abstract by E.R.)

MACDONALD, R.W.J., BARRETT, T.J. and **SHERLOCK, R.L.**, 1996, Geology and lithogeochemistry at the Hidden Creek Massive sulfide deposit, Anyox, west-central British Columbia: Explor. Mining Geol., v. 5, no. 4, p. 369-398. First author at Mineral Deposit Research Unit, Dept. of Earth and Ocean Sci., Univ. of British Columbia, 6339 Stores Rd., Vancouver, BC, Canada, V6T 1Z4.

The Hidden Creek Massive sulfide deposit produced 21 Mt of ore grading 1.57% Cu with minor precious metals. It consists of eight ore zones of variable size that occur near the volcanic-sedimentary contact. Hydrothermal alteration increases in proximity to the mineralized zones. Chlorite-epidote-quartz alteration is prevalent in the footwall volcanic rocks. Alteration in the sedimentary sequence is zoned outward from a quartz-chlorite core to a quartz-sericite-pyrite margin. In the sediment-hosted ores, quartz and calcite are the common gangue minerals, whereas in volcanic-hosted ores, Mg-Ca-Al silicates are common. FI Th for feeder veins in the Hidden Creek footwall range from 194 to 295°C, with sal of 4.6 to 8.9 wt.% NaCl eq. Mass change calculations for the volcanic rocks indicate a progressive loss of CaO + Na_2O and gain in MgO + FeO corresponding to breakdown of plagioclase and formation of chlorite during hydrothermal alteration. K has been added (now in biotite) to the upper volcanic rocks. FI data from the Hidden Creek deposit are similar to data from sediment-covered hydrothermal systems at Windy Craggy, and in the Guaymas Basin in the Gulf of California. These modern systems provide partial analogs for the seafloor setting and styles of mineralization at Anyox. (From authors' abstract by E.R.)

MACLEOD, Gordon, JONES, Martin and **CHEN, Mei**, 1996, Petroleum fluid inclusion research: NRG News, May 1996.

Over the last twelve months, staff at the NRG have made some significant steps forward in petroleum FI technology. The application of confocal scanning laser microscopy (CSLM) has been further developed and it is now possible to obtain an effective C_1-C_{20+} characterisation of the trapped "live" petroleum, within micro sized petroleum I. Method development has also been undertaken to provide a satisfactory methodology for the molecular characterisation of petroleum trapped inside petroleum FI. These new technologies allow the evolution, maturity and source of petroleum moving through carrier beds and into reservoirs to be traced during burial. It may also be possible to time the biodegradation of petroleum via FI compositional analysis. This data can then be further combined with FI microthermometry, field and/or regional geochemical studies, allowing more detailed and otherwise unobtainable understanding of petroleum generation and migration in different geological units to be gained (Authors' abstract)

This is a 4-page summary that appeared in the May, 1996, issue of NRG News on the NRG home page under title Fluid Inclusion News; URL (http://nrg.ncl.ac.uk/ilg/nrg-news96/fluidinclusions.html) (E.R.)

MACLEOD, G., LARTER, S.R., APLIN, A.C., PEDERSEN, K.S. and **BOOTH, T.A.**, 1996, Determination of the effective composition of single petroleum inclusions using confocal scanning laser microscopy and

PVT simulation (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 81-82. First author at Newcastle Research Group In Fossil Fuels and Environmental Geochem., Postgraduate Inst., Newcastle upon Tyne, Drummond Building, Univ. of Newcastle, Newcastle upon Tyne, NE1 7RU, UK.

It is desirable to determine an accurate composition (e.g. C_1-C_{20} + alkanes) of petroleum in FI within diagenetic cements from petroleum reservoirs and carrier units for two reasons. Firstly, when coupled with microthermometric data, it enables us to track the compositional evolution of petroleum during S migration and field filling. This information allows exploration and production geoscientists to determine the timing and direction of petroleum movement in sedimentary basins, and to determine filling histories for reservoirs. This information can be used to help locate satellite reservoirs and fill-spill sequences. Secondly, an accurate compositional analysis is required to model the PVT behaviour of included petroleum. This is central to the use of coeval aq and petroleum I in the determination of palaeopressure using the "intersecting isochores" technique. Accurate palaeopressures can then be used to determine the timing of such phenomena as seal failure and the onset of overpressure. Thus we require an assessment of the composition and PVT properties of petroleum within single I.

Our approach to this problem has been to exploit the ability of the Confocal Scanning Laser Microscope (CSLM) to produce a three-dimensional image of the L and V within a FI with the expected relationship between the composition of petroleum and its L:V ratio. [Three examples are shown on a P-T plot, along with bubble point and dew point curves, in Fig. 1.] The software also enables one to calculate the isochores displayed in Figure 1.

Analysis of the 3D images from the CSLM enables one to calculate the true volume percent of V and L inside the I. These are usually very different (lower) to those estimated by 2-dimensional observation in the heating-freezing stage. By combining the measured Th of the I being studied, with the CSLM measured volume percent of V and L at room T, we can use commercially available PVT software to iteratively back calculate the 'effective' C_1-C_{20} + composition of the 'live' included petroleum. It also allows isochores to be calculated and gives a representative GOR of the petroleum in the I this can then be used to interpret the compositional evolution of petroleum through time. This powerful new technology allows petroleum FI micro-thermometry to be linked to petroleum composition, offering exciting applications of FI studies in petroleum exploration. (From authors' abstract by E.R.)

MAEDA, Katsuhiko, IZAWA, Eiji, WATANABE, Koichiro, and KUSAKABE, Minoru, 1996, Hydrothermal alteration of rhyolite and sandstone in the Arita-Hasami area, western Kyushu, Japan (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 26. First author at Dept. of Mining, Kyushu Univ., Japan.

The FI study on quartz veins from the epithermal Hasami gold deposit indicates that hydrothermal solution was boiling at about 240°C. Erosional depths from the paleo-surface is estimated to be at least 200 m by the hydrostatic boiling point-depth relation and geological evidences. Hydrothermal alteration of the igneous rocks can be classified into four zones on the basis of hydrothermal mineral assemblages. (From authors' abstract by E.R.)

MAEDA, S., TAKAGI, H., SANADA, K., HAYASHI, M., TAGUCHI, S., SASADA, M., SAWAKI, T. and UCHIDA, T., 1996, Application laser Raman microprobe to gas analysis of fluid inclusions from active geothermal fields: 1996 Annual Meeting of the Geothermal Research Society of Japan, Abstracts with Programs, p. 49 (in Japanese).

MAGAKYAN, R.G., CASEY, J.F., TSAMERYAN, O.P. and SUSHCHEVSKAYA, N. M., 1996, Compositional heterogeneity of melts parental to low Na & K-MORB (Hayes Transform, Petrov Discontinuity, North of Atlantis Transform, Deep Royal Trough, and TAG areas of Atlantic) (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F833, November 12, 1996. First author at Dept. of Geosci., Univ. of Houston, Houston, TX 77204-5503; e-mail (Ruben@uh.edu)

Mid-oceanic ridge basalts and glasses can be subdivided into four MORB populations on the basis of major elements (Na and K). These include: low Na&K-MORB, High Na-MORB, High K-MORB, and High Na&K-MORB. Our detailed geochemical studies of MI for each of these end-member types of MORB show that primitive I in a single sample can be characterized by large compositional ranges and strong heterogeneity. (From authors' abstract by E.R.)

MAHER, D.J., 1995, Spatial and temporal relationships of hydrothermal mineral assemblages at Veteran Extension in the Robinson (Ely) porphyry copper system, Nevada (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A48-A49. Author at Geosci. Dept., Oregon State Univ., Corvallis, OR 97331.

Jasperoid (oxidized silica-pyrite alteration) at Veteran Extension covers over two million square feet and extends from the present surface to depths of 600-800 feet. Jasperoid is characterized by very fine-grained quartz and variable amounts of goethite±hematite (both after pyrite) ±relict hypogene specular hematite±Au. In the central portion of the pervasive altered zone and along strike with a major pre-mineral fault lies a zone of intense brecciation. Here the abundant chert nodules in the Ely Formation have been fractured and completely dissociated and the carbonate matrix replaced by silica. Jasperoid also contains Au with values that range from below the detection limit of 0.001 to greater than 0.2 ounces per ton, with no distinct relationship between grade and textural or spatial characteristics. Numerous, small FI in the jasperoid were observed and range from L+V $\pm CO_2$ to multiphase I with halite + sylvite ± hematite daughter products, indicating very sal (>26 wt% NaCl eq.) F. Variability of Au grades, FI sal, and other evidence suggest a minimum of two different hypogene jasperoid occurrences or at least a range of conditions under which jasperoids formed.

A space-time model has been generated for Veteran Extension using the aforementioned data. Predominantly sill-like porphyries were intruded into the core and along the flanks of the anticline at Veteran Extension and hydrothermal F and related alteration extended along numerous bedding contacts in the Ely Formation. Initial, saline, magmatic F at Th (≈350-400 to 500°C), formed silica + pyrite±chalcopyrite alteration in more distal areas of wall rock, destroyed skarns and may have deposited much of the gold at Veteran Extension. Later, diluted, meteoric F at lower T (≈200 to 350-400°C), resulted in sericitic alteration of porphyry and deposited more silica-pyrite (±chalcopyrite?) in distal environments, partially altered local skarn bodies, and may have deposited more gold at lesser grades.

Low T (100 to 200°C), base metal sulfide-bearing veins formed in the most distal locations. Finally, supergene alteration characterized by dilute, meteoric, very acidic solutions at low T (25 to 200°C), altered porphyry to quartz+cristobalite+alunite/jarosite and formed jasperoid that extended from the paleo-surface to a few hundred feet below the current surface and caused goethite, hematite, and additional silica deposition, as well as secondary Cu enrichment. (From author's abstract by H.E.B.)

MALI, H., 1996, Genesis of Hg- and Sb-vein-type mineralisations in the Austroalpine units of the Eastern Alps: Plate tectonic aspects of the Alpine metallogeny in the Carpatho-Balkan region, Proceedings of the Annual Meeting, Sofia, UNESCO-IGCP Project No. 356, v. 1, p. 93-98.

In the Austroalpine units of the Eastern Alps, seven small deposits of mercury and antimony (Gratwein, Bruckl, Guginock, Lessing, Radlbergalm, Mariengrube, Obertillach) were studied. The deposits comprising veins, faults and shear zones penetrating limestone, marbles, gneisses, mica schists, basic and acid volcanics are controlled by structures sometimes paralleling major faults which were active during the Alpine orogeny. Open-space filling with crustification, combstructure, symmetrical banding, small cavities, telescoping and cockade structures indicating a hydrothermal and shallow seated circulating F system were observed. The mineralisation process usually starts with an As-Fe(-W)-association followed by a base metal stage containing phases of Cu, Sb, As, Fe, Pb, Zn, Ni and Bi. The latest and main stage is characterized by a paragenesis of Sb-, Fe- and As-minerals; in the Gratwein deposit cinnabar is the final ore mineral.

Interpretation of microthermometric data of pseudosecondary FI in quartz containing ore dm and oxygen isotopic fractionation of oxygen bearing minerals point to formation T of the main stage between 270°C and 80°C with Radlbergalm and Lessing being on the high T end, and Gratwein showing the lowest T. P are low and lie in the range of a few 100 bars. Ore bearing FI are often highly saline, sometimes containing salt cubes. CO_2, N_2, CH_4 and H_2S were detected in the G bubbles. Dilution and oxidation, pH and Eh changes, simple cooling and boiling of the metal bearing F lead to precipitation of the ore. Hydrogen and oxygen isotope data suggest a metamorphogenic origin of the F.

In accordance with other vein type deposits of the Kreuzeck Mountains the heat source for the hydrothermal systems except those from Bruckl and Gratwein could be found in a late Alpine shallow-seated plutonic or subvolcanic magma emplaced along the great Periadriatic lineament. (Author's abstract)

MALININ, S.D. and **KRAVCHUK, I.F.,** 1995, Behavior of chlorine in equilibria between silicate melts and aqueous chloride fluids: Geokhimiya 1995, no. 8, p. 1110-1130 (in Russian, translated in Geoch. Int'l, v. 33, no. 7, p. 49-71, 1996) Authors at Vernadskiy Inst. of Geoch. and Analytical Chemistry, Russian Acad. of Sci., Moscow.

A critical survey of the published data on the geochemistry of chlorine (chlorides) in magmatic processes and of research on the behavior of chlorine in equilibria between aq chloride F and silicate M is presented. (From author's abstract by E.R.

MALININ, S.D. and **KUROVSKAYA, N.A.,** 1996a, Fluorite and scheelite equilibrium with heterogenous supercritical aqueous salt solutions (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 708. Authors at Vernadsky Inst. of Geochem. & Analyt. Chem. RAS, Moscow, Russia.

MALININ, S.D. and **KUROVSKAYA, N.A.,** 1996b, The effect of pressure on mineral solubility in aqueous chloride solutions under supercritical conditions: Geokhimiya 1996, no. 1, p. 50-58 (in Russian, Engl. abst.)

In the context of the investigation of F phases as an environment for ore (mineral) material mobilization and transport, the solubilities of fluorite and scheelite were studied by the monocrystal weight-loss technique. Solubility in a 2 M NaCl solution was measured at 600°C and at 0.5, 0.7, 1.0, 1.5, and 2.0 kbar. A maximum solubility of 3 g CaF_2 / kg H_2O and 2.9 g $CaWO_4$ / kg H_2O was reached at 0.5 - 0.7 kbar. The solubility decreases approximately by an order of magnitude as the pressure is increased to 1 kbar, and only slightly increases at 1.5 and 2.0 kbar. This kind of relationship is caused by the NaCl-H_2O F heterogenization at a P less than 1 kbar with the formation of a concentrated phase that has a high capacity for dissolving minerals. The results of an independent calculation of solubility in the heterogeneous system carried out by the lever rule are in good agreement with the experiment. The observed relatively small effect of P on mineral solubility in homogeneous F indirectly supports our previous proposal that charge-free particles of complex composition are produced by fluorite and scheelite dissolution. As opposed to the generally accepted concept, the results obtained show that a decrease in P does not always stimulate ore (mineral) deposition. On the contrary, the heterogenization of natural F solutions, induced by a pressure drop or by gaseous components, may occasionally serve as an additional agent of ore (mineral) mobilization and ore stabilization in solutions. (Authors' abstract)

MALININ, S.D. and **KUROVSKAYA, N.A.,** 1996c, Fluorite solubility in aqueous solutions of NaCl, $CaCl_2$, and their mixtures at 400-600°C and 2kbar: Geochem. Int'l., v. 34, no. 12, p. 1065-xxxx.

MANDEVILLE, C.W., CAREY, Steven and **SIGURDSSON, Haraldur,** 1996, Magma mixing, fractional crystallization and volatile degassing during the 1883 eruption of Krakatau volcano, Indonesia: J. of Volcanol. and Geothermal Res., v. 74, p. 243-274. Authors at Univ. of Rhode Island, Grad. School of Oceanography, Narragansett, Rhode Island 02882-1197.

The 1883 eruption of Krakatau volcano, Indonesia produced approximately 12.5 km^3 (DRE) of magma, 90% rhyodacite, 4% mafic dacite, and 1% andesite (5% lithic material assumed). M compositions in the erupted products based on the study of glass I and matrix glasses span a minimum range of 13 wt.% SiO_2. Well defined linear trends of major elements have been successfully modelled by incremental fractional crystallization of plagioclase, pyroxene, and Fe-Ti oxides from andesitic parental magma to produce rhyodacite. This fractional crystallization model is supported by trace-element and isotopic data.

The 1883 magma chamber was compositionally and thermally zoned with an upper portion of homogeneous rhyodacite at a T of 880-890°C overlying more mafic dacite at 890-913°C, and andesite at 980-1000°C. Mafic dacite represents a hybrid magma formed by mixing small amounts of andesite with larger amounts of evolved rhyodacite. Evidence for magma mixing consists of banded pumice, glass I that are more mafic than whole rock and matrix glass compositions, heterogeneous matrix compositions, and disequilibrium phenocrysts of anorthite-rich plagioclase in rhyodacite and mafic dacite. The 1883 rhyodacitic magma was probably not water saturated until it reached a shallow depth in the crust of 4-5 km. Glass I indicate pre-eruption dissolved volatile content in rhyodacite and mafic dacite of 4.0±0.5 wt.%.

Estimated sulfur discharge from erupted magma is 2.8×10^{12}g S, and estimated Cl discharge is 9.7×10^{12} g Cl. Two potential sources of additional sulfur from this eruption may be vaporization of seawater during entrance of pyroclastic flows into the sea, and degassing of nonerupted andesitic parental magma lying beneath evolved rhyodacitic magma in the zoned 1883 chamber. (Authors' abstract)

MANDEVILLE, C.W. and **SASAKI, Akira,** 1996, Sulfur isotopic indication of eruptive degassing of Krakatau 1883 magma (abst.): Eos, Trans. Amer. Geophys. Union, v. 77, no. 17, Suppl., p. S290. Authors at Mineral Resources Dept. Geological Survey of Japan 1-1-3 Higashi Tsukuba Ibaraki 305 Japan; e-mail (cmandy@gsjrstn.gsj.go.jp)

Sulfur isotopic compositions of Krakatau 1883 erupted products can be used to evaluate "open system" versus "closed system" models of degassing, and to determine the degree of magma-sea water interaction, if any. Sulfur isotopic analyses of matrix glass separates from 1883 rhyodacite samples spanning much of the eruption stratigraphy range from $\delta^{34}S$ of 7.2 to 17.5 per mil. Part of the variation seen in the $\delta^{34}S$ values may be attributed to degassing of SO_2 from the fairly oxidized rhyodacite magma. Previous electron microprobe analyses of sulfur concentration in plagioclase-hosted MI indicate an average sulfur concentration of 200 ppm; 80% of the sulfur occurs as SO_4^{2-} based on the wavelength shift of sulfur Kα X-rays. Matrix glass separates from the lowermost pumice fall deposits yield $\delta^{34}S$ values of 9.2 and 11.6 per mil, whereas matrix glass from pyroclastic flow pumice samples and degassed rhyodacite obsidian higher in the 1883 stratigraphy have heavier $\delta^{34}S$ values of 14.4 to 17.5 per mil. Whole rock rhyodacite samples yield $\delta^{34}S$ values of 6.7 to 10.6 per mil, whereas one more mafic 1883 gray dacite has a $\delta^{34}S$ of 4.3 per mil.

The present whole rock and matrix glass sulfur isotopic data cannot represent the intrinsic sulfur isotopic composition of the bulk magma because 60-80% of the initial sulfur content was degassed, based on the sulfur concentration difference between MI and matrix glasses. Whole rock and matrix glass data will be used in conjunction with experimental determination of sulfate-sulfide fractionation at magmatic T to assess whether the present $\delta^{34}S$ values of the matrix glasses can be accounted for by 60-80% degassing of SO_2 from the bulk rhyodacite magma. SIMS analysis of the sulfur isotopic composition of pyrrhotite I in phenocrysts will be done to examine the sulfate-sulfide fractionation, identify one or multiple generations of pyrrhotite, and to constrain the intrinsic $\delta^{34}S$ of the bulk rhyodacite magma prior to eruptive degassing. (Authors' abstract)

MANJUNATH, Y.S., SHOBHITA, K. and RAMANAMURTHY, K.V., 1994, Fluid inclusion study of the granites and its relevance to uranium mineralization in the Lambapur area, Nalgonda district, Andhra Pradesh: J. of Atomic Mineral Sci., v. 2, 1994, p. 19-27. Authors at Atomic Minerals Div., Dept. of Atomic Energy, Hyderabad-500-016.

FI study of quartz occurring in uranium mineralised granite, Srisallam quartzite, and vein quartz cutting across the granite in Lambapur area has indicated a large degree of similarity in their Th and sal. Most of the I are bi-phase L + V type and fall in the size range of 10 µm to 30 µm. Th is 150° to 300°C in granite, 150° to 250°C in quartzite and in vein quartz a T range of 100° to 200°C is obtained. Tm ice in FI of quartz in granite vary from -19 to -23°C corresponding to a sal of more than 22 wt.% eNaCl; in quartzite -3 to -20°C corresponding to 5 to 23 wt.% eNaCl. Highly saline solutions of 100-200°C T range could be responsible for deposition of uranium in basement granites and Srisallam quartzites in this area. (Authors' abstract)

MANLEY, C.R., 1996, Morphology and maturation of melt inclusions in quartz phenocrysts from the Badlands rhyolite lava flow, southwestern Idaho: American Mineralogist, v. 81, p. 158-168. Author at Dept. of Geol., Box 871404, Arizona State Univ., Tempe, Arizona 85287-1404.

Morphologies of primary rhyolitic MI in three successive populations of quartz phenocrysts in a single volcanic unit illustrate the change of I shape after trapping. The 14 Ma Badlands lava flow on the Owyhee Plateau of southwestern Idaho contains two magmas with three distinct quartz populations differing in size and morphology. In tiny quartz crystals that nucleated shortly before the eruption, large MI retain their initial, irregular shapes, whereas the smallest I show mature negative crystal shapes. I in a population of larger quartz crystals that nucleated earlier all show either negative crystal shapes or faceted shapes transitional to negative crystals. All I in a third population of large corroded quartz crystals have mature negative crystal shapes regardless of I size. In silicic magmatic systems, irregularly shaped I in a quartz may imply trapping just before eruption; analyses of such I should have the greatest likelihood of revealing the magmatic volatile conditions driving the eruption.

Electron microprobe analyses show that maturation had no effect on the composition of the trapped M. After eruption, however, slow cooling led to coarse crystallization and loss of silica from the M; when these I were revitrified in the laboratory, they did not regain all lost silica and did not become completely homogeneous. Revitrification of I that cooled more quickly showed no such loss of silica to the host. Thus, given appropriate cooling conditions, even very old (Precambrian?) silicic MI may be suitable for microbeam analysis after any necessary revitrification in the laboratory. (Author's abstract)

MAO, Jingwen, CHEN, Yuchuan and **YANG, Baichuan,** 1996, Geology, mineralogy, geochemistry, fluid inclusion, and isotope studies of the Dashuigou tellurium deposit, West Sichuan, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 778. Authors at Chinese Acad. of Geological Sci., Beijing, China.

The Dashuigou tellurium deposit is unique. It is mainly hosted by Triassic metabasalt. Mineralization developed in three stages: pyrrhotite-pyrite stage (I), tetradymite stage (II), and chalcopyrite-pyrite stage (III). FI studies of calcite, dolomite, and quartz from stage I, II, and III yield Th of 356°C to 260°C, 295°C to 198°C, and 235°C to 152°C, respectively. Sal 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.

Isotopic studies show that $\delta^{34}S$ values of sulfides and $\delta^{13}C$ and $\delta^{18}O$ values of calcites and dolomites are quite different from those from the Triassic carbonates in the deposit. Values of $\delta^{18}O_{water}$ computed from FI trapping T are +3.9 and +7 per mil. S, O, C, and H isotope data indicate the ore-forming substances of the Dashuigou tellurium deposit were derived from deep-seated sources, and the mineralizations are probably associated with Late Mesozoic alkaline or alkaline granitic magmatism. The estimated sulphur fugacities (fs_2) are $10^{-16.7}$ for stage I and 10^{-14} $10^{-11.5}$ for stage II, whereas the tellurium fugacities (fte_2) are 10^{-15} to 10^{-14} and $10^{-11.2}$ to $10^{-10.5}$ respectively.

MARCOUX, E., MILÈSI, J.P., SITORUS, T. and **SIMANDJUNTAK, M.**, 1996, The epithermal Au-Ag-(Mn) deposit of Pongkor (West Java, Indonesia): Indonesian Mining J., v. 2, no. 3, p. 1-xx. First author at BRGM, DR/MGG 1, Avenue Claude Guillemin BP 6009, 45060 Orleans cedex 2, France.

The Pongkor gold-silver epithermal deposit consists of four main steeply dipping quartz veins located close to the internal border of a Miocene volcanotectonic depression due to an explosive ignimbritic eruption.

Mineralized bodies are thick (average of 6 meters), usually banded, quartz-carbonate-adularia veins due to tectonic extension. Infilling on the veins show the successive deposition of four facies: 1) carbonate-quartz breccia (CQ facies); 2) network of banded quartz and former carbonate turned into manganese oxides through supergene alteration (MOQ facies); 3) banded opaline milky quartz (BOQ facies); 4) grey locally banded rich-sulfide quartz breccia crosscutting all the other type (GSQ facies). FI [literature data? See Basuki, et al., 1994, FIR 27, p. 10. E.R.] show low T, ranging from 165-205°C, and low sal (less than 4.9 wt% eq. NaCl). (From authors' abstract by E.R.)

MARIGNAC, C., SEMIANAI, A., FOURCADE, S., BOIRON, M.C., JORON, J.L., KIENAST, J.R. and **PEUCAT, J.J.**, 1996, Metallogenesis of the late Pan-African gold-bearing East Ouzzal shear zone (Hoggar, Algeria): J. of Metamorphic Geol., v. 14, no. 6, p. 783-801.

Indexed under FI (E.R.)

MARCOUX, E., MILÉSI, J.P., SITORUS, T., SIMANDJUNTAK, M. and **JÉBRAK, M.**, 1996, The Pongkor gold-silver epithermal deposit, West-Java, Indonesia (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 764. First author at BRGM, Orleans, France.

The Pongkor gold-silver epithermal deposit consists of four main steeply dipping quartz veins located close to the internal border of a volcanotectonic depression.

Initial carbonate deposition is almost a barren stage. It consists mostly of calcite with minor amounts of kutnohorite, rhodochrosite, and rhodonite. FI show low T, ranging from 150-225°C, and low sal (<4.9 wt.% eq. NaCl, Basuki et al., 1994, FIR v. 27, p. 10). Second stage, mainly siliceous, is polyphased. Third stage is a grey locally banded quartz cross-cutting all the other types. FI are similar to carbonates, with even lower sal. Adularia deposition occurs throughout quartz deposition.

Gold and silver grades as well as sulfide mineral abundances are steadily increasing from stage 1 to 3. (From authors' abstract by E.R.)

MARIKO, T., KAWADA, M., MIURA, M. and **ONO, S.**, 1996a, Ore formation processes of the Mozumi skarn-type Pb-Zn-Ag deposit in the Kamioka mine, Gifu Prefecture–a mineral chemistry and fluid inclusion study: Abstracts with Programs, 46th Annual Meeting of the Society of Resource Geology, p. 40 (in Japanese).

MARIKO, Tadashi, KAWADA, Masanobu, MIURA, Mitsuru and **ONO, Shuhei**, 1996b, Ore formation processes of the Mozumi skarn-type Pb-Zn-Ag deposit in the Kamioka mine, Gifu Prefecture, central Japan–A mineral chemistry and fluid incusion study: Resource Geol., v. 46, no. 6, p. 337-354. First author at Inst. of Earth Sci., School of Education, Waseda Univ., Tokyo 169, Japan.

The Mozumi skarn-type Zn-Pb-Ag deposit of the Kamioka mine occurs in crystalline limestone of the Hida gneisses. The ore formation processes are divided into five periods: clinopyroxene-Zn-Pb, calcite-quartz-Pb-Zn, actinolite-Cu, quartz-calcite-Cu and quartz-Ag periods, in order of formation. The clinopyroxene-Zn-Pb period began with the formation of huge amounts of clinopyroxene ($Di_{10-35}Hd_{43-75}Jo_{11-35}$) at 400-330°C, associated with minor amounts of grandite garnet (Ad_{16-78}), calcite, quartz, Ag- and Bi-bearing galena, native bismuth, bismuthinite, Ag-Pb-Bi-S minerals and Fe-poor sphalerite (3-8 FeS mole%). The second stage (240-120°C) of the first period was the main sulfidation stage. The sulfide minerals, which had already begun to crystallize during the first stage, vigorously formed in this second stage and replaced earlier-formed pyroxene and garnet. During the late second stage, the ore F increased in Fe content and produced hedenbergetic pyroxene (Hd_{53-88}) and Fe-rich sphalerite (9-14 FeS mole%), which replaced portions of earlier-formed pyroxene and sphalerite, respectively. During the first stage of the calcite-quartz-Pb-Zn period, early calcite (400-270°C), quartz (360-310°C) and Fe-poor sphalerite (400-270°C; 3-7 FeS mole%) associated with Ag- and Bi-bearing galena, native bismuth, bismuthinite and Ag-Pb-Bi-S minerals were formed by replacing limestone and a part of the clinopyroxene-Zn-Pb ore. In the second stage (300-230°C), infiltrated Fe-rich ore F produced Fe-rich sphalerite (7-21 FeS mole%) which replaced early sphalerite and minor amounts of chalcopyrite, pyrite, pyrrhotite, arsenopyrite and magnetite. Ag- and Bi-bearing galena, native bismuth, bismuthinite and Ag-Pb-Bi-S minerals continued to precipitate at this stage. During the succeeding third stage (230-150°C), late galena (Ag-poor), freibergite and Fe-rich sphalerite (10-14 FeS mole%) were formed. At the end of this stage, a minor amount of hematite crystallized in association with late calcite, quartz and epidote. The actinolite-Cu period was characterized by hydration and Fe and Cu metasomatism of the early-formed barren clinopyroxene skarn and clinopyroxene-Zn-Pb ore. During this period, clinopyroxene was extensively replaced by actinolite in the lower levels of the deposit, associated with quartz, arsenopyrite, magnetite, pyrite, pyrrhotite, chalcopyrite, Fe-rich sphalerite and other sulfide minerals. Ore formation during the quartz-calcite-Cu and quartz-Ag periods was local. Ores produced during these five periods are thought to have been formed by different hydrothermal circulation systems that were controlled by a common igneous heat source. (Authors' abstract)

MARK, Geordie, 1996, Regional episodic Na-Ca alteration: Its relationship to Fe-(Cu-Au) mineralization and shoshonitic granitoids in the Cloncurry District, NW Queensland, Australia (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A473. Author at Dept. of Earth Sci., James Cook Univ., Townsville Qld 4811, Australia; e-mail (Geordie.Mark@jcu.edu.au)

Na-Ca alteration is a significant pre- and syn-ore alteration phase in many Proterozoic and Phanerzoic Fe-(Cu-Au) provinces, and an understanding of the interrelationships between, and the nature of F causing, Na-Ca alteration and Fe-Cu-Au) mineralization has direct implications for mineral exploration in Fe-(Cu-Au) provinces around the world. F producing Na-Ca alteration were hot (> 400°C) and saline (23-31 wt.% NaCl). These F, in the vicinity of the Mt. Angelay Igneous Complex, were focused along structural pathways, toward a regional-scale heat source, and were locally influenced by episodic granitoid intrusion. Three phases of Na-Ca alteration occur around granitoids of the Mt. Angelay Igneous Complex and commonly consist of albite-actinolite-diopside-magnetite-titanite. Mass balance calculations suggest that F which caused Na-Ca alteration may have contributed chalcophile elements, initially leached during Na-Ca alteration, to the F forming Fe-Cu-Au deposits. The synchronous nature and common spatial association between regional sodic-calcic alteration, Fe-Cu-Au mineralization, granitoid emplacement and tectonism in the Cloncurry district suggests that all components are intimately-related to a post-peak metamorphic thermal-tectonic event. (From author's abstract by E.R.)

MARKL, Gregor and **SCHUMACHER, J.C.,** 1996, Spatial variations in temperature and composition of greisen-forming fluids: An example from the Variscan Triberg granite complex, Germany: Economic Geol., v. 91, p. 576-589. Authors at Inst. für Mineralogie, Petrologie und Geochemie, Albert-Ludwigs-Univer., Albertstrasse 23b, D-79104 Freiburg I. Br., Germany.

This granite complex contains cassiterite-bearing greisen assemblages and beryl-bearing pegmatites that have been locally affected by the greisen-forming F.

The systematic variation of mineral assemblages in different parts of the leucogranitic part of the Tribert Granite Complex indicated T and chemical gradients in the F. Calculations of mineral stabilities and FI studies on cassiterite and beryl support the existence of the gradients that were inferred from the field observations. Estimated P and sal were nearly constant: P was estimated to be 1,500 bars and the measured sal was 4 to 5 wt% NaCl eq. From the interior to the margin of the study area, the T decreased from 500° to about 250°C and the concentration of hydrofluoric acid (HF) in the F decreased from 0.06 to 0.002 moles/l. (From authors' abstract by E.R.)

MARQUEZ-ZAVALIA, M.F., and **CRAIG, J.R.,** 1996, Telluride mineralization at Mina Capillitas, a high-sulfidation epithermal-type deposit in northwestern Argentina (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A151–A152. First author at IANIGLA-CRICYT (CONICET), CC330 (5500), Mendoza, Argentina

Mina Capillitas (27°27'S, 66°30"W) is a high sulfidation epithermal-type vein deposit related to volcanism with shoshonitic affinities associated with the inner Miocene magmatic arc of northwestern Argentina. Although more than 100 mineral species have been recognized, pyrite, marcasite, galena, sphalerite, chalcopyrite, enargite, pyrrhotite, bornite and tennantite are the most abundant minerals throughout the ores.

Tellurium and precious metals are concentrated in the fourth stage. Gold occurs as small grains (20 microns on average) and has a fineness of 830-970 (average 920). The gold occurs mostly in quartz and is strongly associated with huebnerite and Bi-minerals; tellurium and tellurides are widespread. Native tellurium occus locally in 2-5 micron grains with tellurides of Ag, Bi, Cu, Ni and Pb. Tellurides identified include: stutzite ($Ag_{5-x}Te_3$), tetradymite (Bi_2Te_2S), petzite (Ag_3AuTe_2), krennerite ($(Au,Aug)Te_2$), goldfieldite ($Cu_{12}(Sb,As)_4(Te,S)_{13}$), hessite ($Ag_2Te$), sylvanite ($AuAgTe_4$), melonite ($NiTe_2$), and volynskite ($AgBiTe_2$). Most grains occur in quartz or pyrite with huebnerite and Bi and Sn minerals. Individual telluride grains are 1-5 microns but they commonly occur in larger irregular polycrystalline aggregates. FI data indicate ore formation at 250°C with log $fS_2 = 10^{-14}$ and log $fTe_2 = 10^{-6}$ to 10^{-8}. (From authors' abstract by H.E.B.)

MARSCHIK, Robert and **FONTBOTÉ, Lluís,** 1996, Copper (-iron) mineralization and superposition of alteration events in the Punta Del Cobre belt, northern Chile: *in* "Andean copper deposits: new discoveries, mineralization, styles and metallogeny," Soc. Econ. Geologists Special Publication No. 5, Camus, F., Sillitoe, R.H. and Peterson, R., eds, 1996, p. 171-190. First author at Département de Minéralogie, Univ. de Genéve, Rue des Maraîchers 13, 1211 Genéve 4, Switzerland.

Two superimposed alteration events control the regional distribution of five main alteration types in the Punta del Cobre belt. The alteration pattern and ore formation T (up to 500-600°C) support an association of the Cu mineralization with deep-seated magmatic intrusion(s). FI data for postore calcite indicate involvement of saline F. A magmatic source of the sulfur is indicated by isotope ratios determined for chalcopyrite and pyrite ($\delta^{34}S$ between –0.7 and +1.1‰). The deposits in the Punta del Cobre belt are somewhat similar and possibly transitional to both the Chilean magnetite (-apatite) deposits and porphyry copper deposits. (From authors' abstract by E.R.)

MARSHALL, Dan, KIRSCHNER, David, BUSSY, Francois, PFEIFER, H-R and **HUNZIKER,J.C.,** 1996, Alpine pressure-temperature-time path for the N-E Mont-Blanc massif: Fluid inclusion, isotopic and thermobarometric evidence (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 86-87. First author at Inst. of Mineral. and Petrog., Univ. of Lausanne, Switzerland.

The Mont Chemin region at the N-E extreme of the Mont-Blanc massif, Canton Valais, Switzerland is predominantly comprised of the granitic rocks of the Mont-Blanc intrusive rock suite and the Mont-Blanc basement gneisses. Hosted within the metamorphic rocks are a variety of sub-economic Au and Pb-Zn-F deposits and veins. FI, fluid-mineral equilibria, stable and radiogenic isotope studies have been used to derive P, T, age (PTt) and F composition constraints for a number Alpine events.

The earliest Alpine event is recorded in a katophorite-paragonite schist hosted within the basement gneisses. The paragonites yield a total fusion $^{40}Ar/^{39}Ar$ age of 48 Ma. Mineral thermobarometry is consistent with formational T in excess of 300°C, with minimum pressures of 1500 bars. A well defined P-T uplift path is recorded in a variety of overlapping Alpine events including stilpnomelane-epidote-quartz-calcite veins, quartz-chlorite veins, quartz-muscovite veins and a remobilization of the Variscan fluorite veins terminating with a gold mineralization event at 10 Ma ($^{40}Ar/^{39}Ar$, adularia) at T in the range 250 to 300°C with P from 500 to 1600 bars. The overall PTt path defines a geothermal gradient of 25°C/km, but portions of this PTt path are consistent with geothermal gradients as high as 50°C/km similar to those observed to the East along the Rhone-Simplon line.

FI and stable isotope studies indicate a diverse source of Alpine F, ranging from metamorphic to meteoric with considerable F chemistry control exercised by the local granitic wallrocks. F compositions range from highly saline brines with variable K:Na:Ca to the CO_2-bearing F typically associated with higher grade metamorphic rocks and some mesothermal gold deposits. (From authors' abstract by E.R.)

MARSHALL, Dan, WATKINSON, Dave, FOUILLAC, A.-M., MOLNAR, Ferenc and **FARROW, Catharine,** 1996, Fluid mixing during the emplacement of the Sudbury igneous complex: fluid inclusion, Ar, O and H isotopic evidence (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 83-85. First author at Earth Sci., Carleton Univ., Ottawa, CANADA K1S 5B6.

In an effort to establish the end-members in this multiple-generation F history, this study concentrates on two separate areas hosting post-SIC FI of consistent composition. These two FI populations are interpreted to be two of the many end-member F found in the vicinity of SIC.

The identification of three distinct F in the Sudbury area still does not account for the most abundant FI type found in the Sudbury ore veins: the variable phase-ratio halite bearing three-phase I. The halite-bearing three-phase I can be accounted for by three different hypotheses: A) necking down of saline two-phase (L+V) FI, B) they represent the residual L component of a boiling system originally composed of a F represented by the P two-phase I found within the potassic feldspars at the Lindsley mine, or C) a fourth halite-saturated F (possibly generated by the SIC magmas) mixed with one of the identified less saline F (Fluid 1 or 2). Hypothesis A seems unlikely as there is a paucity of V-rich I compared to the overwhelming abundance of halite-bearing I. The same observation limits the possibility of closed system boiling, but open system boiling certainly can not be discounted. While there is little evidence to support the boiling hypothesis, there is abundant data available from O, H and Ar isotope studies to support a mixing model. (From authors' abstract by E.R.)

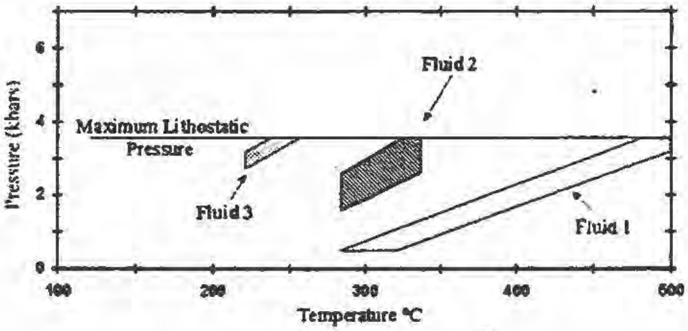


Figure 1. Pressure-temperature diagram showing the possible PT ranges for the different fluids found in the Sudbury region. Fluid 1 = 2-phase P highly saline; Fluid 2 = CO_2-bearing; Fluid 3 = 2-phase, late.

MARTIN-CRESPO, T., LOPEZ-GARCIA, J.A. and **VINDEL, E.,** 1996, Fluids in barren quartz veins from Sierra de Guadarrama, Spanish Central System: IV Spanish Geological Congress, Universidad de Alcala, 1-5 July, 1996, published by Geogaceta, v. 20, no. 7, p. 1561-1562 (in Spanish, Engl. abst.). Authors at Dto. de Cristalografia y Mineralogia, Univ. Complutense, 28040 Madrid.

F together with alteration were studied in representative hydrothermal barren quartz veins from central part of Sierra de Guadarrama (Spain). Three types of F have been distinguished: (i) an early F stage characterized by P H_2O-$CaCl_2$ two-phase I at room T (Lw1); Te: –50/–40°C; Tm: –0.4/0°C and Th: 170/295°C. (ii) a second stage characterized by H_2O-$CaCl_2$-NaCl ($MgCl_2$) two phase I at room T (Lw2); they are P in the borders of quartz crystals and S in the center; Te: is in the range of –65/–60°C; Tm: –24.2/–25.7°C and Th: 60-165°C. (iii) later F inputs in the veins are shown by S high sal H_2O-NaCl ($CaCl_2$) I (Lw-s); they are three phase I including one or more solid phase (dominant halite and/or sylvine) with global Th from 120-260°C and sal of 29-35 wt.% eq. NaCl. Barren quartz veins represents one of the latest events in the hydrothermal evolution of the Sierra de Guadarrama. Evolution of Ca contents is discussed in this paper. Quartz deposition is controlled by the decrease of P-T conditions. (Authors' abstract)

MARTIN-IZARD, Agustin, PANIAGUA, Andres, MOREIRAS, Damaso, ACEVEDO, R.D. and **MARCOS-PASCUAL, Celia,** 1996, Metasomatism at a granitic pegmatite - dunite contact in Galicia: the Franqueira occurrence of chrysoberyl (alexandrite), emerald, and phenakite: Reply: The Canadian Mineralogist, v. 34, p. 1332-1336. First author at Dept. de Geologia, Univ. de Oviedo, Arias de Velasco s/n, 33005 Oviedo, Spain.

A rebuttal to a discussion by G. Franz, et al., 1996 (this volume) of FI evidence and its interpretation. (E.R.)

MASON, Roger and **MARTIN, R.F.,** eds., Origin and significance of zoning in minerals: Preface: The Canadian Mineralogist, v. 34, p. 1109-1110.

This series of papers came from a special session of GAC/MAC in 1995. A number of the papers, not listed in this volume, are pertinent to FI studies. (E.R.)

MASUTA, Kenzo, KAMIKI, Takashi and **NARUI, Eiichi,** 1996, Polymetallic mineralization in the Toyoha South District, Hokkaido, Japan: Resource Geol., v. 46, no. 2 (256), p. 45-61.

Indexed under FI (E.R.)

MATMON, Ari and **NAVON, Oded,** 1996, Solubility experiments in a diamond anvil cell: NaCl-H_2O to 2 GPa and 300°C: Israel Geological Society Annual Meeting, March, 1996, p. 68. Authors at Inst. of Earth Sci., The Hebrew Univ., Jerusalem, Israel.

We report a new, simple method for measuring the solubility of salts at high pressure and T using the diamond anvil cell (DAC) and apply it to the study of the NaCl-H_2O system in the range 0-300°C, 10^5 -2 × 10^9 Pa (1 bar-20 kbar).

Water and halite in approximately known proportions are loaded in a hydrothermal DAC (Shen and Bassett, 1992) together with a small ruby grain and the cell is pressed to about 0.2 GPa. T is then raised and the size of the halite crystal is monitored until it almost fully dissolves. P is determined using the ruby, equilibrium is demonstrated by watching the crystal dissolution and growth as T is varied by ±2°C.

Additional points on the halite liquidus are determined by cooling, increasing pressure, and heating to almost full dissolution. P is then lowered until the final point is determined in the presence of halite+solution+bubble. This point lies on the three phase line (Potter et al., 1977) and the dissolution T exactly defines the composition.

Seven compositions with 27-38 wt% dissolved NaCl show mild dependence of solubility on P. Solubility increases with increasing P up to about 0.5-1 GPa, and then decreases slowly with further increase. The effect of P decreases with increasing T (dP/dT) of the liquidi becomes steeper and more negative). These trends can also be recognized in the data of Bodnar (1994) for solution with 40 wt%

halite which are in very good agreement with our results. (Authors' abstract)

MATSUDA, J-I, MARUOKA, Teruyuki, PINTI, D.L. and **KOEBERL, Christian,** 1996, Noble gas study of a philippinite with an unusually large bubble: Meteoritics & Planetary Sci., v. 31, p. 273-277. First author at Dept. of Earth and Space Sci., Fac. of Science, Osaka Univ., Toyonaka, Osaka 560, Japan.

A philippinite with a large bubble (volume ≈5 cm^3) was crushed in a specifically constructed device under vacuum. The total pressure, the major G components, and the concentration and the isotopic composition of noble gases in the trapped G were measured. The total G pressure was found to be low, ~10^{-4} atm. Compared to terrestrial atmosphere, the abundances of He and Ne are considerably more enriched than the concentrations of the heavy noble gases. Unusually high ^{20}Ne / ^{22}Ne and ^{21}Ne / ^{22}Ne ratios were measured in the bubble G. These ratios are higher than values expected for any steady state process and are interpreted to reflect very fast nonsteady state diffusion in the early stages of tektite formation. (Authors' abstract)

MATSUEDA, Hiroharu, NAKAMURA, Noboru, YUI, Shunzo and **AKAMATSU, Kazuo,** 1996, Hydrothermal alteration and gold mineralization at Otaru-Akaiwa, southwestern Hokkaido, Japan (abst.): 30th Int'l. Geol. Cong. Abstracts, v. 2, p. 657. Authors at Dept. of Earth & Planetary Sci., Hokkaido Univ., Japan.

Extensive hydrothermal alterations are well developed. The alteration can be divided into three zones. Based on the FI and sulfur isotope studies, the estimated formation T of these alteration zones are about 190-240°C. Stable isotopic studies for oxygen and sulfur of altered rocks and minerals show clear water/rock interaction process in the hydrothermal alteration of this area.

Considering these facts mentioned above, propylitization might have followed just after the Miocene volcanic activities of andesite and dacite in this area, and is superimposed by acid and neutral hydrothermal alterations. The eastern part of alteration zones could have been formed by the strong acid sulfate hydrothermal F originated in magmatic F or circulating sea water, while the western part by neutral and relatively higher saline hydrothermal water. Gold precipitation might be caused by the decomposition of gold bisulfide complex according to oxidation of sulfur species in mixing of F with meteoric water at the shallow level of the eastern part, while cooling and/or dilution of hydrothermal F at the western part. (From authors' abstract by E.R.)

MATTHEWS, Alan, LIATI, Anthi, MPOSKOS, Evripidis, and **SKARPELIS, Nikos,** 1996, Oxygen isotope geochemistry of the Rhodope polymetamorphic terrain in northern Greece; evidence for preservation of premetamorphic isotopic compositions: European J. of Mineral., v. 8, no. 5, p. 1139-1152.

Full paper for previous abstract (E.R.)

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: Dok Ross Akad Nauk, 1995, v. 345, no. 3, p. 367-371 (in Russian, translated in Trans. (Doklady) Russian Acad. Sci., Earth Sci. Sect., v. 345A, no. 9, p. 356-361, 1996)

Abst. in FIR v. 28, p 96 (E.R.)

McDONALD, S.J. and **SKILBECK, C.G.,** 1996, Authigenic fluid inclusions in lithic sandstone: A case study from the Permo-Triassic Gunnedah basin, New South Wales: Australian J. of Earth Sci, v. 43, p. 217-228. Authors at Dept. of Applied Geol., Univ. of Tech., Sydney, P.O. Box 123, Broadway, NSW 2007, Australia.

The Gunnedah Basin is a structural subdivision of the Permo-Triassic Sydney-Bowen Basin, a major Permian coal province in eastern Australia. Coarse-grained sediments of the Permian Maules Creek, Porcupine and Watermark Formations within the basin are predominantly volcanolithic to quartz-lithic conglomerate and sandstone that were deposited in alluvial, marine fan delta and marine shelf environments. Triassic strata of the Digby and Napperby Formations were deposited in alluvial and lacustrine environments respectively. FI in authigenic quartz overgrowths and healed grain fractures identified in sandstone from these rocks comprise four distinct types (Types 1-4) generated during three discrete diagenetic episodes (GI [oldest] - GIII [youngest]). Two of the I types (Types 3 and 4) are hydrocarbon-bearing and their distribution indicates that migration of hydrocarbons occurred late in the diagenetic history of the rocks, although Th imply that emplacement of these I pre-dated maximum burial T. Microthermometric analysis of 57 aq I gave Th ranging from 62°C to 140°C. The majority of samples are now located at depths shallower than those at which the F were entrapped and data are used to constrain the palaeothermal and tectonic history of the basin. Freezing runs yielded first melting between -65°C and -31°C suggesting the presence of a Ca-Na-Cl system. Th ice ranged from -8.5°C to -0.2°C and are interpreted to represent much lower sal than would have been present in the original marine depositional environment of the Porcupine and Watermark Formations. (Authors' abstract)

McEWAN, C.J.A., FALLICK, A.E. and **RICE, C.M.,** 1996, The Rosita Hills epithermal Ag-base metal deposits, Colorado, USA: Mineral. Deposita, v. 31, p. 41-51. First author at Dept. of Geol. and Petro. Geol., Univ. of Aberdeen, Aberdeen AB9 2UE, Scotland, U.K.

The vein-hosted, adularia-sericite type, epithermal Ag and base-metal mineralisation, with minor Au, shows from stable isotope studies (O and H) of whole rock and mineral separate (quartz and sericite) samples from veins and hydrothermal eruption breccias, that the hydrothermal F had both magmatic and meteoric components. The δD and $\delta^{18}O$ values of the hydrothermal F, calculated from mineral values, range from -22‰ to -103‰ and 0.5‰ to 5.9‰ respectively. FI data from vein minerals (quartz, baryte and sphalerite) and from an advanced argillic lithocap overlying the veins again show that the hydrothermal system had more than one component F. FI have sal which range from 1.7 to 25.1 wt% NaCl equivalent and show evidence of boiling in the advanced argillic lithocap. Th range from 135°C to 298°C. L CO_2 is present in some I. These data indicate that a saline, isotopically heavy F mixed with a dilute, isotopically light F to precipitate the ore. We argue that the saline, isotopically heavy F is magmatic and derived from a resurgent rhyolitic magma below the mineralisation. (From authors' abstract by E.R.)

McFARLAND, B.P. and **CARLSON, E.H.,** 1996, Evidence for late Paleozoic brine migration in the Serpent Mound District, southwestern Ohio, (abst.): Abstracts with Programs - Geological Soc. of America, v. 28, no. 3, p. 79. Authors at Oglebay Norton Refractories & Minerals, Warren, Ohio.

Indexed under FI. (E.R.)

McINNES, B.I.A. and **EVANS, N.J.**, 1996, Cu- and Pd-rich immiscible sulphide liquids in submarine shoshonitic lavas from the Tabar-Lihir-Tanga-Feni island arc, Papua New Guinea: Geol. Soc. of Australia Abstracts, v. 41, p. 288.
Indexed under FI (E.R.)

McLAUGHLIN, O.M., HASZELDINE, R.S. and **FALLICK, A.E.**, 1996, Quartz diagenesis in layered fluids in the South Brae Oilfield, North Sea: Soc. for Sedimentary Geol., Special Publication, v. 55, p. 103-113.
Indexed under FI (E.R.)

McNAUGHTON, N.J., 1996, The source of ore fluids and solutes in Archaean mesothermal gold systems (abst.), in Mesothermal Gold Deposits : A Global Overview. Volume of extended abstracts to accompany short course, Perth, 11-12 July, 1996. Pub. No. 27, p. 84-87. Geol. Dept (Key Centre) & UWA Extension, Univ. Western Australia, 135 pp. ISSN 0156-9287.

McNEIL, B., 1996, Characterisation of low molecular weight hydrocarbons in fluid inclusions from fracture-filling anhydrite in the southern North Sea gasfields: J. of Petroleum Geol., v. 19, no. 2, p. 227-234. Author at Dept. of Geol., Imperial College, Univ. of London, Prince Consort Rd., London SW7 2BP.

Studies of crushing crystals while viewing them under a microscope ("stage-crushing" studies) were carried out on fracture-filling anhydrites from the Vulcan and Vanguard gasfields in the UK sector of the southern North Sea. These studies were performed after the appearance of clathrate solids during microthermometric freezing experiments which indicated the presence of a G component within the I. After several attempts at a very difficult analytical technique, a series of photographs were taken of the process whereby the V phase in the I expanded. This indicated the existence of a G under pressure in the I. G chromatographic studies suggested the dominance of methane, and that the overall component is comparable to that of the southern North Sea G reservoirs. (Author's abstract)

McNEILL, A.W. and **DANYUSHEVSKY, L.V.**, 1996, Composition and crystallization temperatures of primary melts from Hole 896A basalts: Evidence from melt inclusion studies: *in* Alt, J.C., Konoshita, H., Stokking, L.B., and Michael, P.J. (Eds.) 1996 Proceedings of the Ocean Drilling Program, Scientific Results, v. 148, p. 21-32. Authors at Geol. Dept., Univ. of Tasmania, Hobart, G.P.O. Box 252c, Tasmania 7001, Australia.

Glass and mineral geochemical data are presented for basalts from Ocean Drilling Program (ODP) Hole 896A. Phenocryst assemblages are dominated by calcic plagioclase ($An_{76-94.5}$) with olivine ($Fo_{80-91.6}$), Cr-Al spinel, and clinopyroxene. The origin of the calcic plagioclase phenocrysts was investigated by heating-stage experiments on silicate MI in plagioclase and olivine mineral separates. Tt of 1195°-1215°C are inferred for plagioclase ($An_{83-94.5}$). I compositions, interpreted to be in equilibrium with host platioclase, are similar to the range of pillow-rim glasses from this hole. Primary M, in equilibrium with $Fo_{91.6}$, are estimated to have ~15 wt% MgO and crystallization T of ~1340°C. (Authors' abstract)

McVEY, D.E. and **HUFF, W.D.**, 1996, K-bentonite formation by alteration of rhyolitic glass (abst.): Eos, Trans. Amer. Geophys. Union, v. 77, no. 17, Suppl., p. S280. Authors at Dept. of Geol., Univ. of Cincinnati, Cincinnati, OH 45221-0013; e-mail (mcveyde@uc.edu)

Middle Ordovician K-bentonites represent some of the largest and most widespread pyroclastic ash beds preserved in the Phanerozoic record. Two of these beds, the Deicke and Millbrig, cover minimally 2.2×10^6 km^2 in eastern North America and a third bed, the Kinnekulle, covers minimally 6.9×10^5 km^2 in northwestern Europe. Interactions involved in the alteration of the original silicic ash to clay-rich K-bentonite beds include F and various cation species. By comparing bulk densities and compositions of both K-bentonite and pristine glass M I that occur in P quartz grains in the K-bentonites we have quantitatively assessed the nature of these interactions.

The estimated volumes for the Deicke, Millbrig, and Kinnekulle beds are 658 km^3, 1000 km^3, and 695 km^3 respectively. MI and K-bentonite samples of the Deicke and Millbrig were both selected from the southern Appalachians in order to minimize any regional variations in glass or bulk chemical composition that might be inherent in the beds. MI SiO_2 values were in the range 73-75% indicating the glass was rhyolitic in composition. Average Al_2O_3 for 12 Deicke MI was 11.92% with a standard deviation of 0.17, for 26 Millbrig MI it was 12.11% with a standard deviation of 0.29, and for 19 Kinnekulle MI it was 12.32% was a standard deviation of 0.18. The glass density was determined to be 2.32 g/cm^3. K-bentonite density measurements averaged 1.93 g/cm^3 for the Deicke and Millbrig, and 1.92 g/cm^3 for the Kinnekulle.

Mass balance calculations were made by normalizing the glass and rock (K-bentonite) chemical data to Al. Converting on the basis of total Al_2O_3 the glass:K-bentonite ratio for the Deicke is 1.43, for the Millbrig 1.51, and for the Kinnekulle 1.40. The calculated dense rock eq. values based on the total volume measurements are 943 km^3 for the Deicke, 1509 km^3 for the Millbrig, and 972 km^3 for the Kinnekulle. We show that one third of the mass of the original ash (expressed as dense rock) was lost during the formation of K-bentonite, most of which was silica. Approximately 55% of the original silica was removed during devitrification and subsequent diagenesis. Surprisingly, 50% of the original K_2O was also lost during the process. It is commonly thought that the process of illitization which resulted in conversion of much of the original smectite to mixed-layer illite/smectite was the result of K-metasomatism, principally during episodes of brine migration associated with regional tectonism. Under this concept the K-bentonite layer is a geochemically open system with K coming mainly from external sources. Our data indicate that more than enough K was present in the parent glass to account for the present amount of illite/smectite and that a substantial portion of original K was in fact removed during post-emplacement processes. Therefore, the illitization reaction(s) need involve only short-range transport of K rather than a regional migration, although the timing of this process may in fact be related to tectonic or other regional thermal events. (Authors' abstract)

MEI, Lianfu, 1996, Geochemical evolution of the fractured reservoirs in Wangchang area, Jianghan basin (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 845. Author at China Univ. of Geosci., Wuhan, P.R. China.

The Qianjiang formation of the Eogene consists of sandstone, mudstone and saltstone with argillaceous carbonate rock, in which there are a large quantities of tension fractures. These fractures are filled by three-stage minerals which are Sulphate Stage I (gypsum and glauberite), Sulphate Stage II (gypsum and glauberite) and Carbonate Stage (calcite) arranged in order from early to late times. Based on mineral combination, FI (hydrocarbon inclusion), isotope geochemistry, organic geochemistry and element analysis, the thermal F activities of Sulphate Stage I and II caused a large quantities of gypsum and glauberite being deposited in these fractures. The I of Sulphate Stage I occurred during the immature stage of the source rock, and a few light hydrocarbons were separated from the adsorption of the source rock, and are combined with the brine solution rich in CO_2, H_2S etc. for the migration, which represents the simple hydrocarbon-drainaging and migration. Because of the presence of high abundance hydrocarbon I and the absence of inorganic elements such as CO_2, H_2O and H_2S in Sulphate Stage II, the crude oil generated in the peak period, and migrated mainly in a form of the continuous oil phase in the fractures. The presence of the high content of the low-carbon-number saturated hydrocarbon in the I in Carbonate Stage signify the crude oil feature of low density and high maturity, and the migration phase is the immiscible emulsion phase, which can be proved by the composition and phase of the hydrocarbon-bearing I. (From authors' abstract, by E.R.)

MENG, XiaoLian and **WANG, LiMing**, 1996, Geological characteristic and origin of Song Xi Ag(Sb) deposit of Guangdong (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 658. First author at GuangZhou Metro Corporation.

The rich GuangDong SongXi Ag(Sb) deposit is in faults in carbon shale and micritic limestone which is rich in carbon, organic matter and pyrite, and basalt and tuff accompanied by them. Wallrocks alteration contain silicify, pyritization, carbonatization etc., and have zonal distribution. The main mineral compositions are pyrite arsenopyrite, stibnite, [sulfides] of Ag. The main element composition are Ag and Sb. The [ore-forming] L was $HCO_3^- > Cl^- > SO_4^{2-} > F^-$, $K^+ > Ca^{2+} > Na^+ > Mg^{2+}$, the gas is H_2O-CO_2, PCO_2 ranges from 76.61 to 240.57 Pa. The ore was formed [at] average T 162°C. (From authors' abstract by E.R.)

MERNAGH, T.P., 1996, Gold mineralisation at Mount Charlotte; evidence for fluid oxidation from fluid inclusions: Geological Soc. of Australia Abstracts, v. 41, p. 292. Author at Australian Geol. Survey Organisation, Canberra, Australia.

MERNAGH, T.P. and **WITT, W.K.**, 1994, Early, methane-rich fluids and their role in Archaean gold mineralisation at the Sand King and Missouri deposits, Eastern Goldfields Province, western Australia: AGSO J. of Australian Geol. and Geophys., v. 15, no. 3, p. 297-312. First author at Australian Geol. Survey Organisation, GPO Box 378, Canberra ACT 2601, Australia.

The Sand King and Missouri lode gold deposits in the Siberia district of the Eastern Goldfields Province are situated within an amphibolite-facies metamorphic aureole in deformed greenstones flanking a monzogranitic batholith, which crops out less than 1 km to the west. The Missouri deposit was mined from 1899 to 1912 and again in 1987-1988 and produced approximately 921 kg of gold. The Sand King mine has produced about 4000 kg of gold since 1980. Gold occurs in the margins of the quartz (-biotite-pyrite) veins and in the alteration assemblage adjacent to the vein systems. FI in quartz and carbonate veins from both deposits have been studied by microthermometry and Raman spectrometry and have been classified into six types according to their chemical composition. The V phase of Type I inclusions contains pure or nearly pure CH_4 and the L-rich I which appear least likely to have leaked contain up to 5 mole% CH_4 and 95 mole% H_2O. Rare Type II inclusions are multiphase and contain approximately equal amounts of CO_2 and CH_4 in the V phase. They may also contain up to four solid phases, of which muscovite and carbonate have been identified by Raman spectroscopy. Type III inclusions may also contain a muscovite dx, but have highly variable V contents and CO_2/CH_4 ratios. Type IV inclusions are CO_2-rich and may be either monophase or occur as L+V CO_2 ($\pm H_2O$) at room T. Type V inclusions are aq I with an average sal of 5.8 eq. wt.% NaCl, and Type VI are high sal I (~27 eq. wt.% $CaCl_2$) that may contain halite and two other unidentified solids.

The textural evidence suggests that Type I inclusions were trapped in the early phases of mineralisation at both the Sand King and Missouri deposits, around 500-600°C and 3-4 kbar. The FI also provide evidence for mixing of the CH_4-rich Type I F with a CO_2-rich F. The latter may be related to a pervasive synmetamorphic F responsible for regional carbonation of the deformed metavolcanic rocks. Heterogeneous trapping is thought to be largely responsible for the variation in V content and CO_2/CH_4 ratio in I Types II and III. The presence of muscovite as a dm in Types II and III links them to a potassic alteration event which is evident at both deposits. Type IV inclusions contain little or no detectable CH_4, which indicates that CO_2-rich F continued to circulate after most of the CH_4 and H_2 in the system had been consumed. The aq Types V and VI inclusions are thought to represent, respectively, late influx of meteoric waters and connate brines.

The early methane-bearing F indicate low fO_2 conditions, which may have been generated during the serpentinisation of nearby ultramafic rocks or, alternatively could have been derived from a deep source in the crust or lower mantle. The addition of methane to the CO_2-rich ore-bearing F by F mixing greatly increases the field of F immiscibility over that of the conventional CO_2-H_2O-NaCl system. Thus, the F unmixes over a larger range of P-T conditions when methane is present and the sulphur content of the F diminishes as H_2S is strongly partitioned in the V phase during subsequent phase separation. These effects destabilise the auriferous sulphide ligands in solution and, hence, trigger gold precipitation. They may thus be important factors controlling gold precipitation under greenschist and amphibolite facies conditions. (Authors' abstract)

See also FIR v. 27, p. 91 (E.R.)

MÉTRICH, N. and **RUTHERFORD, M.J.**, 1996, Crystallization paths of H_2O-saturated Hawaiitic melts at low pressures: Implications for open degassing volcanic systems (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F830, November 12, 1996. First author at Laboratoire Pierre Sue, CNRS-CEA; CE-Saclay 91191 Gif/Yvette France; e-mail (metrich@nimitz.saclay.cea.fr)

Based on MI, the hawaiitic-basaltic magmas from Mt. Etna (Sicily) were described to contain between 3 and 1 wt.% H_2O, prior to the eruption (e.g., Métrich et al., *J. Volc. Geoth. Res.* 39, p. 131-144, 1993). The effect of H_2O degassing during magma ascent has been experimentally constrained between 1135 and 1009°C, for $P_{H_2O} = P_{total}$ varying from 800 to 270 bars. The starting material was a hawaiitic lava sample (MgO = 7.1 wt.%) representative of the less evolved lava emitted at Mt. Etna. Experiments were conducted in TZM P vessels, with $Ag_{70}Pd_{30}$ capsules in order to minimize the FeO loss. Increasing the water content of hawaiitic magmas expands the stability field of the olivine (relative to the other phases), lowers the crystallization T of pyroxene and plagioclase, and results in the development of a more An-rich plagioclase. These results support the model of early and moderate crystallization of olivine from Etnean hawaiitic magmas, containing close to 3.0 wt.% H_2O with NNO oxygen buffering conditions and later H_2O degassing at low P (prior to the eruption) resulting in extensive crystallization. These conclusions may apply to any open degassing volcano. (From authors' abstract by E.R.)

MIAO, Qin, 1996, Coexisting of eclogitic and peridotitic inclusions in one Chinese diamond (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 481. Author at 6th Exploration Team, Pulandian, Liaoning, P.R. China.

It is well known that the eclogitic and peridotitic inclusions occur separately in diamonds. However, one diamond with both eclogitic and peridotitic mineral inclusions was discovered from the No. 50 kimberlite pipe, Liaoning Province of China, and preliminary average composition of I of olivine, garnet, and omphacite are presented here.

Coexisting of eclogitic and peridotitic inclusions in [the] same diamond demonstrates that this diamond was formed under disequilibrium condition. The dynamic process which caused the changing of diamond growth circumstance is very important but quite unclear. Measurement of trace elements in these I is going on. (From author's abstract by E.R.)

Average compositions of inclusions

Miner	olivine	garnet	omphacite
SiO2	42.01	41.47	55.49
Al2O3	0.01	22.21	8.51
TiO2	0.00	0.32	0.19
Cr2O3	0.01	0.08	0.05
FeO	8.45	13.37	4.09
NiO	0.36	0.03	0.04
MnO	0.12	0.31	0.06
MgO	50.35	10.68	10.78
CaO	0.00	12.01	16.45
Na2O	0.01	0.14	3.99
K2O	0.01	0.00	0.23
Total	101.33	100.63	99.87

MICHARD, Gil, PEARSON, F.J.. Jr. and **GAUTSCHI, Andreas**, 1996, Chemical evolution of waters during long term interaction with granitic rocks in northern Switzerland: Applied Geochem., v. 11, p. 757-774. First author at Lab. de Géochimie des eaux, Univ. Paris 7 et IPG Paris, 2 place Jussieu, F 75252 Paris cedex 05, France.

As part of an assessment of crystalline rock as a potential host for a nuclear waste repository, water samples were collected from more than 50 locations from the crystalline basement where it is under sedimentary cover in Northern Switzerland and where it is at the surface in the Black Forest. These samples describe the changing chemistry of water in an extended flow system from dilute recharge waters far from chemical equilibrium with its host rock to saline waters at T of 50 to 100°C with residence times far in excess of 10^5 a that have reached chemical equilibrium with their host rock.

This unique set of samples allows an analysis of the chemical evolution of granitic waters from surficial waters far from equilibrium to almost equilibrated waters. Mobile ions, rare G and isotopic data are used to estimate the extent of reaction between waters and their host rock. The evolution of controlled elements is interpreted as a function of this extent of reaction. Silica contents correspond to approximate equilibrium even in the recharge waters. The relative concentrations of Ca and especially Mg are significantly lower in the borehole waters than in recharge waters indicating a trend towards equilibrium. The Na/K ratios correspond to equilibrium only in the most evolved, older, waters which are shown to be at full equilibrium. (Authors' abstract)

MIGASZEWSKI, Z.M., HALAS, Stanislaw and **DURAKIEWICZ, Tomasz**, 1996, The age and origin of the calcite mineralization in the Holy Cross Mts. based on lithologic-petrographic and isotopic evidence: Przeglad Geologiczny, v. 44, no. 3, p. 275-281 (in Polish, Engl. abst.)

This report presents the results of lithologic, petrographic, isotopic and chemical investigations performed on calcites from the Holy Cross Mts. (Fig. 1). In general, 5 phases, i.e., A–Variscan (Visean/Namurian), B–older postvariscan (Late Carboniferous through Permian to the bottom of Zechstein conglomerates), C and D–younger Postvariscan (Permian/Triassic and middle/late Early Triassic), and E and F–Cimmerian-Alpine (Late Jurassic and Late Cretaceous), have been distinguished. This division has been confirmed by the highly diverse δC and $\delta^{18}O$ values of these calcites clustered in 4 populations (Fig. 3 in Migaszewski et al., 1995). The "rose-like" calcite (phases C and D) are most common (Figs. 4-7). This calcite occurs within the same fault system. Nearly all these faults extend in the close to N-S direction cutting different consolidated Variscan structures. This unique structuro-tectonic position of the "rose-like" calcite indicates a rare geologic event that took place here in Early Triassic time. Acc. to Migaszewski, the Holy Cross Mts. area probably shifted toward NW along the western margin of the East European Platform. This shift must have been coupled with a slight clockwise rotation. These two combined movements of the crystalline basement brought about forming echelon faults featured by a close to N-S strike. The produced heat was enough to warm up the seawater and to trigger its circulation. The calcites from the Holy Cross Mts. formed under different geologic conditions: from a typical marine off-shore zone (phases E and F), through marine relict basins originated at the end of Variscan movements (phase A), to a terrestrial environment (phase B), at the final stage with strongly developed karstic processes (phases C and D). The marine provenance of the E and F phase calcites has been proved by the presence of fossil formation of sea-floor hot springs in Upper Cretaceous rocks (Migaszewski et al., 1987, 1995) and the ^{87}Sr / ^{86}Sr ratio varying from 0.70726911 to 0.70812912. In turn, the continental origin of the C and D phase calcites has been evidenced by their strongly variable isotopic composition (C, O and Sr) and the presence of characteristic elongated I. The development of karstification during precipitation of these calcites has been supported by a large number of different forms resembling flowstones and dripstones, as well as karstic authigenic and allogenic intercalations, karstic-tectonic breccias etc. (Figs 5-6, 9). The simultaneous determinations of $\delta^{18}O$ and Th of gaseous-L I in the same calcite crystals indicated that hydrothermal F had been of marine provenance (Fig. 2 in Migaszewski et al., 1995). The mean $\delta^{18}O_{SMOW}$ is 1‰ being close to that found in mid-ocean hydrothermal F (±1‰); it is completely different from the $\delta^{18}O_{SMOW}$ for meteoric waters (-5 to -22‰).

MIHALYNUK, M.G. and **GHENT, E.D.,** 1996, Regional depth-controlled hydrothermal metamorphism in the Zymoetz River area, British Columbia: Canadian J. of Earth Sci., v. 33, no. 8, p. 1169-1184.

Indexed under FI (E.R.)

MIN, Kyoungwon and **CHO, Moonsup,** 1996, Metamorphic evolution of pelitic and mafic schists in the Chungju area, northwestern Ogcheon metamorphic belt, Korea (abst.): 30th It'l. Geol. Cong., Abstracts, v. 2, p. 583. Authors at Dept. Geol. Sci., Seoul Nat'l. Univ., Seoul, 151-742 Korea.

The NE-SW trending Ogcheon metamorphic belt consists primarily of meta-pelites, meta volcanics, amphibolites, pebble-bearing phyllites, quartzites and calc-silicate rocks. FI in deformed quartz veins were studied to determine retrograde P-T path. The peak metamorphic assemblages are affected by second stage regional-thermal metamorphism at 400-500°C during late Triassic to Early Jurassic times. Retrograde P-T path based on FI studies suggests that final stage exhumation of the OMB, passing through the P-T range 1-3 kbar and 350-500°C, has occurred along the isochore curves of the CO_2 I. In conclusion, the clockwise P-T evolution of the OMB is accounted for by (1) rapid burial and tectonic thickening and (2) regional-thermal metamorphism associated with the Mesozoic granitoids. (From authors' abstract by E.R.)

MINGYOU, He, 1996, Physicochemical conditions of differential mineralization of Au and As in gold deposits, southwest Guizhou Province, China: Chinese J. of Geochem., v. 15, no. 2 (1996) p. 189-192 [in Engl.] Author at Inst. of Geochem., Chinese Acad. of Sci., Guiyang, 550002.

FI data pertaining to Au mineralization is presented. (HEB)

MIRONOVA, O.F., SALAZKIN, A.N. and **NAUMOV, V.B.,** 1995, Bulk and spot methods in analyzing volatile components in fluid inclusions: Geokhimiya, no. 7, p. 974-984, 1995 (in Russian, translated in Geochem. Int'l., v. 33, no. 6, p. 44-55.) Authors at Vernadskiy Inst. for Geoch. and Analytical Chem., Russian Acad. of Sci., Moscow.

Abstract in FIR 28, p. 101 (E.R.)

MISHRA, B. and **PANIGRAHI, M.K.,** 1996, Contrasting fluid evolution in the Kolar gold field: Evidence from fluid inclusion studies (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 88. Authors at Dept. of Geol. & Geophys., Indian Inst. of Tech., Kharagpur 721302 INDIA.

The structurally controlled lode-type Au mineralization in the Kolar Gold Field occurs within the metabasic rocks in the Dharwar Craton, S. India. Two distinct modes of occurrence of the metal has been identified on the bases of field observation and microscopic studies. These are: (i) Au- quartz (+ calcite + scheelite) lodes constituting of the bulk of mineralization in the Champion Reef and (ii) Au-quartz-sulfide veins (Oriental lode), parallely disposed with respect to the general NNW-SSE trend. Detailed FI studies in quartz from the two ore associations reveal some of the hitherto unreported gross differences in F chemistry vis-a-vis mechanism of transportation and deposition of Au.

The dominance of a carbonic-component in the F giving rise to the Au-quartz lodes is indicated by the presence of aq-carbonic and monophase-carbonic (CO_2+CH_4) I, as against their total absence in the Au-bearing quartz-sulfide veins (Oriental lode). Though aq-biphase and halite-bearing polyphase I are common to both the types, a paucity of the latter variety in the Au-quartz-sulfide lodes is clearly marked. The P-T conditions of evolution of the ore-F and the mineralization event have been worked out for the Champion Reef from appropriate I assemblages. The FLINCOR software package (Brown, 1989) was used for the P-V-T-X properties of pertinent I F. P determined from aq-carbonic I using the methods outlined by Brown and Lamb (1986, 1989) and Parry (1986), range from 3.6 to 3.1 Kb at a T range of 300 - 282°C. Intersecting isochores of coexisting aq (L+V) and carbonic I furnished a P range of 1.9 - 0.65 Kb at T of 260 - 200°C. These P-T values necessarily indicate a dominantly decompression phenomenon which brought about the unmixing of the parent H_2O-CO_2 F. This picture when collated with the F evolution (T-sal) diagram for the Champion Reef helps in delimiting the P-T condition of mineralization. A clustering of points on the T-sal plot within a T interval of 300 - <200° C for the high saline polyphase and some low-saline aq-biphase I indicate that the bulk of Au (+quartz) precipitated in that interval in response to a P drop and concomitant unmixing of the parent F. However, there is no evidence of boiling in any stage of evolution of the ore-F in either of the two ore regimes, contrary to an earlier reported work (Santosh, 1986). Lack of appropriate I assemblage rules out any P-T estimation for the Au- quartz-sulfide ores. The simple and reasonably linear trend obtained from T-sal plots of mostly the aq-biphase I therein, indicates mixing of two F components - (i) a high-temperature (>350°C) high-saline(up to 30 wt% NaCl eq.) and (ii) a low-T (< 150°C) low-saline (~4 wt% NaCl eq.) F. Though the origin of the first component is debatable, the second component is likely to be of meteoric ancestry.

The deduced F evolution path in the Champion Reef indicates that the CO_2 derived during the metamorphism of the regionally extensive mafic volcanics, has been the major carrier of Au in the form of carbonyl (CO) complexes. Lack of data does not allow speculation on the mode of transport of Au in the Au-quartz-sulfide regimes. (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: Dok. Ross. Akad. Nauk, 1995, v. 345, no. 2, p. 243-246 (in Russian, translated in Trans. (Doklady), Russian Acad. Sci., Earth Sci. Sect., v. 345A, no. 9, p. 454-459, 1996). First author at Geological Inst., Kola Sci. Center, Russian Acad. of Sci., Apatity, Murmansk Province.

Abst. in FIR v. 28, p. 102 (E.R.)

MO, Cehui, WANG, Xiuzhang, and **CHENG, Jingping,** 1996, Auriferous quartz veins from the Dongping gold deposit, NW Hebei Province and metallogenesis–fluid inclusion Rb-Sr isochron evidence: Chinese J. of Geochem., v. 15, no. 3, p. 265-271 (in Engl.). Authors at Guangzhou Inst. of Geoch., Chinese Acad. of Sci., Guangzhou, 510640.

The Dongping gold deposit, situated on the northern margin of the North China Platform, is a composite deposit composed of auriferous quartz vein-type and altered rock-type ore bodies. It is hosted in the inner contact zone of an alkaline intrusion which was intruded into Archean metamorphic rocks and was formed not later than the Hercynian period. Auriferous quartz veins of the deposit are dated with the FI Rb-Sr isochron method at 103±4 Ma, indicating that the gold deposit was formed in the Yenshanian period. ^{87}Sr / ^{86}Sr source-tracing shows the ore-forming materials came dominantly from alkaline intrusions. These results, combined with other isotope and REE data, suggest that the Dongping gold deposit is not a traditional magmatic hydrothermal deposit, but a reworked hydrothermal deposit related to heated and evolved meteoric water. (Authors' abstract)

MOHAMED, M.A.M., 1996, Petrogenesis and post-magmatic evolution of the Homolka tin-bearing granite, Moldanubian batholith, Bohemian Massif: Ph.D. Thesis, Charles Univ., Prague, Czech Republic, 121 pp (in Engl.).

The study comprises mineralogical, petrographical and geochemical data on two granitic bodies with distinct types of mineralization: (1) Sn-bearing granite of Homolka with related Sn-(Nb-Ta), W, polymetallic sulphides (Pb, Zn, Cu) and fluorite mineralization, and (2) Mo-bearing granite of Kozi Hora. Both granites are located in the Moldanubian Batholith near Nova Bystrice near Czech-Austrian border.

The Homolka granite is unique in mineralogical and geochemical composition relative to other granite types of the Moldanubian Batholith. This highly metallogenic specialized granite represents the product of magmatic crystallization of a highly evolved F-rich M.

Microthermometric measurements of FI in the Homolka granite varieties revealed several generations of aq H_2O-NaCl-KCl±$CaCl_2$±$MgCl_2$ I with Th in a wide range, from 80 to 360°C, and sal between 2 and 13 wt.% NaCl eq. The early F was responsible for pervasive hydrothermal alteration such as microclinization of albite and sericitization of feldspar. Greisenization, accompanied by quartz veins and Sn-(Nb-Ta) mineralization, probably took place at T 200 to 350°C.

W-bearing quartz veins are characterized by aq I of similar composition with very limited amounts of CO_2 with Th up to 360°C and sal between 2 and 8 wt.% NaCl eq.

In contrast, partial mixing of two originally unrelated homogeneous F, low saline H_2O-CO_2 and aq H_2O-NaCl-KCl with sal up to 13 wt.% NaCl eq., is responsible for Mo-mineralization precipitation and greisenization of the Kozi Hora granite. Greisenization took place at T between 350 and 200°C and P of about 2000 bars.

There is a similarity in composition and Th of F in the Mo-bearing granite of Kozi Hora (Czech Republic) with the Mo-bearing granites of Nebelstein and Hirschenschlag in Austria (Koller et al. 1992, 1994). Mo-mineralization in the Kozi Hora granite seems to represent an extension of the same type of mineralization from the Austrian territory. (Abstract courtesy of P. Dobes.)

MOHAN, A., PRAKASH, D. and SACHAN, H.K., 1996, Fluid inclusions in charnockites from Kodaikanal massif (South India): P-T record and implications for crustal uplift history: Mineral. and Petrol., v. 57, p. 167-184. First author at Dept. of Geol., Banaras Hindu Univ., Varanasi, India.

The Kodaikanal massif is part of a Precambrian terrane characterized by granulite facies rocks. It is dominated by the widespread occurrence of charnockites. The observed textural relationships in these rocks are consistent with the following main reactions:

i. Biotite + Quartz = Orthopyroxene + Alkali feldspar ± Garnet + Vapour
ii Garnet + Quartz = Orthopyroxene + Plagioclase
iii. Pyrope = Mg Tschermaks + Enstatite (in Opx)

Garnet consuming reactions and the preservation of biotite-quartz-orthopyroxene-plagioclase symplectites are indicative of a decompression event. Progress of such reactions with decreasing P together with FI data has implications for the construction of P-T vectors. Quartz from the charnockites contains the following FI: (1) monophase high density CO_2-rich (0.968/-1.014g/cm^3) as the dominant F phase; (2) aq biphase CO_2-H_2O (0.888-0.915g.cm^3) and (3) late minor aq H_2O I with no visible CO_2, CO_2-isochores for the high density FI yield a pressure limit of ca. 6.5 kbars, at granulite facies T of ca. 800°C, which is in accordance with the estimation from mineralogical thermobarometry. The P-T path delineated from combined mineralogical and density data on carbonic I is characteristically T-convex suggesting an isothermal decompression path and rapid uplift followed by cooling of a tectonically thickened crust. (Author's summary)

MOISETTE, A., SHEPHERD, T.J. and CHENERY, S.R., 1996, Calibration strategies for the elemental analysis of individual aqueous fluid inclusions by laser ablation-ICP-MS: J. Anal. Atom. Spec., v. 11, p. 177-186.

MOISEYENKO, V.G. and MIRONYUK, A.F., 1996a, Composition peculiarities of gas-liquid inclusions of native gold deposits in the East of Russia (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 552. Authors at Amur Integrated Research Inst., Far East Branch, RAS, Blagoveshchensk, Russia.

Together with ore quartz for studying gold-ore deposits of different formations in the East of Russia the composition of GLI in native gold has been investigated by the authors.

Composition of GLI in quartz is mainly water-base. The quantity of G is not higher than 5 mass % [sic], of salts-20 mass %., cations are represented by Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+. But only Na^+, K^+, and NH_2^+ [sic]are consonant components in GLI of all deposits, moreover the contents of NH_4 are usually lower 8 eq.%. Among anions HCO_3^-, Cl^-, Br^-, I^- are constantly present, F^- and S^- are not so frequent. HCO^- and Cl^- predominate. The share of halogens is up 78 eq.%.

G components of F is represented mostly by CO_2, CO, N_2, C_2H_4, C_2H_6 and by other hydrocarbons, seldom by H_2S and H_2. CO_2 predominates.

By salt composition GLI in native gold are similar to GLI in quartz, but they essentially differ by concentration of salts [method not stated], G saturation and G composition. The total amount of G and salts in I is about 25-75 mass%, G are up to 40 mass%. Water-G-salts ratio significally changes in gold samples even of the same deposit.

In G compositions of I in gold just as in quartz CO_2, CO, often N_2, hydrocarbons (CH_4, C_2H_4, C_2H_6 et al.), in some cases H_2 are present. But H_2S in GLI in quartz is present not often and in small quantities. H_2S content in I in gold of almost all deposits is more than 25 mole % and in some near-surface volcanogene deposits 50-90 mole%.

Among other components of I in native placer gold from upper horizons of ore bodies that presence of fatty acids (palmitic, oleic et al.) has been established. Availability of fatty acids in placer gold as well as presence of microorganisms-gold concentrators at gold-ore deposits in the East of Russia (established by V.G. Moiseyenko and S.A. Marakushev, 1987) makes it possible to assert the participation of biogenic processes in placer gold formation and in often observed enrichment of upper horizons of gold-ore deposits (Tokur, Lebedinskoe et al.). (Authors' abstract.)

MOISEYENKO, V.G. and **MIRONYUK, A.F.,** 1996b, Composition peculiarities of gas-liquid inclusions of native gold deposits in the east of Russia (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 9-10. Authors at Amur Integrated Research Inst., Far East Branch, RAS, Blagoveshchensk, Russia.

The composition of LI in quartz from unspecified Au deposits is given, as well as the G.

By salt composition GLI in native gold are similar to GLI in quartz, but they essentially differ by concentration of salts, G saturation and G composition. The total amount of G and salts in I is about 25-75 mass%, G are up to 40 mass%. Water-G-salt significantly changes in gold samples even of the same deposit.

In G composition of I in gold, just as in quartz, CO_2, CO, often N_2, hydrocarbons (CH_4, C_2H_4, C_2H_6, et al.), in some cases H_2 are present. But H_2S in GLI in quartz is present not often and in small quantities. H_2S content in I in gold of almost all deposits is more than 25 mole% and in some near-surface volcanogene deposits 50-90 mole%.

Among other components of I in native placer gold from upper horizons of ore bodies, the presence of fatty acids (palmitic, oleic et al.) has been established, making it possible to assert the participation of biogenic processes in placer gold formation and in often observed enrichment of upper horizons of gold-ore deposits. (From authors' abstract by E.R.)

MOKHARTI, A., WAGNER, C. and **VELDE, D.,** 1996, Discovery of a carbonatite inclusion in a camptonite from the Taourirt area (Morocco). Geological implications: Comptes Rendus-Academie des sciences, Serie II: Sciences de la Terre et des Planetes, v. 323, no. 6, p. 467-474 (in French).

MOLCHANOV, A.V., 1996, Gold-uranium deposits of the Uguisk and Oldongsinsk Graben-Synclines (Aldan Shield) (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 694. Author at VSEGEI, Russia.

The South Uguisk ore field is related to intersection of the Tokkinsk gold-silver-uranium and the Kondinsk uranium geochemical zones. The main ore formation process was gumbeitization that was represented by the new low-T minerals like potassium feldspar (adularia), carbonate, sulfides, chlorite and quartz. Two following metasomatic facies have been recognized: alkaline (adularia, sulfides, chlorite, carbonates) and acidic (quartz, sulfides, adularia). It is established that alkaline facies is the main in the formation of uranium deposits whereas acidic facies is the main in the formation of gold deposits. 2- and 3-phase state of ore-bearing black quartz has been recognized after study of 40 fluid inclusions. The Th varies from 130° to 200°C. (From author's abstract by E.R.)

MOLLING, Philip, ZHU, Chen, and **KOENIG, Brian,** 1996, Analysis of volatile chloride production using chemical equilibrium of brine-rock-steam at The Geysers geothermal field, California (abst): in Chapman Conference Abstracts, Crater Lakes, Terrestrial Degassing, and Hyper-acid Fluids in the Environment, September 4-9, 1996, Crater Lake, Oregon, Johan C. Varekamp and Gary L. Rowe, convenors, p. 23-24. Authors at Unocal Corporation, Geothermal & Power Operations, Geoscience Group, 3576 Unocal Place, Santa Rosa, CA, 95403-1774.

Volatile chloride, as $HCl_{(gas)}$, produced in The Geysers steam is thought to promote low pH in condensed liquid films that form on pipe walls and corrode the steam-gathering system. It is therefore important to identify the cause of volatile chloride ($HCl_{(gas)}$) generation and predict $HCl_{(gas)}$ levels in produced steam.

This study investigates the hypothesis of volatile chloride production from portions of The Geysers undergoing 'dry-out'. Here 'dry-out' refers to a condition in the reservoir defined by concurrent chloride, boron, and total non-condensible G increases. Recent advances in chemical thermodynamic data (Sverjensky et al., 1991; Berman, 1988) coupled with geochemical modelling of steam chemistry using CHILLER (Reed, 1992), have been combined with constraints from geological data, FI data, and adsorption theory to investigate the 'dry-out' model. The equilibrium constant for the L-V partitioning reaction of HCl was extracted from Robie et al. (1984) and Sverjensky et al. (1991). The model presumes FI sal are enriched to levels consistent with adsorption experiments. Geochemical modelling presented here suggests equilibrium between boiled residual pore brine ('dry-out'), and identified mineral assemblages at The Geysers can generate the measured range volatile chloride contents. (From authors' abstract by E.R.)

MOLNAR, Ferenc, WATKINSON, D.H. and **EVEREST, J.O.,** 1996, Heavy-metal rich, highly saline fluid inclusions from the cu-rich Footwall contact, Little Stobie Ni-Cu-Pge mine, Sudbury, Canada (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 89-91. First author at Dept. of Mineral., Eotvos L. Univ., Budapest, Hungary.

The Little Stobie Mine (INCO Ltd.) consists of two Ni-Cu-PGE orebodies (Davis 1984); one is composed of pods and lenses of pyrrhotite-pentlandite-chalcopyrite in the Contact Sublayer between norite of the Sudbury Igneous Complex, and the footwall Murray granite and metabasalt of the Elsie Mountain Formation. Some Cu-enriched vein-like protrusions cut the footwall.

Quartz grains from sulfide-bearing veins contain at least four major types of FI. (These four types are subdivided into 11 subtypes, whose phase assemblage, description, degree of fill, occurrence and relative abundance in the two orebodies and the barren vein in ore summarized in a large diagram, Fig. 1). Most FI are S, occurring in fractures cutting grain boundaries; some isolated type III and CO_2-rich I also occur. CO_2-rich I occur in fractures with aq I; variability in the volume of CO_2-rich phase suggests inhomogenous trapping conditions.

SEM-EDS analysis of opened I revealed abundant cubic or round halite, sylvite, acicular Fe,Mn hydroxychloride, and round or bipyramidal-rhombohedral Pb and Ba chlorides. Minor Ca chloride was also detected in analyses. Homogenization of the V phase occurred between 70 and 270°C. Th V versus Ts halite diagrams show significant differences between the samples from sulfide-bearing and barren veins.

Most type III I failed to nucleate ice during undercooling; when freezing was achieved, eutectic T were –64 to –78°C, ice melting occurred at –21 to –45°C, and metastable hydrohalite melting was above 0°C. The estimated apparent sal are 39 - 49 NaCl + $CaCl_2$ wt% eq. True concentration cannot be calculated due to metastability (lack of hydrohalite nucleation), the mode of homogenization (Ts halite>Th vapor) and the presence of Fe, Mn, Pb and Ba chlorides. In I with acicular phases, freezing occurred between –30 - –60°C and yellowish-greenish anisotropic assemblages appeared under crossed polars. These solids did not resorb the halite phase, but slight resorption of the acicular phase was observed in a few runs. Melting began at about −35°C, but abundant L was developed only between −20 and −24°C. The anisotropic phases melted reproducibly between +10 and +35°C. Ice was not observed. Behaviour of these I may be explained in the $CaCl_2$-rich part of the $NaCl$-$CaCl_2$-H_2O system (Schiffries, 1990), but SEM-EDS data suggest that $FeCl_2 \bullet 6H_2O$, $FeCl_2 \bullet 4H_2O$ or $MnCl_2 \bullet 4H_2O$ phases were formed instead of antarcticite.

Pure CO_2 I show different microthermometric data as a function of mode of occurrence. Tmelt CO_2 data slightly below −56.6°C imply the presence of other species, such as methane. The synchronously trapped pure CO_2 I and CO_2-free aq I may represent the end-member F of the immiscible system. The minimum P for entrapment of type III I was estimated by the P range corresponding to halite Th on the isochores of type IVA I. This range is 1.8-2.2 kbars for single I, 1.5-1.7 kbars and 0.7-1.2 kbars for fracture-hosted I. Intersecting isochores for type IVA and type IIA Is indicate a P range between 0.2-1 kbars. This is compatible with entrapment during uplift.

The results suggest that high-T, high-P, very saline solutions, interacted with P magmatic ores and host rocks, and redistributed metals into stringers and veins at the base of the Little Stobie orebody. The detection of heavy metal-rich, polyphase I may be useful in exploration for enriched ores in footwall environments of other magmatic Ni-Cu-PGE deposits. (From authors' abstract by E.R.)

MOON, S.H., PARK, H-I, RIPLEY, E.M. and **LEE, Insung,** 1996, Mineralogic and stable isotope studies of cassiterite greisen mineralization in the Uljin area, Korea: Economic Geol., v. 91, p. 916-933. First author at Korea Inst. of Geol., Mining, and Materials, Gajung Dong 30, Yusung Ku, Taejeon 305-333, Korea.

Vein-type, greisen-related cassiterite deposits occur at the Uljin, Yuchang, and Dongseog mines in eastern Korea within a Precambrian pegmatite dike swarm, and locally, within granite gneiss and metasedimentary rocks.

T of greisen I stage mineralization, determined from FI Th studies, arsenopyrite composition, and quartz-muscovite $\delta^{18}O$ values, range from 450°C to 600°C. The coexistence of sulfide and oxide minerals suggest that during ore deposition f_{S_2} increased and f_{O_2} was constant or decreased slightly. FI analyses indicate that the ore F was of low to moderate sal (2.89-8.55 wt.% NaCl eq.), with variable CO_2 content. Oxygen and hydrogen isotope values of quartz and muscovite decrease along a distance of 1,500 m from the northeast (Uljin mine) to the southwest (Dongseog mine) and suggest that F $\delta^{18}O$ and δD values decreased from ~11 to 9 permil, and -55 to -61 per mil, respectively. A similar decrease in F $\delta^{18}O$ and δD values is recorded temporally with the paragenetic stage at the Uljin mine. Sulfur isotope values of arsenopyrite and molybdenite range from -1.2 to 1.2 per mil.

A genetic model of F derivation from an underlying Mesozoic granitic pluton, accompanied with the involvement of meteoric water in later stages, is proposed. (From authors' abstract by E.R.)

MOORE, F. and **JAMI, M,** 1996b, First report on the occurrence of a celestite horizon at the base of Asmari Formation, Bangestan anticline, Behbahan, Iran (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 703. Authors at Dept. of Geol., College of Sci., Shiraz Univ., Shiraz, Iran.

Detailed petrographic, geochemical and strontium isotope studies combined with field observation and microfacies investigations indicate that syngenetic celestite deposition has taken place directly from Tertiary sea water in an intrasupratidal to supratidal environment.

FI geothermometry and FTIR analyses suggest that the F medium in which recrystallization of the celestite has taken place, among other constituents was also rich in immature hydrocarbons. It is demonstrated that the concretions were subjected to several low T thermal events, the maximum of which did not exceed 275°C. (From authors' abstract by E.R.)

MOORE, J.N., HULEN, J.B. and **NORMAN, D.I.,** 1995, Evolution of the Geysers (U.S.)–Data from fluid-inclusion microthermometry and gas geochemistry: Proceedings 17th NZ Geothermal Workshop 1995, M.P. Hochstein et al., eds., Geothermal Inst., The Univ. of Auckland, p. 77-82. First author at Earth Sci. and Resource Inst., Salt Lake City, Utah, USA.

The Geysers, California, is the site of an active hydrothermal system that initially developed between about 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, and epidote ± chlorite ± wairakite within the intermediate parts of the thermal system, and calcite in the outer parts. Potassium feldspar and quartz are present in all assemblages. Maximum P-corrected Th and apparent sal 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 approximately 1500 m from the intrusion. We suggest that the shallow, moderate-sal F are crustal waters modified by water-rock interactions and that the high-sal F are magmatic brines. The formation of V-dominated conditions is reflected in the abrupt appearance of low sal (0.0 to 0.4 wt.% NaCl eq.) FI with Th near 265°C. These IF are thought to represent steam condensate formed as the L-dominated system boiled off. (Authors' abstract)

MOORE, J.N. and **NORMAN, D.I.,** 1996, Fluid-inclusion gas analyses in active geothermal systems: examples from liquid- and vapor-dominated fields (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 92-94. First author at Earth Sci. and Resources Inst., Univ. of Utah, Salt Lake City, UT 84108.

F-I G can provide information on the origins of hydrothermal F and the extent of boiling and mixing these F have undergone. In this study, F-I G from three high-T geothermal systems were determined by quadrapole mass spectrometry. Two of the systems, Broadlands-Ohaaki, New Zealand, and Tiwi, Philippines are L-dominated. The third, The Geysers, U.S., is V-dominated.

The G were released from the FI by either thermal decrepitation at 300 to 500°C or by crushing. G found in the I include N_2, He, H_2, Ar, Ne, CO_2, CO, CH_4, H_2S, SO_2, and hydrocarbons (C_2-C_7). A capacitance manometer was used to measure the G contents. Water was frozen in a capillary tube and determined by weighing or by P measurement. Details of the methodology are described by Norman and Sawkins (1987).

In the Broadlands-Ohaaki field, the compositions of F-I G from a single quartz crystal from well BR-12 were determined. The analyses are characterized by high total G contents (to about 23 mol%), a relatively wide range of N_2 / Ar ratios that exceed values found in air-saturated water, and variable N_2 / CH_4 and CO_2 / CH_4 ratios (Fig. 1a). A strong correlation exists between CH_4 and C_{2-7} organic species but there is little correlation between N_2 and the organic compounds. Thus, the analyses suggest that the I F were deeply circulating waters that interacted with carbonaceous basement rocks and accumulated upward-fluxing magmatic volatiles. Helium isotope compositions of the modern geothermal F provide independent evidence for the presence of a magmatic component (Giggenbach, 1986).

The G contents of some of the analyses are unreasonably high if it is assumed that only a single phase L was present when the I F were trapped. Thus, these analyses must reflect a contribution from V-rich I. The effects of boiling at 260°C on the N_2-CH_4-CO_2 G ratios of coexisting L and V are shown in Figure 1b. The results indicate that boiling can account for only a small proportion of the variation in these G species.

Tiwi is a large geothermal system associated with an andesitic volcano on Luzon, Philippines. Th of FI in vein quartz, calcite, and anhydrite ranged from 195 to 325°C, although most were above 240 to 250°C at depths below 1100 m. Sal are less than 1.7 wt.% NaCl eq. within the volcanic sequence, but are similar to sea-water (>2.5 wt.% NaCl eq.) in the underlying marine sediments.

In contrast to Broadlands-Ohakki, Tiwi samples have N_2/Ar ratios similar to air-saturated water. These data suggest that the Tiwi F are dominantly meteoric waters that have reacted to varying degrees with the basement rocks. Only a few of the analyses are characterized by enrichments in N_2. These samples may contain magmatic F that preferentially utilized some of the fracture zones cut by the well.

The Geysers provides an example of a long-lived hydrothermal system intimately associated with the intrusion of a hypabyssal granitic pluton. F-I, mineralogic, and isotope data show that the present V-dominated conditions evolved from a larger, L-dominated system that developed mainly in Franciscan metagraywacke and in the underlying intrusives. P-corrected Th and apparent sal of L-rich FI range from 440°C and 44 wt.% NaCl eq. at distances of <600 m from the pluton to 325°C and 5 wt.% NaCl eq. at distances of approximately 1500 m from the intrusion. The apparent sal of the shallow F suggest that the bulk of the hydrothermal system was dominated by connate waters modified by water-rock interactions while the high-sal F are interpreted as magmatic brines. Meteoric waters appear to be represented by low-sal I F with Th of <200°C. Widespread boiling apparently occurred as T within the initial hydrothermal system dropped to about 265°C. Present-day T are close to 240°C in the main steam reservoir, but can reach as high as 342°C in the highest-T zones in the northwest portion of the field.

I from The Geysers and metamorphic veins, like those from Tiwi, are dominated by G derived from meteoric and crustal sources. Similar G ratios characterize the modern steam. Two of the samples containing I with hypersaline brines yielded high N_2/Ar ratios, consistent with a magmatic origin, but variable CH_4 contents. These differences could be due to either variations in the CH_4 composition of the initial magmatic F or to the subsequent trapping of crustal-derived volatiles. The third sample was enriched in Ar, reflecting the incursion and trapping of meteoric waters. Thus, the F-I data document the early development of a hydrothermal system dominated by crustal and magmatic F and the subsequent influx of meteoric waters. Boiling and the formation of the present V-dominated conditions may be reflected in the high G contents of the analyses.

The results of these investigations demonstrate that F-I G analyses are powerful tools for tracing F sources and evaluating the paleohydrology of geothermal systems. Ratios of N_2-Ar-CH_4 allow the distinction between magmatic, crustal, and meteoric sources of G. G distributions and the presence of excess G can provide direct evidence of boiling, while variations in G ratios not related to boiling may indicate mixing or the heterogeneous trapping of G species from different sources. (From authors' abstract by E.R.)

MORALES, S., 1994, Mineralogy, geochemistry, and metallogeny of the hydrothermal ore deposits of southeastern Spain (Aguilas-Sierra Almagrera): Ph.D. thesis, Univ. of Granada, Granada, Spain (in Spanish).

FI studies of quartz from stage I and II of the paragenetic sequence show two populations. In those associated with stage I, Th ranges from 405 to 508°C, and the sal, from 17 to 22 wt.% NaCl eq. For stage II, Th ranges from 160 to 310°C, and the sal, from 2 to 8 wt.% NaCl eq. Isochores calculated following Zhang & Frantz (1987) for FI from stage I can be bracketed between 400 and 450°C (see above). F pressure in this T range varied from 200 to 900 bars.

As discussed by Morales-Ruano and Fenoll Hach-Ali, 1996 (see next item) (E.R.)

MORALES, S., BARBANSON, L., BÉNY C., LAGGOUN-DEFARGE, F., TOURAY, J.-C., and **FENOLL, P.**, 1996, Complex fluids with (H_2S + CO_2 + CH_4 + N_2 + S_8) and hydrocarbons enclosed in stratiform fluorite from Turon: visible and UV Raman microprobe data (abst.): 16th Earth Sciences Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 156 (in French). First author at IACT, CSIC-U, Granada, Spain.

Fluorite from the F-(Pb-Zn) district of Turon (Alpujarride, Beltic Cordillera, Southern Spain) encloses eight types of FI. Types A and B, the most frequent ones, are always P, and contain a [vapor] phase with CO_2 and an aqueous phase (type A) with sometimes a crystal of halite (type B). The other (5) types are very variable: monophase $CO_2 \pm CH_4$ gas (type C) or with an opaque fluorescent (in UV light) organic compound (type D); biphase (type E; gas + organic L of orange color, non-fluorescent in UV); type F contain complex compositions (H_2S + CO_2 + CH_4 + N_2 + S_8 + saline L); type G contain a gas rich in CO_2, a brine and different combinations of solids (halite, sylvite, organic matter, sulfides); biphase organic L of yellow color fluorescent in UV (type H). The deposition of fluorite is linked to saline solutions rich in CO_2 (types A and B), probably corresponding with basin F. After the deposition of the mineralization a complex tectonic and sedimentary evolution induced the circulation of later F represented by the types C to H, probably responsible for the precipitation of sulfides associated with the fluorite. In these F it is difficult to distinguish between components (CO_2?, N_2?) from outside the system and components formed locally through the evolution of organic matter (L hydrocarbons, CH_4, H_2S?). (From authors' abstract, translated by E.A.J. Burke.)

MORALES-RUANO, Salvador and **FENOLL HACH-ALI, Purificacion**, 1996, Hydrothermal argentopentlandite at El Charcon, southeastern Spain: mineral chemistry and conditions of formation: The Canadian Mineralogist, v. 34, p. 939-947. Authors from Dept. de Mineralogía y Petrología and Inst. Andaluz de Ciencias de la Tierra, CSIC-Univ. of Granada, Avenida Fuentenueva s/n, E-18002 Granada, Spain.

The estimated conditions of formation for argentopentlandite from El Charcón are: T between 400 and 450°C, sal between 17 and 22 wt.% NaCl eq., log $f(S_2)$ between -9.6

to -15.7 atm., and P between 200 to 900 bars. (From authors' abstract by E.R.)

FI data quoted from Morales, 1994 (this volume E.R.)

MORALES-RUANO, S., TOURAY, J.C., BARBANSON, L., and FENOLI HACH-ALI, P., 1996a, Genesis of Ge mineralisation related to sphalerite bearing "incompatible" fluids from Cerro del Toro (Alpujarride, SE of Spain): IV Spanish Geological Congress, Universidad de Alcalá, 1-5 July, 1996, published in Geogaceta, v. 20, no. 7, p. 1567-1570 (in Spanish, Engl. abst.). First author at Instituto Andaluz de Ciencias de la Tierra y Departamento de Mineralogia y Petrologia, CSIC-Universidad de Granada, Avda. Fuentenueva, s/n. 18002 Granada, España.

The problem addessed in this article is a tentative explanation of the coexistence of partially miscible "incompatible" F in different P I of the same crystal (or group of crystals). It is based on a study of sphalerite crystals from Cerro del Toro, containing two groups of P I with fillings displaying contrasting compositions, repectively suggestive on one hand of a "Mississippi Valley type" (MVT) brine, and on the other hand of a metamorphic F. The interpretation is based on a comparison of the composition of both "primary" F and a tentative explanation involving partial metamorphic recrystallization whose possible markers are solid inclusions of briartite (a Ge-rich mineral). (Authors' abstract.)

See also adjacent item (E.R.)

MORALES-RUANO, Salvador, TOURAY, J-C, BARBANSON, Luc and FENOLL HACH-ALI, Purificacion, 1996b, Primary cavities with incompatible fluid fillings in Ge-bearing sphalerite from Cerro Del Toro, Alpujarride (Spain): Economic Geol., v. 91, p. 460-465. First author at Dept. de Mineralogía y Petrología and Inst. Andaluz de Ciencias de la Tierra, CSIC-Univ. of Granada, Avenida Fuentenueva s/n, E-18002 Granada, Spain.

Within different FI generations, incompatible F are common; their possible localization in different primary I of the same crystal (or group of crystals) is more puzzling.

The problem addressed in this article is a tentative explanation of this coexistence. It is based on a study of sphalerite crystals from Cerro del Toro which contain two groups of primary I with fillings displaying contrasting compositions, respectively suggestive on one hand of a Mississippi Valley-type brine, and on the other hand, of a metamorphic F (Morales et al., 1995). The interpretation is based on a comparison of the composition of both P F and a tentative explanation involving partial metamorphic recrystallization whose possible markers are solid I of briartite (a Ge-rich mineral). (From authors' abstract by E.R.)

MORATA, D., DOMINGUEZ-BELLA, S., and MORALES, S., 1996, Scapolites origin associated to Triassic dolerites from North of Cádiz province): IV Spanish Geological Congress, Universidad de Alcalá, 1-5 July, 1996, published by Geogaceta, v. 20, no. 7, p. 1527-1530 (in Spanish; Engl. abst.). First author at Dpto. Cristalografia, Mineralogia, Estratigrafia, Geodinámica, Petrologia y Geoquimica, Universidad de Cádiz, 11510 Puerto Real, Cádiz.

Scapolites are present in some doleritic tectonic blocks ("ophites") in the External Zones of the Betic Cordilleras, in North of Cádiz province. These scapolites fill veinlets and replace plagioclases from the dolerites in the proximity of fissures. Scapolites (Me_{26-29}) are partial or totally replaced by low-iron prehnites ($XFe^{3+} = 0.13$-0.66). FI found in scapolites show high sal (40-55% wt. eq.) multications (Na-Ca-K.?) aq F. No volatile phases have been detected in microthermometric runs. Ths run from 380 to 540°C. These scapolites filling dolerite veinlets are interpreted as a result of magma-exaporite interactions during dolerite emplacement into the Triassic evaporitic formations. (Authors' abstract.)

MORAVEK, Petr, (Ed.), 1996a, with contributions from Morávek, P., Pertold, Z., Puncochár, M., Studnicná, B. and Zachariás, J., 1996, Gold deposits in Bohemia: Czech Geological Survey, Prague, 96 pp.

Briefly discusses the FI evidence relevant to the ore paragenesis. (H.E.B.)

MORAVEK, Petr, 1996b, The Mokrsko gold deposit: Czech Geol. Survey *in* Gold deposits in Bohemia, Petr Moravek, ed., p. 31-56.

Indexed under FI (E.R.)

MOREIRA, M., VALBRACHT, P.J., STAUDACHER, T. and ALLEGRE, C.J., 1996, Rare gas systematics in Red Sea ridge basalts: Geophysical Research Letters, v. 23, no. 18, p. 2453-2456.

MORGAN, J.A., 1996, A documentation and study of vein-hosted base metal deposits on the Avalon Peninsula, Newfoundland: Bachelor's thesis, Memorial Univ. of Newfoundland, St. John's, NF, Canada, 101 pp.

There are two genetically separate types of vein-hosted base metal occurrences in the Placentia bay area. The majority of veins appear to have formed from low to medium T (200-260°C), low sal hydrothermal F during the Silurian-Devonian Acadian Orogeny. These veins contain copper ± or ± zinc sulphide mineral assemblages. A second, younger set of veins contains lead and zinc sulphides, and are enriched in copper ± or ± gold ± or ± silver. A number of vein-hosted base metal occurrences exist elsewhere on the Avalon Peninsula, but generally do not appear to be as economically significant as those in the Placentia Bay are; the one notable exception is the Turk's Gut copper showing, located in Colliers Bay. FI data for all of these veins are consistent with those of high-level epithermal deposits. Host rock brecciation is a common feature associated with these veins, especially the lead-zinc bearing type. Apart from wallrock silicification directly adjacent to these veins, there are generally no pronounced hydrothermal alteration assemblages associated with those in the Placentia Bay area. The copper ± or ± zinc veins in Placentia appear to have formed in association with regional deformation during the Acadian Orogeny, while the lead-zinc bearing veins have a genetic affiliation with the granitic batholith underlying northeastern Placentia Bay. (Author's abstract)

MORIIZUMI, M. and UI, T., 1996, Changes in eruption styles accompanied with the variation of total water content of the glass inclusions (abst.): Eos, Trans. Amer. Geophys. Union, v. 77, no. 22, May 28, 1996, p. W131. Authors at Dept. of Earth and Planetary Sci., Hokkaido Univ., Sapporo 060, Japan; e-mail (moriizumi@s2.hines.hokudai.ac.jp)

During pyroclastic eruption, eruptive style commonly change from Plinian to pyroclastic flow. This type of eruption is often associated with the formation of Caldera. However, the reasons for the change in eruption style have not been clarified. Infrared spectroscopic (H_2O) analyses of glass I in phenocrysts reveal the pre-eruption concentrations of volatiles in separate parts of the body of magma. The total water content of glass I analyzed can be used to interpret the relationship between total water content and the eruptive style. Kuttara Cladera forming eruption occurred at ca. 42 ka in southwest Hokkaido, Japan. The eruption consisted of a Plinian (pfa-L) and plinian accompanying with pyroclastic flow (air fall:pfa-U and pyroclastic flow:pfl-a, deposits) eruptions. Glass I within quartz and plagioclase phenocrysts of pyroclastic deposit were analyzed. Glass I in phenocrysts of plinian deposits contained 0.66 to 3.62 pyroclastic flow: air-fall deposit I contained 0.80 to 2.82 H_2O and I in phenocrysts of the pyroclastic flow deposits contained 0.27 to 1.54 water contents during the eruption. Estimated major chemical composition of M also changed from SiO_2 rich in pfa-L (SiO_2 75 deposits to SiO_2 poor in pfa-U) SiO_2 69 and H_2O concentration of M may influence the eruptive style of pyroclastic eruptions. On the assumption that all volatiles in magma are H_2O, magma would become saturated with water at ca. 850 bar in pfa-L and ca. 550 bar in pfa-U. The silicic magma chamber in Island Arc is estimated to lie at a depth of ca. 10 km. Thus under these conditions, bubble formation in the magma could not have occurred within the magma chamber. Bubble formation could have occurred if (1) the magma rose from the magma chamber, or (2) volatiles were added from different magma to the magma discharged at the Kuttara Caldera forming stage. The presence of banded pumice and reverse zoning of plagioclases in the deposits indicate that magma mixing occurred in the magma chamber or vent just prior to or during eruption. Thus bubble formation is interpreted to be the result of volatile addition. (Authors' abstract)

MORITZ, Robert and **GHAZBAN, Fereydoun,** 1996, Geological and fluid inclusion studies in the Muteh gold district, Sanandaj-Sirjan zone, Isfahan Province, Iran: Schweiz. Mineral. Petrogr. Mitt., v. 76, p. 85-89. First author at Départernent de Minéralogie, Univ. de Genéve, rue des Maraîches 13, CH-1211 Genéve 4, Switzerland.

Metamorphic rocks of the Sanandaj-Sirjan zone host the Muteh gold mining district. The gold occurrences are in northwest-striking and northeast-dipping normal faults crosscutting the regional ductile pattern of the host rocks. This faulting is possibly related to a Tertiary extensional uplift event. The hydrothermal alteration assemblage quartz-muscovite-pyrite-carbonate-albite overprints the metamorphic assemblage. Gold is associated with pyrite. FI data suggest that gold deposition is related to mixing between a regional CO_2-bearing saline F and a dilute F, possibly of meteoric origin. (Authors' abstract)

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. of Geol. and Geoch., Stockholm Univ., S-106 91 Stockholm, Sweden.

The Alnö alkaline-carbonatite complex consists in its northernmost part at Långarsholmen of a ring-type intrusion composed of pyroxenite, sövite and ijolite, emplaced in that order. 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 at ca. 5-6 kbar 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 separted at ca. 5 kbar 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 hydro-carbonic F trapped as I in diopside (di) and apatite (ap) (type B2 I reluctant to dissolution up to 550°C). As P_{H_2O} started to increase, Fe-pargasite began to replace the pyroxene. It appears that the F present at that stage was aq and contained ca. 40% NaCl. With decreasing PT, the F separated into two immiscible phases of high- and low-sal (type B1 of 65% NaCl and Cl of 7% NaCl), respectively. At the shallow depths of the final emplacement, the composition of the F phase was most probably controlled by supply of meteoric water as indicated by the dilution trend of some B1 type I. Around 4 kbar, a CO_2-bearing aq F of low sal (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 toward a late (Na+K) hydrocarbonic F during cooling at the shallow depths of the final emplacement. (From authors' abstract by E.R.)

MORRIS, G.A., NESBITT, B.E. and **MUEHLENBACHS, K.,** 1996, Paleohydrogeology of the Nahanni River region, NWT, Canada: Resolving multiple events from a long and complex fluid history (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A319. First author at Dept. of Earth and Atm. Sci., Univ. of Alberta, Edmonton, AB, T6G 2E3, Canada; e-mail (george.morris@ualberta.ca)

Field, mineralogical and geochemical studies in Ordovician to Carboniferous shelf carbonate from the South Nahanni River area, Northwest Territories, have been used to examine and interpret F history in relation to the tectonic evolution of this region. By using FI studies, stable isotopes and radiogenic isotopes, 6 distinct events have been resolved. These range from very low sal to 23 wt.% NaCl eq., and Th 135-235°C, and a wide range of C, H and O isotopes. (E.R.)

MORRIS, G.A., NESBITT, B.E., MUEHLENBACHS, K. and **FRASER, S.,** 1996a, Paleohydrogeology of the Nahanni River Region, Northwest Territories (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A67. First author at Dept. of Earth and Atmospheric Sci., Univ. of Alberta, Edmonton, Alberta, T6G 2E3, Canada.

Field, mineralogical and geochemical studies have been used to examine paleo-F flow in the Nahanni River region, Northwest Territories. Four major F events have been identified. The first event produced syngenetic Ordovician sulphide mineralisation. This was followed by widespread diagenetic dolomitisation producing fine-grained gray mosaic dolomite. Lower and middle Devonian strata are host to the broadly stratiform, and regionally developed Manatoe Facies, an extensive body of megacrystalline white sparry dolomite. Lower in the stratigraphic sequence a late diagenetic dolomite event consisting of dolomite/calcite vugs and veins associated with occasional and minor pyrite, clearly predating the Laramide deformation. The final phase of F flow was associated with Laramide orogenic activity. This event can be subdivided into two distinct but related events, consisting of earlier, thrust fault related, calcite/quartz veining, crosscut by later high angle, brittle calcite/quartz/dolomite veins. The final Laramide events are related to quartz vein hosted lead-zinc-silver mineralisation.

Samples of Manatoe Facies dolomite vary in $\delta^{18}O$ from 12 to 20‰ (SMOW) and in $\delta^{13}C$, from –2 to 2‰ (PDB). Extracted IF from these dolomites vary from –80 to –12‰ (SMOW). The late diagenetic calcite/dolomite event shows a clear gradient in $\delta^{18}O$ (SMOW) for both the calcite (22.1‰ → 2.8‰ west to east) and dolomite (20.5‰ → 14.6‰ west to east). This gradient is mirrored by $\delta^{13}C$ (PDB: calcite, –0.1‰ → –3.4‰; dolomite, 0.3‰ → –2.9‰) and δD (SMOW: –184‰ → –136‰ from IF). Variations in isotopic values appear to be related mainly to the host stratigraphy and, to a lesser extent, structural complexity. In comparison, the later Laramide F event shows a strong correlation with structural complexity, returning high $\delta^{18}O$ and $\delta^{13}C$ values (19‰ → 22‰, SMOW, and –0.4‰ → 1.1‰, PDB, respectively) where the rock is unfolded to weakly folded at the western and eastern ends of the traverse, and lighter values ($\delta^{18}O$, 10‰ → 13‰ and $\delta^{13}C$, –4.9 → –3.3‰) where the rock has undergone a high degree of deformation towards the centre of the traverse. (Authors' abstract)

MORRIS, G.A., NESBITT, B.E., MUEHLENBACHS, K. and **FRASER, S.**, 1996b, Paleo-hydrogeology of the Nahanni River region, Northwest Territories; initial results: Lithoprobe Report, v. 50, p. 22-24, published by Univ. of British Columbia, Lithoprobe Secretariat [for the] Canadian Lithoprobe Program, BC, Canada. Authors at Univ. of Alberta, Dept. of Earth & Atm. Sci., Edmonton, AB, Canada.

Indexed under FI

MORTEANI, Giulio, YAO, Yong, and **TRUMBULL, R.B.**, 1996, A wall rock alteration study of a gold vein deposit in Archean amphibolites and Mesozoic granites: The Niuxinshan deposit (eastern Hebei Province, NE China) (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 59.

The Niuxinshan gold deposit consists of quartz lodes that occur in Archean amphibolite as well as in a Mesozoic granite intruding the amphibolites.

In the amphibolites, the alteration starts at the border of the veins with a zone of silicification followed inward by sericitization, pyritization, chloritization and carbonatization zones. Near the contact to the granites very locally k-feldspathization and fluoritization are also found. In the granite, the alteration zones start near the border of the veins again with a silicification, but the following zones show pyritization, fluoritization, and sericitization. The mineralogical compositions of the alteration zones therefore depend on the country rocks.

$Tm_{clathrate}$ of +9.8 to +6.0°C indicates that the F have a sal of 0.4-7.5 wt% NaCl eq. The Th is between 217°C and 368°C and the FI are of the H_2O-CO_2 type. From this data a minimum P of 1.5-3 kbar can be estimated. Based on unpublished data of Ministry of Metallurgical Industry, Beijing, the composition of the F phase is Na^+-Ca^{2+}-K^+ rich.

Stable isotope determinations on quartz gave $\delta^{18}O_{Qz}$ = +12.1 to +13.3‰. Using the Th of the FI the isotopic composition of the ore fluids results to be between $\delta^{18}O_{H_2O}$ = +5.2‰ and +6.4‰. According to unpublished data of the Geological Bureau of MMI the deuterium composition of the FIs is between -64‰ and -85.5‰ (Bai et al., 1990). Such an isotopic composition is similar to that of a magmatic or deep-seated F (Taylor, 1979).

The enrichment in gold and other elements found in the alteration zones, together with evidence from FI and isotope data suggest that the mineralization was formed by granite-related or deep-seated F and not produced by leaching of the exposed granitic or amphibolitic wall rocks of the quartz veins. (From authors' abstract by E.R.)

MUCHEZ, Philippe and **SLOBODNIK, Marek,** 1996, Recognition and significance of multiple fluid inclusion generations in telogenetic calcites: Mineralogical Magazine, v. 60, p. 813-819. First author at Fysico-chemische geologie, K.U.Leuven, Celestijinenlaan 200C, B-3001 Leuven, Belgium.

Ferroan and non-ferroan calcites occur in fractures in the Lower Carboniferous of the Variscan foreland of southern Belgium. These fractures post-date the Variscan orogeny and the calcites have a telogenetic origin. The non-ferroan calcites formed by recrystallization of the ferroan calcites. Two types of monophase aq FI are present in the ferroan calcite cement. Although both types of I formed at a T not exceeding 50°C, one type contains a moderately saline F (3.6-16.3 eq. wt.% NaCl) and the other type fresh water (Tm ice = 0°C). The FI in the non-ferroan calcite also contain fresh water.

Detailed petrography of the FI indicate that the fresh water migrated through the crystals along opened cleavage planes and microfractures. Therefore, they have a secondary origin. The recrystallization of the ferroan calcites to non-ferroan calcites occurred in this fresh water. The saline FI are not related to the above mentioned microstructures and although their origin remains unknown, they could represent the ambient F from which the ferroan calcites precipitated. The study of the relationship between the occurrence of FI and the microstructures seems promising for the identification of FI representing post mineral formation F and T conditions in calcite cements. (Authors' abstract)

MUKHERJEE, Abhijeet and **BALLURKAR, Ashok,** 1996, Sulfur isotope variations in barite and pyrite of hydrothermal barite deposits of Cuddapah basin, Andhra Pradesh: J. Geological Soc. of India, v. 47, p. 425-430. First author at National Mineral Development Corp. Ltd., Masab Tank, Hyderabad - 500-028.

The $\delta^{34}S$ X-CDT values for barite and pyrite range from +23.6 to +25.5 per mil and -0.9 to +1.9 per mil respectively. Data of FI studies enable T of deposition to be 250°C after pressure correction of Th. The $\delta^{34}S$ X-CDT values of pyrite and barite suggest igneous source for pyrite and marine for barite implying that they are not formed together. The $\delta^{34}S$ X-CDT values of barite agree with $\delta^{34}S$ X-CDT values for contemporaneous Proterozoic sea water. (Authors' abstract)

MULLIS, Josef, 1996, P-T-t path of quartz formation in extensional veins of the central Alps: Schweiz. Mineral. Petrogr. Mitt., v. 76, p. 159-164. Author at Mineralogisch-Petrographisches Institut, Univ. Basel, Bernoullistrasse 30, CH-4056 Basel, Switzerland.

The evolution of crystal growth in extensional veins from the Central Alps is visualized in space and time by combining FI data, radiometric ages, and plate tectonics. The main precipitation of quartz crystals in extensional veins from La Fibbia (Gotthard massif) and Zinggenstock (Aar massif) occurred 21 to 13 Ma before present, caused by continent subplating, crustal thickening, exhumation, erosion and cooling of the Alpine mountain belt. (Author's abstract)

MULSHAW, S.C., 1996, A critical evaluation of the use of hydrocarbon gases in rocks as a pathfinder for base-metal mineralisation in Shannonbridge, central Ireland: J.

of Geochem. Exploration, v. 56, no. 3, p. 265-277. Author at Imperial College, Dept. of Geol., London, UK.

This paper discusses the results of a light hydrocarbon G (LHG) lithogeochemical survey carried out at Shannonbridge in central Ireland Two methods of LHG extraction (dry grinding and sample solution in EDTA) are compared with a heat extraction method developed by Carter (1981). The results show that due to a more complete breakdown of the sample, LHG contents of up to an order of magnitude greater are released by grinding and sample solution, with no apparent decrease in precision. As a result, a potential problem relatd to the generation of additional G by the thermal breakdown organic matter during heating, can be avoided. Similar LHG component distribution patterns are produced by dry grinding and EDTA extraction suggesting that both methods could be useful alternatives to the heating technique. This is strengthened by the identification of a possible target zone in Shannonbridge based on the distribution of samples depleted in methane and enriched in butyl G, C_4 (butane plus butene plus their associated isomers). However, this empirical interpretation was not supported by the results of heating. Furthermore, subsequent exploration failed to establish the presence of a significant mineral occurrence at Shannonbridge. Evidently, the LHG patterns were either misinterpreted or they reflect hydrocarbon sources which are not related to mineralisation. Further evaluation of the data showed that LHG component distributions are significantly influenced by variations in lithology. Once this effect was reduced, it became apparent that the patterns are principally controlled by regional faulting. Since fault structures would be permeable to hydrocarbon G formed from a variety of processes (such as maturation of organic matter in the host limestones), no relationship with buried mineralisation is necessary to explain the patterns observed. By using the Shannonbridge data as an example, this paper attempts to emphasise the equivocal nature of data collected using prospecting methods of this type. The aim is not to refute innovative and quality research already carried out in this field because the association of hydrocarbon G with mineralisation is too frequent to be simply classified as coincidental. However, anomalous levels of LHG can be attributed to other processes which, in many cases, are too easily overlooked. (Author's abstract)

MUMIN, A.H., FLEET, M.E., and **LONGSTAFFE, F.J.,** 1996, Evolution of hydrothermal fluids in the Ashanti gold belt, Ghana: Stable isotope geochemistry of carbonates, graphite, and quartz: Economic Geol., v. 91, p. 135-148. Authors at Dept. of Earth Sci., Univ. of Western Ontario, London, Ontario, Canada N6A 5B7.

The oxygen and carbon isotope systematics of ankerite, siderite, calcite, quartz, and graphite from the Bogosu and Prestea mining districts of the Ashanti gold belt, Ghana, are used to speculate on the processes leading to hydrothermal alteration and gold deposition.

Evidence of alteration that preceded gold mineralization is best preservd in spatially associated altered mafic dikes. The compositions of F responsible for the gold mineralization and associated alteration have been reconstructed using T from carbonate-mineral geothermometry.

Alteration of country rocks occurred under rock-dominant, greenschist facies conditions. The isotopic composition of the least altered mafic dikes was influenced by interaction with F generated from Birimian greenschist facies metasedimentary rocks. Later, extensive carbonate alteration of mafic dikes adjacent to the structural conduit occurred during slow upward migration of F. Lateral diffusion of hydrogen into the structural conduit permitted partial conversion of CO_2 to methane, resulting in ^{13}C enrichment of both the residual CO_2 and the deposited carbonate minerals.

Rapid, even explosive, expulsion of deep-seated F and CO_2-H_2O phase separation occurred episodically throughout the evolution of the hydrothermal system. This caused precipitation of sulfides, aresenides, and gold at relatively high crustal levels and low ambient pressure and T. During mineralization, F ascent was too rapid for isotopic and chemical reequilibration between the deep-seated ore F and adjacent country rocks. The ore F had chemical and isotopic compositions consistent with deep-seated metamorphic F that were subsequently modified by preferential partitioning of ^{18}O and ^{13}C into a G phase. The composition of the deep-seated metamorphic F determined using chemical equilibria (CO_2-H_2O rich; 7-25 mole % CO_2) is in approximate agreement with that required to produce the isotopic depletion of the residual F via phase separation. (From authors' abstract by E.R.)

MURAMATSU, Yoichi and **KOMATSU, Ryo,** 1996, Fluid evolution in the Kakkonda shallow geothermal reservoir, Iwate prefecture, northern Japan: A fluid inclusion study: J. Japan. Assoc. Mineral. Petrol. Econ. Geol., v. 91, p. 145-161 (in Japanese with Engl. abstract). First author at Dept. of Liberal Arts, Faculty of Sci. and Tech., Science Univ. of Tokyo, Noda 278, Japan.

Kakkonda geothermal system, Iwate Prefecture, northeastern Japan, consists of two reservoirs with different T and permeability: shallow and deep reservoirs. The shallow reservoir which is located at shallower than about 1,500 m in depth, was developed for the Kakkonda geothermal power plant unit 1 (50 MWe) operated since 1978. FI in quartz, calcite, anhydrite and gypsum veinlets, and in quartz fragments of dacitic tuff from the shallow reservoir have been studied using microthermometric and crushing stages to clarify the F evolution in a natural-state shallow reservoir. Sal of FI were determined after correction of Tm ice for CO_2 content estimated semiquantitatively from the bubble behavior on the crushing stage.

Four stages with different thermal and chemical properties of evolution of F with time were recognized, based on the FI data, combined with chemical analyses of the production F from the shallow reservoir: State I, polyphase I-forming F; 280 to 350°C, 31 to 35 wt.% sal; Stage II, primary L I-forming F; 220 to 310°C, 0.0 wt.% and 0.4 to 2.0 wt.% CO_2 contents, 0.0 to 1.2 wt.% (average 0.5 wt.%) sal (NaCl eq.); Stage III, secondary L I-forming F; 220 to 250°C, 0.2 to 0.3 wt.%, 0.0 to 0.7 wt.% (average 0.1 wt.%); Stage IV, geothermal F after the operation of the Kakkonda power plant unit 1; 215 to 261°C, 0.01 to 0.04 wt.%, 0.06 to 0.08 wt.%.

Magmatic F at stage I [was] probably caused by igneous activity related to Kakkonda granite intrusion (slightly younger than 0.7-1.0 Ma; Kanisawa et al., 1994), [and] is assumed to represent the first step in the geothermal evolution of the Kakkonda system. The subsequent geothermal F at the shallow reservoir evolved generally to lower values of T, CO_2 content and sal with time. The precipitation of hydrothermal minerals such as quartz, anhydrite, and K-feldspar (0.2-0.1 Ma; Koshiya et al., 1993) is related to stage II. Considerably decreasing CO_2 content from stage III to IV indicates that degassing was caused by a production test at the early stages after the end of drilling.

Distribution of T and polyphase I in and around the field suggests that high T F ascends at the northwestern area in the field through all stages. Open fractures had gradually self-sealed with the hydrothermal minerals of stage II, but geothermal F of stage IV still flows through the non-mineral-filled open fractures. (Authors' abstract)

MURAMATSU, Y., KOMATSU, R., SAWAKI, T. and **SASAKI, M.,** 1996, Gas compositions of fluid inclusions from the Mori geothermal area, Hokkaido, Japan: Abstracts with Programs, 1996 Joint Meeting of the Japanese Association of Mineralogists, Petrologists and Economic Geologists, the Mineralogical Society of Japan, and the Society of Resource Geology, p. 171 (in Japanese).

MURAYAMA, M., SUGISAKI, R., IIYAMA, Y. and **MIMURA, K.,** 1996, Genetic environment of quartz veins evaluated by FI compositions in the Hishikari mine, Kyushu, Japan: Abstracts of 1996 Meeting of the Geochemical Society of Japan, p. 259 (in Japanese).

MUSAEV, A.M. and **MUSAEV, A.A.,** 1996, Studies of fluid inclusions and the experimental determination of tungsten distribution among unmixed fluid phases (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 484. Authors at Inst. of Geol. and Geophy., Science Acad. of Uzbekistan.

Widely variable CO_2 contents, sal, Th, and P are listed for the various stages of the Koitash W-skarn deposit in W. Uzbekistan. (E.R.)

NABELEK, P.I. and **TERNES, Kim,** 1996, Fluid inclusion evidence for the evolution and solubility of fluids in the Harney Peak leucogranite magma, Black Hills, South Dakota (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 95-96. Authors at Dept. of Geological Sci., Univ. of Missouri, Columbia, MO 65211, USA.

P and S I in tourmaline and quartz were analyzed. The P consist of variable H_2O-CO_2-Salt ± (CH_4) mixtures. Sal of the I increases with water concentration. Because most P I decrepitated before homogenization, trapping T were estimated from positions of calculated isochores (following Brown and Lamb, [1989]), assuming the ~4 kbar emplacement pressure of HPG, but there are some caveats given.

Using published solubility models for H_2O and CO_2 in granitic M and the composition of the most CO_2-rich P I ($XH_2O = 0.45$), the initial concentrations of H_2O and CO_2 in the HPG magma are deduced to have been ~ 4 wt.% and 1500 ppm CO_2 respectively. The relatively low water concentration is consistent with dehydration-melting reactions that are thought to have produced the M and the estimated crystallization T indicated by oxygen isotope equilibration among minerals. The presence of CO_2 in the magma and the evident change in F composition with decreasing T are incorporated into a model for crystallization of coupled aplite-pegmatite layers, such as those found in much of the Harney Peak Granite. Secondary CO_2 I in quartz are consistent with unmixing of the P magmatic F during subsolidus fracturing of the granite or uplift ot the terrane. (From authors' abstract by E.R.)

NADEN, Jonathan, 1996a, Fluid inclusions: analysis and applications: J. of the Russell Soc., v. 6, no. 2, p. 63-74. Author at British Geol. Survey, Kingsley Dunham centre, Keyworth, Nottinghamshire NG12 5GG.

FI research is one of the principal methodologies for examining F processes, ancient and modern, in the Earth's crust. In this review, the main procedures for analysing FI are described, and some of the research applications are presented. (Author's abstract)

NADEN, J., 1996b, *CalcicBrine*: a Microsoft Excel 5.0 add-in for calculating salinities from microthermometric data in the system $NaCl$-$CaCl_2$-H_2O (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 97-98. Author at The British Geol. Survey, Sir Kingsley Dunham Centre, Keyworth Notts, NG12 5GG, UK; e-mail (j.naden@bgs.ac.uk)

Published experimental data in the system $NaCl$ - $CaCl_2$ - H_2O have been regressed, using a stepwise procedure, to give four equations. Values are given for coefficients in these equations in five phase fields.

An algorithm, written in *Visual Basic for Applications*, has been developed to calculate weight percent equivalent $NaCl + CaCl_2$ and the $NaCl / (NaCl+CaCl_2)$ weight ratio from microthermometric data ($T_{m\ ice}$, $T_{m\ hydrohalite}$, $T_{m\ halite}$). The algorithm uses similar principles to those described in Bodnar *et al.* (1989) to solve the above equations for T, using paired input data of T_{ice}-T_{hyd} for compositions in the ice and hydrohalite fields or T_{ice}-T_{halite} for compositions in the halite field.

Experimental bulk-sal data are generally reproduced to within 3% for final-melting in the ice-field, 10% for bulk compositions in the hydrohalite-field and 6% for compositions in the halite-field. The regression equations tend to model the data of Oakes *et al.* (1990) and Vanko *et al.* (1989) better than the data Yanatieva (1946).

Limitations to the applicability algorithm are as follows:

1. Final-ice melting ($T_{m\ ice}$)must be between –52 and 0.0°C
2. Hydrohalite melting ($T_{m\ hydrohalite}$) must be between –52 and 0.1°C
3. Final ice-melting and hydrohalite melting must not be above –21.2°C
4. Halite ($T_{m\ halite}$) dissolution should be between 0.1 and 500°C
5. For final-melting/dissolution in the halite field, ice-melting must be in the presence of hydrohalite.

Copies of the Excel Add-in are available, by e-mail, from the author. (From author's abstract by E.R.)

NAGAO, K. and **TAKAHASHI, E.,** 1993, Noble gases in the mantle wedge and lower crust: An inference from the isotopic analyses of xenoliths from Oki-Dogo and Ichinomegata, Japan: Geochem. J., v. 27, p. 229-240.

NAKAMURA, M. and **SHIMAKITA, S.,** 1996, Partial dissolution kinetics of plagioclase: Implication for magma mixing time scale and origin of melt inclusion (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F841, November 12, 1996. First author at Dept. of Earth Planet. Sci., Tokyo Inst. Tech., 2-12-1 Ookayama, Meguro-ku, Tokyo 152, Japan.

Partial dissolution kinetics of plagioclase was experimentally examined in the system Di-Ab-An-H_2O under 200 MPa and 1025-1150°C. Plagioclase single crystal (An60) was sealed with synthesized glass which is in equilibrium with more calcic plagioclase than the seed crystal. Plagioclase partially dissolved and "sieve texture" composed of calcic plagioclase and sodic M was formed as shown in the dry, 1 atm experiments of Tsuchiyama (1985). The reaction rate in our hydrous experiment is, however, one to ten thousands times as large as that extrapolated from the dry experiments where the interdiffusion in plagioclase solid has been proposed to be the rate controlling step. BEI observation of the run products reveals that the texture is formed by congruent dissolution of the seed crystal at the reaction front to form M channels followed by diffusion in

M and growth of calcic plagioclase. No compositional gradient is found in M along the channel, suggesting that the reaction rate is governed by surface kinetics of dissolution. The result of time study is consistent with this model. Based on the reaction rate, time scale of magma mixing is estimated to be from weeks to months for plagio-clase phenocryst with reaction zone of tens of micrometers width at 950°C. As reaction proceeds, the M channels are choked to be MI [sic]. Our experiment implies that some kinds of MI are formed by dissolution of phenocryst, not by rapid growth, and their compositions are different from that of host. (Authors' abstract)

NAND, A.S., 1989, The geochemistry of the Fosterville goldfield, Victoria: Bachelor of Science thesis, Univ. of Tasmania, 114 pp.

The Fosterville goldfield is a sedimentary rock-hosted gold deposit along the Fosterville Fault Zone. Gold occurs within sediment hosted arsenopyrite and pyrite, in crystal lattice and/or as minute I. The mineralized fault breccia and associated stockworks are vertical to sub-vertical and up to 30 m in width; only very minor quartz veining occurs. The deposit is considered to be genetically related to a granite source, with a T for the mineralizing F of approximately 370°C. The depth of the system ranges from 6.5 - 10 km. PIXE and AAS have been very useful in analyzing for trace elements in vein quartz. The Fosterville quartz shows generally high levels of trace elements. The analyses showed positive correlation between the presence of K, Ge, Al and As with Au in the host rock and the intensity of the EPR (electron paramagnetic resonance) of quartz veins. The high correlation between Ge, Au and EPR suggests that EPR and Ge may be used as an indicator of gold mineralization in this type of deposits. Ge is an element typically enriched in late magmatic and hydrothermal minerals. (From author's abstract by E.R.)

The following conclusions can be made from the FI studies on the Fosterville deposit: The average Th is at least 255°C for vein quartz associated with mineralization and the Tt obtained from the maximum Th of 288.5°C was 370°C. There is no evidence of boiling; Type 1 inclusions have a sal of 2.8 to 7.6 NaCl eq. wt.%; Type 2 have 4.7 to 12.8 NaCl eq. wt.% and are enriched in CO_2 with a concentration of approximately 9.5 wt.%. The sal of the F obtained seem higher than that of seawater, suggesting that another source is present for the higher sal. This source could be a granite; the P estimated from concentration of CO_2 and Th of Type 2 FI gave a minimum of 2 ± 0.5 kbar which is eq. to a depth of 8 ± 2 km, and Th from Type 1 FI gave a depth of 6.3 - 8.5 km assuming a geothermal gradient of 30-40°C/km which is not unusual if a granite source is situated beneath the Fosterville goldfield. (From author's text by E.R.)

NAOUMKO, I.M., 1996, Topaz and beryl from chamber pegmatites of Volyn (Ukraine): fluid inclusions and paragenetic associations studies in leaching zones (abst.): 30th Int'l Geol. Cong., Abstract, v. 2, p. 487. Author at Inst. of Geol. and Geochem. of Combustible Minerals of the Ukrainian National Acad. of Sci., Lviv, Ukraine.

Pegmatites of so called chamber type in the northwestern part of the Ukrainian Shield are genetically and spatially related to rapakivi-like granitoids of Korosten Pluton. Leaching zone usually is confined to fully-differentiated pegmatite bodies under chamber region. Silica transport and redistribution with quartz varieties formation as well as topaz and beryl crystallization are directly related to leaching zone mineral parageneses development.

Populations of primary fluid inclusions (FI) are found as follows:

in topaz: L-G FI that are" sticked" to quartz crystals [sic] with phase relations 40L +60G, C = 10 wt.% NaCl+KCl, $61.1CO_2 + 34.8N_2 + 4.1CH_4$ (vol.%); and complex carbon dioxide FI: a) in growth pyramid {011}, 10-14L + 5-1L_1 + 85G, $ThCO_2$ = 19-22°C G, $96.8CO_2 + 3.2CH_4$ (vol.%); b) that formed during mutual pushing, growth and capturing of solid particles, 25-60L + 35-20L_1 + 40-20G.

in beryl: essentially gaseous to L-G FI elongated parallel to L6, L up to 30%, Th = 425°C G; and G-L FI elongated across prism grain {1010}, 80-85L + 20-15G, Th = 275°C L.

Various types of early- and late-secondary FI in topaz and beryl from leaching zone also are described in detail [data from literature]. (From author's abstract, by E.R.)

NARASIMHA, K.N.P., JANARDHAN, A.S. and **MISHRA, V.P.,** 1996, Granulites of Bhopalpatnam and Kondagaon belts, Bastar Craton, M.P.; Petrological and fluid inclusion studies: J. of Southeast Asian Earth Sci., v. 14, no. 3-4, p. 221-229. First author at Univ. of Mysore, Dept. of Geol., Mysore, India.

NARTIKOEV, V.D. and **GIGASHVILI, G.M.,** 1996, Gases in granites of the tectonomagmatic activization zone from the circum-Pacific segment of the earth's crust (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 561. Authors at VNII geosystem, Russia.

The G composition of magmatic rocks was studied by the VNII geosystem method in samples from similar-age granite massifs with rare-metal deposits of Chukotka and granite pluton with the White Tiger oil deposit, South Vietnam.

All studied samples contain methane, hydrogen and heavy hydrocarbons, including hexane; this indicates that the G is related to oil. Methane is highly predominate relative to the heavy hydrocarbon G.

The diorite-granodiorite-granite series in the intrusive massif of the White Tiger deposit is noted by a strong increase of methane's average values.

Special studies of the mode of G occurrence in granites in the White Tiger deposit revealed that quartz grains are saturated by oval, rectangular and reticulate gaseous-FI. The I are mostly composed of benzine fractions with methane bubbles; occasionally, the vacuoles contain traces of wax. All gaseous-FI formed during metasomatism (intense quartzification). Comprehensive experimental studies make it possible to conclude that hydrocarbon G in granites from rare-metal deposits of Chuktoka and the White Tiger oil deposit are enclosed in restricted micro-fissure pores as gaseous and gaseous-F bubbles formed during pneumatolitic processes. Hence, rocks of granite massifs with rare metal deposits of Chukotka and granitoids of the White Tiger oil deposit are similar in petrochemical composition and G distribution mode. The difference lies only in the G concentration level, the hydrogen/methane ratio and the absence of He in the Chukotka granites due to erosion.

It is noteworthy that rare-metal granites intrude coaliferous Jurassic deposits and even acid effusives at the Upper Jurassic-Lower Cretaceous boundary. Therefore, we assume that the hydrocarbon formation at the White Tiger deposit, South Vietnam, at depths as much as 5 km is linked to a secondary reservoir filled by alien secondary F (gaseous condensates, oil, gas and water); this reservoir served as a peculiar fluidized chamber similar to the volcanic, magmatic or seismic chamber. (From authors' abstract, by E.R.)

NATIV, Ronit, 1996, The brine underlying the Oak Ridge Reservation, Tennessee, USA: Characterization, genesis, and environmental implications: Geoch. Cosmo. Acta, v. 60, no. 5, p. 787-801. Author at Soil and Water Dept., The Hebrew Univ. of Jerusalem, Rehovot 76100, Israel.

The deep hydrogeologic system underlying the Oak Ridge Atomic Reservation contains brine. Its origin was assessed using existing and newly acquired chemical and isotopic data. The proposed model which best fits the data is modification of residual brine from which halite has been precipitated. Potential sources for this brine are in the Appalachian Mountains in the east, where bedded halite is documented, and where the hydraulic gradient needed to move the residual brine exists. Other models, such as ultrafiltration and halite dissolution, were also evaluated. In places, contaminants such as radionuclides, heavy metals, nitrates, and organic compounds have reached the deep system. The chemical and isotopic features of the brine were examined with respect to its potential discharge, contaminated in places, into shallow, freshwater systems. The observations suggest that whereas the origin of the salts in the brine may be very old, influx of recent water takes place. Consequently, the brine is not isolated (in terms of recharge and discharge) from the overlying active and fresh-water-bearing units. (Author's abstract)

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: Dok. Ross. Akad. Nauk, 1995, v. 343, no. 1, p. 99-102 (in Russian, translated in Doklady Acad. Sci., xxxx v. 343, p. 242-246, 1996)

Abst. in FIR v. 28, p. 111 (E.R.).

NAUMOV, V.B., KOVALENKO, V.I. and IVANITSKIY, O.M., 1995, The H_2O and CO_2 concentrations in magmas based on the study of inclusions in minerals: Geokhimiya, No. 12 (1995) p. 1745-1759 (in Russian, translated in Geoch. Int'l., v. 33, no. 12, 1996, p. 37-49). Authors at Vernadskiy Inst. of Geochem. and Analytical Chem., Russian Acad. of Sci., Moscow.

Abst. in FIR v. 28, p. 111 (E.R.)

NAUMOV, V.B., KOVALENKO, V.I., IVANITSKIY, O.M. and SAVEL'YEVA, N.I., 1995, Concentration of chlorine in magmatic melts (based on inclusions in minerals): Geokhimiya, no. 6, p. 798-808, 1995 (in Russian, translated in Geoch. Intl'l., v. 33, no. 2, p. 144-155, 1996). Authors at Vernadskiy Inst. of Geoch. and Analytical Chemistry, Russian Acad. of Sci., Moscow.

Abstr. in FIR v. 28, p. 111 (E.R.)

NAUMOV, V.B., TOLSTYKH, M.L., KOVALENKER, V.A., and KONONKOVA, N.N., 1996, Fluid overpressure in andesite melts from central Slovakia: Evidence from inclusions in minerals: Petrologiya, v. 4, no. 3, p. 228-239, (in Russian, translated in Petrol., v. 4, no. 3, p. 209-220). First author at Vernadsky Inst. of Geochem. and Analytical Chem., Russian Acad. of Sci., ul. Kosygina 19, Moscow, 117975 Russia.

Unusual M I, containing a very dense hydrous solution in addition to glass, were found in plagioclase phenocrysts (*An* 68-36) of andesite from the Stiavnica caldera in Central Slovakia. The F component of the I is homogeneous or contains a G phase. According to measurements in 65 I, ice melting T vary from -0.6 to -7.8°C, which corresponds to a sal of 0.9-11.5 wt % eq. NaCl with an average value of 4.5 wt %. At $T = 20°C$, the solution of this sal has a density of 1.00-1.08 g/cm^3 with an average of 1.03 g/cm^3. The solution from M I with a two-phase F component homogenizes into a L phase at 140-285°C, which gives 0.79-0.97 g/cm^3 for the density of the hydrous F. The chemical composition of glass from the M I is characterized, according to 15 electron micro-probe analyses, by high concentrations of SiO_2 (72.6 wt %), K_2O (6.4 wt%), and Cl (0.28 wt%), and low contents of TiO_2, MgO, and CaO. The calculation of water concentration in the magma, including water in M I, yielded high values of 7.1 to 13.3 wt%. The F P was very high during magma crystallization -- 5.6 to 15-17 kbar at $T = 800$-900°C. At the same time, the CO_2 FI found in the cores of the phenocrysts have a relatively low density (0.35 g/cm^3), which corresponds to a F P of not more than 0.9-1.1 kbar at 800-1000°C. This value may be indicative of a magma chamber at a depth of 3-4 km. The occurrence of two different F in the same phenocrysts–early CO_2 at 0.9-1.1 kbar and late H_2O at 5.6-17 kbar–indicates that water was injected into a closed magma reservoir. Apparently, the super-high F P was the factor reponsible for magma rise towards that earth's surface. (Authors' abstract.)

NAVON, Oded, FREY, F.A. and TAKAZAWA, E., 1996, Magma transport and metasomatism in the mantle: a critical review of current geochemical models–discussion: American Mineralogist, v. 81, p. 754-759. First author at Inst. of Earth Sci., The Hebrew Univ., Jerusalem, Israel.

NAYAK, V.K. and AHMAD, S., 1996, Fluid inclusion characteristics, genetic and metallogenic analysis of fluorspar ore field, Chandidongri, district Rajnandgaon, Madhya Pradesh, India (abst.): 30th It'l. Geolg. Cong., Abstracts, v. 1, p. 389. Authors at Dept. of Applied Geol., Indian School of Mines, Dhanbad 826-004, India.

In the F-Cu-Pb-Zn mineralization of Chandidongri (21°05'N ; 80°38'E), India, fluorite is associated with the minor sulphides–chalcopyrite, galena, sphalerite, and pyrite, in silicified fault-breccia and quartz reef within a granitoid complex along a 20 km-long N-S shear zone. Minute specks of fluorite have also been documented in granite, pegmatite veins and basic rocks. Fluorite is the dominant mineral with some yttrofluorite and traces of cerofluorite and borofluorite. Fluorite of various colours and grain size occurs as disseminations, small lenticles, stringers, veins and veinlets and is exploited from two main productive quarries with an average grade of 18% CaF_2.

The microthermometric examination of fluorite, quartz associated with it, and quartz of granite revealed four types of FI: (a) Aq bi-phase (b) Mono-phase (c) Poly-phase (d) Aq Carbonic phase. Th in P I in fluorite, quartz associated with it and quartz of granite ranges between 175-225°C, 159-180°C, and 132-203°C respectively, thereby indicating low to moderate T. The density varies between 0.80-1.10 in fluorite; 0.96-0.99 in quartz associated with fluorite and 0.957-1.115 gm/cm^3 in quartz of granite. Sal in fluorite and quartz associated with it, ranges between 3.0-13.0 and 9.1-12.99 wt.% NaCl eq. Significance of major, minor and trace elements in 7 fluorite samples are interpreted and discussed. The deposit of fluorspar is recognized as a vein, fracture-filling, structurally controlled, low T epithermal deposit type. (From authors' abstract by E.R.)

NEHLIG, P. and **MARCOUX, E.,** 1992, The epithermal gold deposit of Cirotan (East Java, Indonesia): Microthermometric constraints: C.R. Acad. Sci., Paris, v. 315, ser. II, p. 821-827 (in French).

Studies were carried out on quartz- and sphalerite-hosted FI from seven samples representative of the five stages of deposition. The F are characterized by moderate sal (2.89 to 7.15 wt.% eq. NaCl) and show a progressive increase in sal from the initial stage of silicification until the bonanza stage (IV). Th L is between 207°C and 292°C. If one assumes an unconstrained hydrostatic column to the surface and almost no CO_2 content, the absence of phase separation within FI is consistent with erosion of a minimum of 410 m since mineralization or recrystallization. [These and other data suggest that] the Cirotan deposit is considered to reflect a genetic link with porphyry-tin deposition and could be explained by a progressive upward migration of an underlying magma. (As summarized by Jobrak et al., 1996, this volume.) (E.R.)

NESBITT, B.E., 1996a, Regional paleo-hydrogeologic mapping in exploration for Au mineralization (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A69. Author at Dept. of Earth and Atmospheric Sci., The Univ. of Alberta, Edmonton, AB T6G 2E3.

Using a variety of geological and geochemical techniques, it is possible to map distinctive paleohydrogeological regimes in the Canadian Cordillera. Because occurrences of epithermal and mesothermal styles of Au mineralization are restricted to particular types of hydrogeological systems, it is possible to use the mapped features to identify regions likely to host Au mineralization.

For epithermal Au-Ag mineralization, the most distinctive geochemical feature of use in identifying exploration target areas is variation in $\delta^{18}O$ values of the host volcanics. In southern B.C. and northern U.S., epithermal Au mineralization is invariably associated with whole rock $\delta^{18}O$ values <6‰ (SMOW).

For mesothermal Au deposits, the three distinctive criteria for the identification of target areas are: association with quartz-carbonate veins, visible CO_2 in FI, and low δD values in IF. In the southern third of B.C., approximately 50% of the region can be eliminated from consideration for exploration, due to the regional presence of either quartz-only or carbonate-only veining. Within the region defined by quartz-carbonate veining, approximately 50% of the area can be dropped from consideration due to the absence of visible CO_2 in I. Of the remaining region, approximately 20% of the area can be eliminated from consideration due to having δD values of I F> –100‰. Using these criteria an area of approximately 60,000 km^2 out of an original area of 300,000 km^2 can be defined as having potential for hosting mesothermal Au mineralization. All known mesothermal Au deposits in southern B.C. are contained within this region.

The development of local scale (100's meters to a few kilometers) geochemical indicators for mesothermal Au mineralization is not as advanced, though preliminary studies suggest that strontium isotopic ratios of vein carbonate have potential as local indicators of the presence of mineralization. (Author's abstract)

NESBITT, B.E., 1996b, Applications of oxygen and hydrogen isotopes to exploration for hydrothermal mineralization (abst.): SEG Newsletter, 1996, no. 27, p. 8-13. Author at Dept. of Earth and Atm. Sci., Univ. of Alberta, Edmonton, AB, Canada T6G 2E3.

A review (E.R.)

NESBITT, B.E., 1996c, Fluid inclusions in the study of crustal scale paleo-fluid regimes (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 99-101. Author at Dept. of Earth and Atmospheric Sci., Univ. of Alberta, Edmonton, AB T6G 2E3.

See Nesbitt and Muehlenbachs, FIR v. 28, p. 112. (E.R.)

NESBITT, B.E., MORRIS, G.A. and **MUEHLENBACHS, K.,** 1996, Crustal scale processes in the generation of hydrothermal dolomite in the western Canada sedimentary basin (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A319. First author at Dept. of Earth and Atmos. Sci., Univ. of Alberta, Edmonton, AB T6G 2E3; e-mail (b.nesbitt@ualberta.ca)

There are two models proposed for the origin of these dolomites: 1) Late Devonian to Early Mississippian west to east migration of basinal brines; 2) Late Cretaceous to Early Tertiary west to east, gravity-driven flow of meteoric water. Results of new stable isotope and I studies indicate: minimum T for the dolomite depositing F of 200°C (west) and 90°C (east) and sal of 20 to 25 eq. wt.% NaCl with high concentrations of Ca and/or Mg and no west to east variation. $\delta^{18}O$ values of 10 to 20‰ (SMOW) and a tendency to increase in $\delta^{18}O$ to the east [sic]. IF yield δD values of –75 ± 15‰ in the south increasing to –50 ± 20‰ in the north. These δD values are too high to be Late Cretaceous or Early Tertiary meteoric water. Br/Cl ratios of IF range from 0.004 to 0.007, which is similar to values for evaporitic brines. The Br/Cl ratios are substantially greater than both sea water and values obtained via dissolution of evaporites.

It is concluded that the gravity-driven, meteoric water model for the genesis of these dolomites is inconsistent with the geological and geochemical results, in particular the sal, $\delta^{18}O$, δD, and Br/Cl values. It is more likely that the dolomites formed in the Late Devonian or Early Mississippian from residual evaporitic brines migrating west to east driven by the Antler orogeny. (From authors' abstract by E.R.)

NEWELL, K.D. and **GOLDSTEIN, R.H.,** 1996, Paleobarometry using low-temperature heterogeneously entrapped fluid inclusions in quartz cement, Upper Ordovician Viola formation, Kansas USA (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 102-103. First author at Kansas Geological Survey, Univ. of Kansas, Lawrence, KS 66047.

Coarsely crystalline euhedral quartz represents first-stage mineralization in a vug (1187 m depth) in shelfal carbonate strata of the Upper Ordovician Viola Formation in the Sedgwick basin of Kansas. The vug containing the quartz occurred after an episode of regional dolomitization because dolomite rhombs in the rock matrix along the side of the vug are truncated and corroded. Succeeding minerals filling the vug include coarsely crystalline saddle dolomite and calcite.

The quartz contains P FI having characteristics of heterogeneous entrapment (i.e., highly variable L-to-V ratios, all-liquid I, and numerous V-rich I). The variable L-to-V ratios could not have resulted from necking-down of high-T FI because many FI contain greater than 15 volume % G. The heterogeneously entrapped FI are concentrated in four separate growth bands (F-I assemblages) in the quartz. The first and third growth bands are relatively thick and contain abundant FI and solid I of acicular anhydrite. The second and fourth growth bands are relatively thin and free of anhydrite, but have FI in thin zones oriented parallel to the crystal faces. Secondary FI, mostly elongate ones in healed microfractures, cut across P growth bands.

Chips of the quartz were removed from the thin-section glass and placed in a crushing stage. Crushing runs used glycerine or kerosene as immersion media. Two types of behavior were observed, with bubbles either expanding or contracting. The contracting bubbles are associated with the late-stage S FI, and probably represent entrapment of a G-deficient L at elevated T. The I with expanding bubbles are from the P FI. Using Boyle's Law, the calculated P range from 1.3 to 11.4 atm., with a dominant mode at 1.5 to 2 atm. and a minor mode at 6.5 to 7 atm. Released bubbles dissolve within seconds in kerosene, thus methane or other organic G are indicated.

Because all-liquid I are present within F-I assemblages, entrapment was at low T. Thus, the P determined from the P FI is approximately equal to entrapment P with a minor correction for amount of dissolved G (see Goldstein and Reynolds, 1994). The water column necessary for the highest P is approximately 110 m. The mode at 1.5 to 2 atm. corresponds to water-column depths of 10 to 20 m; the mode at 6.5 to 7 atm. corresponds to water-column depths of 60 to 70 m, depending on water sal.

The paleobarometric data from the heterogeneously entrapped FI indicate precipitation of the quartz occurred at shallow depths.

The vug formation, its early quartz mineralization, and probably the dolomitization prior to the vug formation, occurred within influence of the near-surface during arid periods of the Silurian and during fresh-water influx during development of unconformities. (From authors' abstract by E.R.)

NEWMAN, B.D., NORMAN, D.I., GUNDIMEDA, M. and **LEVY, S.S.**, 1996, Understanding the genesis of nonmarine calcite deposits through quadrupole mass spectrometric analysis of fluid inclusion gases: Chemical Geology, v. 132, p. 205-213. First author at Environmental Sci. Group, Los Alamos Nat'l. Laboratory, Los Alamos, NM 87545, USA.

Quadrupole mass spectroscopy was used to analyze FI volatiles in different types of nonmarine calcites including travertines, phreatic calcretes, hydrothermal vein calcites, and pedogenic calcites. The objectives of the study were to determine if there were any diagnostic or characteristic differences between the I volatiles from the different calcites, and to see if the quadrupole results could be used to understand the processes and environmental conditions that controlled calcite precipitation. The calcites formed under saturated conditions have water-dominated I with well-constrained N_2/Ar ratios and either CO_2 or N_2 as the dominant I G. Some calcretes and travertines were exceptions to the above characteristics, but it is likely that these were subjected to secondary precipitation in an environment different from the primary precipitation phase. Results for the pedogenic calcites are quite different from calcites formed in water-saturated systems. Pedogenic calcites have gas-dominated (water-poor) I, unexpectedly large CH_4 contents, low O_2 contents, and highly variable N_2/Ar ratios. The dominance of CH_4 and low O_2 contents in the pedogenic calcites suggest that anaerobic conditions occurred during at least part of the precipitation process. Scanning electron microscope (SEM) examination of the pedogenic calcites shows fungal remains, bacteria-like forms, and gels from fungi or plant roots. The quadrupole and SEM results suggest pedogenic calcite precipitation occurred as a result of aerobic and, ultimately, anaerobic microbial decay processes. (Authors' abstract)

NIELSEN, R.L., JONES, V. and **SOURS-PAGE, R.**, 1996, The diversity of parent magmas at the Chile Ridge: Evidence from melt inclusions (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F833, November 12, 1996. First author at COAS, Ocean. Admin. 104, Oregon State Univ., Corvallis, Oregon 97331-5503; e-mail (rnielsen@oce.orst.edu)

In recent work by Klein and Karsten (*Science*, 1996) and Bach et al. (*EPSL*, 1996), researchers have identified several mixing components that make up the array of parent magmas for Chile Ridge MORB. The most controversial was an "arc" type component postulated to be related to subducted crust from the nearby Chile Trench. Normal ridge processes such as mixing and fractionation make characterization of the mixing endmembers difficult. This type of information can be derived from study of MI in primitive phenocrysts. Investigations of several other areas have shown that high An plagioclase phenocrysts found in many highly plagioclase phyric lavas contain MI characterized by primitive Mg# (up to 74) and diversity of minor and trace elements (Nielsen et al. CMP 1995)

I from several plagioclase phyric samples from the Chile Ridge (supplied by J. Karsten) were analyzed in order to describe the range of parent magma diversity. Our results indicate that the I have diverse minor and trace element compositions and a relatively narrow range of major element compositions, consistent with what we have found elsewhere. In addition, despite their diversity, most MI compositions fall within the range of their associated lavas, but are significantly more primitive (up to Mg# 74). Equally important, the I compositions are correlated with their host lava compositions in that depleted lavas contain a higher % depleted I and enriched lavas contain a higher % of enriched I.

In the Chile Ridge system, there appear to be at least 3 mixing endmembers: an enriched, high K, a depleted, low K and a high Ti, P, low K component. The first two are similar to components we have identified at other ridges and seamounts. The high P, Ti endmember (up to 1% P_2O_5, 2.7% TiO_2 at Mg# 68) has not been identified from other areas. It is not clear at this point if there is a relationship between this component, or any other component we have identified, and an "arc" component. (Authors' abstract)

NIELSON, J.E. and **WILSHIRE, H.G.**, 1996, Magma transport and metasomatism in the mantle: A critical review of current geochemical models–Reply to Navon et al.: Amer. Min., v. 81, p. 760-765. Authors at U.S. Geol. Surv., 345 Middlefield Rd., MS 975, Menlo Park, California 94025.

NIKOGOSYAN, I.K. and **SOBOLEV, A.V.**, 1994, Liquid immiscibility phenomena in magmas from the islands of Hawaii (Pacific Ocean) and Reunion (Indian Ocean): Dok. Ross. Akad. Nauk, 1994, v. 338, no. 2, p. 214-218 (in Russian, translated in Trans. (Dokaldy) Russian Acad. Sci., Earth Sci. Sect., v. 341A, no. 3, p. 171-176, 1996). Authors at Geol. Sci. Inst., Armenian Acad. of Sci., Yerevan, and Vernadskiy Inst. for Geoch. and Analytical Chemistry, Russian Acad. of Sci., Moscow.

Abstr. in FIR 28, p. 115 (E.R.)

NIU, Hecai, SHAN, Qiang and **LIN, Maoqing,** 1996, A study on inclusions in minerals from Mianning REE deposit in Sichuan Province: Geochimica, v. 5, p. 560-567. A great quantity of F-MI was found in early-stage·formed fluorite and quartz from aegirine-augite-barite pegmatite vein and carbonatite vein in Mianning REE deposit of Sichuan. Tt of F-MI is higher than 500°C, demonstrating that the two ore-veins are the products of salt-M crystallization. The FI existing in the bastnaesite indicate that the REE mineralization is closely related to hydrothermal process. The ore-forming T ranges from 150 to 270°C. These facts prove that the Mianning REE deposit in Sichuan is a typical hydrothermal deposit related to salt-melt. (Authors' abstract)

NOBLE, J.P.A., CHOWDHURY, A.H. and **YU, H.,** 1996, Fluvial/lacrustine diagenesis; significance for hydrocarbon production and entrapment in the Carboniferous Albert Formation, Moncton Basin, NB: American Assoc. of Petrol. Geologists Annual Meeting Abstracts, v. 5, p. 106. First author at Univ. of New Brunswick, Dept. of Geol., Fredericton, NB, Canada.

The Carboniferous Horton Group Albert Formation sediments include lacustrine source-rock oil shales and fluvial porous reservoir sandstones. The petrography, stable isotopes, FI, CL and minor/trace element chemistry are used to establish the diagenetic history and controlling factors. Early diagenetic calcite, quartz and albite cements with minor chlorite and kaolinite are variably present and related to depositional mineralogy and lake levels which controlled the porewater chemistry. Antitaxial veins occurring preferentially in shales are shown, from heavy $\delta^{13}C$ values and FI, to be related to methanogenesis in overpressured zones at shallow depths. Later burial calcite and albite cements and extensive albitisation are related to mineral reactions during the phase of rapid subsidence at T of 80 to 150°C in the deepest segment of the basin, together with significant dissolution of carbonates and feldspars related mainly to organic acids generated by organic maturation processes. Mass balance calculations indicate that not enough organic matter was present to account for all the estimated S porosity and some evidence suggests that reactions between kaolinite and calcite/ankerite to produce chlorite, and mixed layer illite-smectite ordering reactions, may have produced significant S porosity. Burial history reconstructions and thermal modelling of the Albert Fm. sediments using Arrhenius type maturity models and reflectance and rock-eval data suggest locally variable maturation and reservoir production related to the locally different fault tectonic histories characteristics of strike-slip lacustrine segmented basins. The Horton depositional cycle was followed by a major dextral transpression event with local faulting and inversion and vein cementation. The calcites, dolomites, ankerites and barites in these veins appear to have formed during and after local tectonic uplift and during cooling from T of about 150 to 80°C mainly from circulating brines with $CaCl_2$-NaCl compositions and variable sal of 8 to 27 wt.% as measured from FI. (From authors' abstract by E.R.)

NOLL, P.D., Jr., NEWSOM, H.E., LEEMAN, W.P., and **RYAN, J.G.,** 1996, The role of hydrothermal fluids in the production of subduction zone magmas: Evidence from siderophile and chalcophile trace elements and boron: Geoch. Cosmo. Acta, v. 60, no. 4, p. 587-611. First author at Dept. of Earth and Planetary Sci. and Inst. of Meteoritics, Univ. of New Mexico, Albuquerque, NM 87131, USA.

NOMIYAMA, Kunihiro, ISHIYAMA, Daizo, MIZUTA, Toshio and **ISHIKAWA, Yohei,** 1993, Contact metamorphism of dolomitic limestone in the aureole of Miyako granitoids, Iwate Prefecture, Japan: Reports of the The Research Inst. of Natural Resources, Mining College, Akita Univ., March, 1993, no. 58, p. 1-16 (in Japanese, Engl. abst.). First author at Mining Geol., Grad. School of Mining, Akita Univ.

Five dolomitic skarns of Dainikadokami, Neichi, Nejo, Kebaraichi and Kadokami deposts are related to contact boundary of Miyako granitoids with Paleozoic-Mesozoic strata.

The mineral assemblages of the skarn can be classified into 9 types, and their T are estimated from the experimental data of the MgO-CaO-SiO_2-Al_2O_3-Vapor (H_2O-CO_2) system as follows: Type 1; calcite-dolomite-quartz, Type 2; calcite-dolomite-talc, Type 3; calcite-dolomite-chlorite-tremolite, Type 4; calcite-tremolite-diopside, Type 5; calcite-dolomite-forsterite, Type 6; calcite-diopside-forsterite, Type 7; calcite-dolomite-forsterite-spinel, Type 8; wollastonite-quartz-diopside, Type 9; calcite-brucite.

The prevalent mineral assemblage in those deposits is type 5. FI studies show that type 5 is formed above 400°C, while the type 9 is formed below 600°C. It is thought that the T on formation of those dolomitic skarns ranges from 400 to 600°C. The estimated T of skarns for the Dainikadokami and Neichi deposits are relatively higher than those of the Nejo, Kebaraichi and Kadokami deposits. X(CO_2) of F during contact metamorphism at the Dainikadokami deposit might be decreased to below 0.03.

Th and sal of FI in calcite from those deposits are highly variable. FI in type 5 calcite from the Dainikadokami deposit range from 450 to 100°C and 0.8 to 0.1 wt.% NaCl eq., and I in type 7 calcite from the same deposit range from 350 to 500°C and from 30 to 4.7 wt.% NaCl eq., respectively. FI data of type 5 calcite from the Kebaraichi deposit range from 375 to 150°C and 8.5 to 6.0 wt.% NaCl eq. and in type 5 calcite from the Kadokami deposit, range from 325 to 125°C and 7.2 to 3.7 wt.% NaCl eq., respectively.

Skarns in the area are estimated to be formed under the P of 1 kb from [fluids from the] granitoids. Filling T of FI in type 7 calcite corrected by P and sal data are around 450 to 600°C. Those T data for FI are in agreement with T estimated from the mineral assemblages of skarns, and indicate that the FI, in type 7 with showing high sal, could be magmatic F. (Authors' abstract)

NORMAN, D.I., GROFF, John, KAMALI, Cem, MUSGRAVE, John, and **MOORE, J.N.,** 1996, Gaseous species in fluid inclusions: Indicators of magmatic input into ore-forming geothermal systems: Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A401. First author at New Mexico Inst. of Mining and Tech., Socorro, NM 87801.

Nitrogen-Ar ratios >R_a (atmospheric ratio) are measured in FI from active geothermal systems Broadlands, The Geysers, and Sulphur Springs, which are similar to N_2/Ar ratios in felsic volcano G emissions. A magmatic input into these geothermal systems is indicated by ^3He / ^4He > R_a. Nitrogen / Ar > R_a is measured in FI from epithermal and Carlin-type deposits including Fresnillo, Getchell, Twin Creeks, Lone Tree, and Cochiti. A Getchell, Twin Creeks, Lone Tree, and The Geysers, magmatic F are also indicated by FI thermometric data from some fractures that exhibit Th > 300°C and sal > 25 et. wt.% NaCl. Such data plot on Th-sal diagrams in a backwards "Z" similar to FI data from porphyry-type deposits. Elevated levels of FI H_2S and magmatic deuterium values correlate with FI N_2 / Ar > R_a and depth. Analyses of FI gaseous species plotted on ternary diagrams indicate mixtures of magmatic and crustally derived F in all geothermal and ore deposit systems studied.

Our data suggest that gaseous components may separate from deep geothermal systems and provide the principal evidence of a magmatic contribution to an ore deposit formed at shallow depths. More proximal to an intrusive are fractures mineralized by high sal and sulfur-rich F. These may occur at depths, as at Getchell and Twin Creeks, where no intrusive is exposed. (Authors' abstract)

NORMAND, Charles, GAUTHIER, Michel and **JÉBRAK, Michel,** 1996, The Québec antimony deposit: an example of gudmundite–native antimony mineralization in the ophiolitic mélange of the southeastern Québec Appalachians: Economic Geol., v. 91, p. 149-163. First author at Univ. du Québec à Montréal, Dépt. des Sciences de la Terre, Géoterap, CP 8888 succ. A. Montréal, Québec, Canada H3C 3P8.

The Québec antimony deposit contains a rare type of mineral association in which gudmundite (FeSbS) is the main antimony ore mineral and native antimony is common.

Unusual physicochemical conditions must account for ore deposition in this type of deposit. The paragenesis and presence of methane-rich FI indicate that conditions were strongly reducing during the main stage of the ore-forming process. We propose that elevated CH_4 and H_2 fugacities resulted from fluid-rock interaction and/or from mixing with F derived from the nearby serpentinite bodies. In contrast, F responsible for late stibnite, kermesite, and Sb oxides were oxidizing and relatively iron poor. (From authors' abstract by E.R.)

NOWAK, Marcus, BEHRENS, Harald and **JOHANNES, Wilhelm,** 1996, A new type of high-temperature, high-pressure cell for spectroscopic studies of hydrous silicate melts: American Mineralogist, v. 81, p. 1507-1512. Authors at Inst. für Mineralogie, Univ. Hannover, Welfengarten 1, D-30167 Hanover, Germany.

A novel type of high-T, high-P cell has been designed for near-infrared and optical spectroscopy of hydrous silicate M at P up to 3 kbar and T up to 800°C. It consists of an externally heated cell with a disk-shaped sample chamber (4 mm in diameter and 0.2 mm in height) that is compressed between a tungsten carbide piston and a cylindrical sapphire window. A platinum ring surrounding the sample prevents loss of melt or water during the experiment.

The new spectroscopic cell was used for direct measurement of H_2O species in aluminosilicate M by near-infrared spectroscopy. Other possible applications of the cell include the study of silicate M doped with transition metal ions in the UV-VIS-NIR and the observation of the crystallization and dissolution of minerals in hydrous silicate M under in situ conditions. (Authors' abstract)

Pertinent for FI studies? (E.R.)

NYRKOV, E.A. and **MAKARJUKHA, S.V.,** 1996, Vein quartz–an indicator of the hydrothermal-metasomatic tungsten ore mineralization in the central Caucasus: Proc. Russ. Mineralogical Soc., v. 75, no. 2, p. 88-96 (in Russian, Engl. abst.)

Detail geological and quartz-metric mapping [sic] has been realized in the area of Dumalinskoye tungsten and Cheghet-Djorinskoye W-Au-As ore occurrences. More than 400 samples of vein quartz have been investigated. On this base, lithological, mineralogical, geochemical and thermobarogeochemical factors controlling tungsten mineralization are demonstrated, as well as an age sequence scheme of development of the vein quartz aggregates. Among several typomorphical assemblages of quartz microaggregates, three series have a genetic linkage with scheelite mineralization. (Authors' abstract)

O'BRIEN, G.W., LISK, M., DUDDY, I., EADINGTON, P.J., CADMAN, S. and **FELLOWS, M.,** 1996, Late Tertiary fluid migration in the Timor Sea: A key control on thermal and diagenetic histories?: Appea J. 1996, part 1, p. 399-427. First author at Australian Geol. Surv. Organisation, GPO Box 378, Canberra, ACT, 2601.

An integrated study of the F flow, hydrocarbon charge and thermal histories of a suite of traps from the Timor Sea has revealed the presence of a key F flow event in the latest Miocene/Early Pliocene. This event, which coincided with, and was driven by, the extensive tectonism and fault reactivation associated with the collision of the Australian and Eurasian plates, involved the flowage of hot (90-120°C), saline (>200,000 ppm) brines (probably from deeply buried Palaeozoic evaporite sequences) up major faults and through the Mesozoic and Tertiary sequences. The passage of these hot brines produced a Late Tertiary (<5 Ma), transient heating event evident in fission track and FI data, which is best seen in moderately reactivated traps, such as the Challis and Jabiru oil fields. (From authors' abstract by E.R.)

O'CONNOR, T.K., EDGAR, A.D. and **LLOYD, F.E.,** 1996, Origin of glass in Quaternary mantle xenoliths from Meerfeldermaar, West Eifel, Germany: Implications for enrichment in the lithospheric mantle: The Canadian Mineralogist, v. 34, p. 187-200. First author at Cameco Corp., 2121 11th Street West, Saskatoon, Saskatchewan S7M 1J3.

Intraxenolith glasses from twenty-eight mantle-derived spinel-bearing lherzolite, olivine clinopyroxenite, wehrlite, and olivine websterite xenoliths from the Quarternary mafic-ultramafic ash and pyroclastic rocks from Meerfeldermaar, West Eifel, Germany have been petrographically examined and chemically analyzed. On the basis of Al and Cr contents of clinopyroxene in these xenoliths, the majority are Group-I metasomatized types. The abundance of glass is variable. Small amounts of pargasitic amphibole, phlogopitic mica and spinel are associated with glass. Glass occurs along grain boundaries, in pools and vugs, and occasionally as I in spinel. Widely variable compositions of glass depend on their associated minerals and xenolith type. Glasses are not directly related to the host magma. Microlitic olivine grains in the glass are not in equilibrium with M or F. Similarly, the glass cannot be a partial M of mineral assemblages of the xenoliths, and is an unlikely product of decompression melting of hydrous minerals. In the suite of glass compositions, Ca, Fe and Ti decrease with increasing SiO_2, but there is no correlation between Mg and SiO_2, suggesting that these bodies of glass have a common origin as "frozen" M or F that migrated through the upper mantle and produced the enrichment in the source regions for the kamafugitic magmas. The degree of enrichment of the suite of xenoliths at Meerfeldermaar is not as pronounced as at Gees, only 12 km away, suggesting that metasomatic enrichment was variable within the subcontinental lithosphere underlying this area. (Authors' abstract)

OBERTHÜR, Thomas, MUMM, A.S., VETTER, Ulrich, SIMON, Klaus and **AMANOR,**

J.A., 1996, Gold mineralization in the Ashanti belt of Ghana: Genetic constraints of the stable isotope geochemistry: Economic Geol., v. 91, p. 289-301. First author at Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, D-30655 Hannover, Germany.

This study concentrates on mesothermal hydrothermal gold mineralization. Stable isotope analyses of host-rock and ore components were performed with the aim of obtaining parameters relevant to the origin and evolution of the F that produced gold mineralization.

Carbonaceous matter in the Birimian metasediments display $\delta^{13}C$ values ranging from -11.4 to -28.3 per mil relative to PDB, indicating an organogenic origin. Carbonates display a unimodal distribution of $\delta^{13}C$ values ranging from -9.9 to -17.0 per mil relative to PDB. CO_2 extracted from FI in the auriferous quartz veins has $\delta^{13}C$ values ranging from -9.5 to -15.7 per mil relative to PDB. It is proposed that these carbon isotope compositions of carbonates and CO_2 reflect extensive interaction of the CO_2-rich hydrothermal F with reduced carbon in Birimian sediments in the deeper parts of the hydrothermal systems.

Carbonates and auriferous vein quartz have $\delta^{18}O$ values ranging from 12.9 to 22.2 and 12.8 to 15.6 per mil relative to SMOW, respectively. Carbonates and quartz were deposited in near isotopic equilibrium with respect to $\delta^{18}O$, indicating F-dominated conditions during ore formation, from F of metamorphic or magmatic origin. Such an origin is corroborated by δD values of water extracted from FI in vein quartz (-37 to -53‰ relative to SNOW).

The C, O, H, and S isotope compositions of ore-related hydrothermal minerals and FI components indicate that the mineralizing F interacted extensively with the Paleoproterozoic rocks, especially Birimian sediments, at deeper crustal levels and at high T. The isotopic compositions are most compatible with the formation of F from devolatilization reactions involving Birimian strata during prograde metamorphism at depth (metamorphic F). (From authors' abstract by E.R.)

OELKERS, E.H., BJØRKUM, P.A. and **MURPHY, W.M.**, 1996, A petrographic and computational investigation of quartz cementation and porosity reduction in North Sea sandstones: American J. of Science, v. 296, p. 420-452. First author at Laboratoire de Géochimie, Univ. Paul Sabatier-CNRS, 38 rue des Trente Six Ponts, 31400 Toulouse, France.

Petrographic data indicate that the bulk of silica cement in the Jurassic quartzose sandstones of the North Sea basin originated from quartz dissolution at mica and illitic clay interfaces which border stylolites. Taking account of the observations, a quartz redistribution mechanism was developed that includes dissolution of quartz at stylolite interfaces catalyzed by the interaction of quartz grains and mica/illitic clay surfaces, diffusional transport of dissolved silica into the interstylolite regions, and its subsequent precipitation on quartz grains by kinetically controlled crystallization reactions. (From authors' abstract by E.R.)

OHIRA, Hiroto, HIMENO, Osamu, WATANABE, Koichiro, ZHAOJUN, Liu, and **XU, Jin,** 1996, Thermal history and oil maturation deduced from fission track fading in apatite–case study for the Daqing basin in China and the Niigata basin in Japan (abstr.): 30th Int'l. Geol. Cong., Abstracts, v. 1, p. 351. First author at Kyushu Univ., Japan.

In the case of apatite, T-time conditions of fission track fading have been clearly established from minute stepwise annealing experiments and studies on natural bog hole samples (possibly also from FI). From authors' abstract by E.R.)

OHNENSTETTER, Daniel and **BROWN, W.L.,** 1996, Compositional variation and primary water contents of differentiated interstitial and included glasses in boninites: Contrib. Mineral. Petrol., v. 123, p. 117-137. Authors at CRPG-CNRS, BP 20, F-54501 Vandœuvre-lès-Nancy Cedex, France.

Remarkably fresh and abundant interstitial glasses and glasses in small I in Mg-rich phenocrysts of 14 boninites from New Caledonia, the Mariana Trench, Cpe Vogel and Chichijima were analysed by electron microprobe and the water contents measured in situ by ion microprobe. Water contents in interstitial glasses are ~2 wt.% for the highly glassy high-Mg andesitic glasses from Chichijima, ~5.4 wt.% for the more differentiated andesitic to dacitic glasses from Cape Vogel, and ~6.7-7.0 wt.% in the most differentiated dacitic ones from the Marianas and New Caledonia. Water contents in glass I in olivine, orthopyroxene and clinoenstatite are in the range ~1.9-3.3 wt.%. The interstitial glasses are black and not vesicular, showing that the L did not reach supersaturation after eruption on or intrusion near the sea floor, or were insufficiently so to allow nucleation of water V bubbles. The water is inferred to be P and to increase strongly with crystallization in the residual L down to the glass-transition T. (From authors' abstract by E.R.)

OHTANI, T., SASADA, M. and **MATSUNAGA, I.,** 1996a, Fracturing history deduced from microthermometry of fluid inclusions in minerals from the Hijiori geothermal area, Yamagata Prefecture: 1996 Annual Meeting of the Geothermal Research Society of Japan, Abstracts with Programs, p. 48 (in Japanese).

OHTANI, T., SASADA, M. and **MATSUNAGA, I.,** 1996b, Analysis of healed microcracks in granite from borehole HDR-3 in Hijiori area, Yamagata prefecture (abst.): Newsletter of the Japanese Assoc. Geothermal Fluid Inclusionists, 1996, no. 7, p. 23 (in Japanese).

See FIR v. 25, p. 117 (E.R.)

OISHI, A., MURAMATSU, Y., YOSHIDA, Y. and **HASHIZUME, R.,** 1995, Hydrothermal activity in Hongu Area, Wakayama Pref., based on the fluid inclusion geothermometry: J. of the Balneological Soc. of Japan, v. 45, no. 2, p. 63-75 (in Japanese, Engl. abst.). First author at Kumamoto Univ.

FI study was carried out on quartz and calcite contained in hydrothermal veins and quartz phenocrysts in quartz porphyry dikes from two boreholes (H4-HG-1 and H4-HG-2) drilled in the Hongu area, central part of Wakayama Prefecture.

The hydrothermal activity of this area was not so active in the past time. The period of hydrothermal activity occurred in this area is classified into three stages, from higher than 300°C to low T of around 100°C. The first stage is characterized by both high T ranges from 250 to 350°C and the mineralization of quartz, calcite and pyrrhotite. The second stage is characterized by intermediate T ranges from 150 to 250°C and the mineralization of pyrite, quartz and calcite. The third stage is characterized by low T ranges from 80 to 150°C.

Hydrothermal activity intermittently continues up to the present day within the area where high to intermediate T hydrothermal activities had occurred. Present hydrothermal activities are observed at Yunomine, Kawayu, and Watarase Hot Springs. These activities are, however, not related to the distribution of the quartz porphyry dikes. (Authors' abstract)

ONDRAK, Robert, 1996, Modeling of diagenesis in relation to coupled mass and heat transport: American Assoc. of Petrol. Geologists Annual Meeting Abstracts, v. 6, p. 109. Author at GeoForschungsZentrum Telegrafenberg, Potsdam, Federal Republic of Germany.

Pore F flow is an important factor influencing the diagenetic evolution of rocks, as has been shown by various diagenetic studies, especially in connection with FI measurements. A 3D-computer model is presented, which allows to simulate coupled mass and heat transport in porous rocks. The model is used to study the interaction of heat and mass transport with respect to the temporal and spatial evolution of sandstones. Mineral dissolution or precipitation change the mineralogical composition of rocks, and modify the physical properties at the same time. Altering the permeability of the rock affects the F flow system in the rock which determines the mass transport of the entire system. In addition to mass transport, F flow transports thermal energy, which may modify the T evolution of the rock. The model will be used to examine the effect of convective heat and mass transport on T and diagenetic evolution of clastic rocks. Although the model cannot claim to simulate nature, it can be used to study the effect of different mechanisms, and their interaction within the coupled system. For practical applications, the model may be used to determine possible flow rates, which are necessary to explain the observed diagenetic and thermal history of sandstones. (Author's abstract)

OOSTING, S.E., and **Von DAMM, K.L.,** 1996, Bromide/chloride fractionation in seafloor hydrothermal fluids from 9-10°N East Pacific Rise: Earth and Planet. Sci. Lett., v. 144, p. 133-145. Authors at Dept. of Earth Sci., Univ. of New Hapshire, James Hall, 56 College Rd., Durham, NH 03824, USA.

Hydrothermal F collected from 9-10°N EPR during 5 cruises between 1991 and 1994 were analyzed for Br and Cl. The chlorinity of these F ranges between 32.6 and 860 mmol/kg in comparison to local seawater values of 540 mmol/kg. These very low chlorinity F, some with T high enough to be within the V stability field, were collected following a volcanic eruption in 1991 [1]. Although F with chlorinities less than 250 mmol/kg had been sampled once previously, at Axial Volcano [2], the vent F chlorinities at 9-10°N EPR were much lower than at Axial Volcano. F with Cl≥ 250 mmol/kg had Br/Cl ratios identical to seawater, in agreement with previous studies. In contrast, F with Cl<250 mmol/kg collected from this area, had Br/Cl ratios as much as 40% less than the seawater value. Bromide depletions observed in the low chlorinity F from 9-10°N EPR were probably the result of fractionation of Br from Cl during subcritical phase separation. This fractionation process appeared to be limited to F with C<250 mmol/kg, and to require open system phase separation. To produce V with Cl≥250 mmol/kg at pressure and T conditions appropriate for 9-10°N EPR requires conditions that are close to the critical point, where the properties of the V and L phases are quite similar, resulting in lack of fractionation in the Br/Cl ratio between the two phases. (Authors' abstract)

ORANGE, Daniel, KNITTLE, Elise, FARBER, Daniel and **WILLIAMS, Quentin,** 1996, Raman spectroscopy of crude oils and hydrocarbon FI: a feasibility study: Mineral Spectroscopy Special Publication, 1996, no. 5, p. 65-81. First author at Dept. of Earth Sci. and Inst. of Tectonics, Univ. of California, Santa Cruz, CA 95064, USA.

Visible Raman spectroscopy provides useful constraints on the structure and maturity of both hydrocarbon FI and crude oils. In particular, the presence or absence of hydrocarbon functional groups may be qualitatively identified, as well as relative degrees of maturation. The P constraints on the utility of this technique are: 1) spectral contamination by fluorescence of either the hydrocarbon I or the matrix in which it sits: and 2) photodegradation of hydrocarbons under laser excitation. Both of these difficulties can be averted through a combination of appropriate selection of the laser excitation line and minimization of the excitation volume of fluorescence. We present and interpret spectra of synthetic hydrocarbon I, natural hydrocarbon I contained in a matrix fluorescent under blue-green laser excitation ($CaCO_3$:Mn) from the Hoh Accretionary Complex (Olympic Peninsula, Washington), and of crude oils collected from the same region. The latter two types of samples demonstrate the utility of this technique in providing constraints on the structural differences between natural hydrocarbons. (Authors' abstracts)

ORLANDO, A., CONTICELLI, S., MANETTI, P. and **VAGGELLI, G.,** 1994, The basement of the northern Vulsinian volcanic district as inferred from the study of crustal xenoliths from the Torre Alfina Lavas, Viterbo, Central Italy: Proceedings of the 76th summer meeting of the Società Geologica Italiana, "The Northern Apennines", published in Memorie Della Società Geologica Italiana, v. 48, p. 681-688. First author at Dipartimento di Scienze della Terra, Univ. di Firenze.

The petrologic study of xenoliths enclosed in mafic lavas provides useful information about the nature of the crust intruded by the ascending magma. In particular, lower crustal xenoliths represent the only direct investigation tool on the nature and origin of the crust at the time of eruption.

Fluid inclusions: Abundant FI were observed both in plagioclase and in orthopyroxenes. The I show either a negative or a subspherical shape and appear to be monophase (only L) or multiphase (L/G + silicate glass ± trapped/dm). They are usually found: i) along the growth lines of the host phase, ii) in the cores of the host phase, and iii) along healed fractures. The distribution of i) and ii) suggests an apparently P origin; group iii) I are clearly S. However, no chemical differences in the F phase or in the glass have been observed between S and apparently P I. In addition, the widespread presence of rhyolitic glass in the FI (i.e., MI) confirms that all I are S.

A microthermometric study was performed on monophase and multiphase I. The triple points (i.e., Tm-CO_2) of frozen I were in the range of -56±0.5°C to -59.2±0.5°C, indicating CO_2 as the main F component. All L/G I homogenized to the L phase at T from 16.8±0.2°C to 26.6±0.2°C. Raman analyses (Burke and Lusthenhouwer, 1987) of the F phases were conducted in order to establish the nature of the F coexisting with CO_2. Due to fluorescence of the F phase and/or the host mineral, however, results were inconclusive. (From authors' text by H.E.B.)

ORTEGA, L., OYARZUN, R., and **GALLEGO, M.,** 1996, The Mari Rosa late Hercynian Sb-Au deposit, western Spain: Mineral. Deposita, v. 31, p. 172-187. First author at Dept. de Cristalografía y Mineralogía, Facultad de C.C. Geológicas, Univ. Complutense, E-28040 Madrid, Spain.

The central Iberian zone of the Hesperian Massif hosts a series of late Hercynian vein-type Sb deposits. Hydrothermal alteration consists of a mild sericitization, chloritization and carbonatization of the metasedimentary rocks around the veins. Chemical changes in the hydrothermal halos include a remarkable increase in the ratio K_2O/Na_2O, and a decrease in the ratio SiO_2/volatiles, together with a sharp increase in Sb, Mo, Au and N. F associated with ore deposition lie in the H_2O-NaCl-CO_2-CH_4-N_2 compositional system. These F evolved, progressively cooling, from initial circulation T close to 400°C in the early stage to T of approximately 150°C in the late one. F composition evolution was characterized by a progressive increase in the bulk water content of the F and with an increase in the relative proportion of N_2 with respect to CH_4 and CO_2 in the volatile fraction. Massive stibnite deposition resulted from a boiling process developed at 300°C and 0.9-1 Kb at a depth of 4-5 km. Geological, geochemical and FI evidence suggest that the intrusion of the Albuquerque batholith (late Hercynian S-type granitoids) triggered hydrothermal activity leading to the transport and deposition of Sb and Au in Mri Rosa (From authors' abstract by E.R.)

OTKHMEZURI, Zurab and **DOLIDZE, Izolda**, 1996, Implications of the results of fluids inclusions studies in minerals for solutions of some geological problems (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 480. Authors at GTU, GI, The Republic of Georgia.

The authors investigated chemical composition of FI in the lead-zinc and barite deposits of the southern slope of the Greater Caucasus. It has been established that lead-zinc producing solutions are of calcium-hydrocarbon-sulphate composition, whereas the barite-producing solutions are of calcium-chloride type.

The differences in mineral composition of the lead-zinc and barite ores, their separation in space and time, very rare cases of passage between the two and [a] single case of occurrence of complex barite-lead-zinc ores are strongly against the existence of a complex barite-lead-zinc formation. Presence of the two separate lead-zinc and barite-calcite formations in this belt is indicated by all existing data, [and they were formed from different composition F]. (From authors' abstract by E.R.)

OYARZUN, Roberto, ORTEGA, Lorena, SIERRA, Josefina, LUNAR, Rosario, and **OYARZUN, Jorge,** 1996, The manto-type gold deposits of Andacollo (Chile) revisited: A model based on FI and geologic evidence: Economic Geol., v. 91, p. 1298-1309. First author at Dept. de Cristalografía y Mineralogia, Facultad de C.C. Geológicas, Univ. Complutense, E-28040 Madrid, Spain.

The Andacollo district comprises a variety of gold, copper, and mercury deposits. Central to the district is a porphyry copper of Cretaceous age (Andacollo porphyry). Manto-type epithermal gold deposits occur west of the porphyry, whereas gold veins occur to the northwest, west, and southeast. Mercury veins occur farther to the southeast. Extensive Th and sal data for calcite and quartz from several mantos and veins show systematic drop in Th from ~350 to ~125°C for the four stages of mineralization. Sal is remarkably uniform at ~5-10% throughout except for Stage 4 calcite in Toro manto, when sal is 20-30 wt.%. Three types of FI are present. L-rich (I), V-rich (II), and halite-bearing (III). Types I and II occur together, suggesting heterogeneous trapping. Th (130-370°C) and sal (1-33%) range widely among the four vein stages in the several vein and manto deposits, possibly related to a porphyry Cu at depth. (E.R.)

OZIMA, M. and **ZAHNLE, K.,** 1993, Mantle degassing and atmospheric evolution: Noble gas view: Geochem. J., v. 27, p. 185-200.

PALIN, J.M., EPSTEIN, S. and **STOLPER, E.M.,** 1996, Oxygen isotope partitioning between rhyolitic glass/melt and CO_2: an experimental study at 550-950°C and I bar: Geoch. Cosm. Acta, v. 60, no. 11 (1996) p. 1963-1973. Authors at Div. of Geological and Planetary Sci., California Inst. of Tech., Pasadena, California 91125.

PALINKAS, A.L., BERMANEC, V., ZEBEC, V. and **PAVLOVIC, G.,** 1996, Ammonium iron bearing hyalophane feldspar, Busovaca, central Bosnia; metamorphogenic origin constrained by CO_2-inclusion study (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 472. Authors at Univ. of Zagreb, Pierottijeva 6, Zagreb, Croatia.

The quartz-hyalophane veins cut Lower Paleozoic metasediments, a part of the para- and orthometamorphic greenschist facies complex, built chiefly of chlorite-muscovite-quartz schists. The metamorphics of the regions were formed under 3-5 kbars and 350-450°C. The typical Alpine-type tension fractures are filled with quartz and hyalophane crystals primarily, and less often with siderite, albite, rutile, and sporadic pyrite, anatase, hematite and apatite.

Microscopy reveals following I types; In quartz: 1. ($L_{H_2O} + L_{CO_2} + V$), 2. ($L_{H_2O} + L_{CO_2}$), 3. ($L_{H_2O} + L_{CO_2} + V + S_1$), 4. ($L_{H_2O} + L_{CO_2} + V + S_1 + S_2$), 5. L_{H_2O}, 6. Solid I. In hyalophane: 1. ($L_{H_2O} + L_{CO_2} + V$), 2. (L_{H_2O}) + L_{CO_2}), 3. ($L_{H_2O} + L_{CO_2} + V + S_1 + S_2$), 4. Solid I. Thermometry and cryometry give following data: T_{FM} CO_2 = –60.0 to –57.2°C; T_{LM} CO_2 = –58.1 to –56.5°C, T_{LM} ice = –11.7 to –4.0°C; T_{LM} clathrate = +2.5 to +6.2°C. CO_2 phase homogenized into L phase, T_H CO_2 = +14.6 to +29.2°C, T_H TOT = +300 to 322°C. Sal was determined by clathrate melting T, 6.6 to 13.5 wt.% NaCl eq. FI contain 0.55 to 8.80% CH_4, determined by graphs of Heyen (1982). Micro-Raman spectroscopy recognized CO_2, H_2O and N_2 in FI and carbonates in solid I. Using isocompositional H_2O-CO_2 curves after Bowers and Helgeson (1983), for 19.8 wt.% CO_2 and 10.5 wt.% NaCl, together with T_M TOT = 313°C, and calculated density 0.98 g/cm^3 P approximates to 2.25 kbars. It is close to values obtained by studying metamorphic paragenesis by Majer et al. (1991). (From authors' abstract by E.R.)

PALINKAS, L.A., BALOGH, K., BERMANEC, V., ZEBEC, V.S. and **SVINGOR, E.,** 1996, On use of hyalophane for K-Ar dating in the Central Bosnian Schists Mts.: Acta Geological Hungarica, 39, Supplement (Isotope Workshop III) (1996) p. 149-153. First author at Faculty of Mining, Geol. and Petroleum Engineering, Univ. of Zagreb, Pierottijeva 6, 41000 Zagreb, Croatia.

Within the low-medium metamorphic rocks of the Inner Dinarides, close to Busovaca, Central Bosnia (approximately 50 km. to West from Sarajevo), subvertical, quartz hyalophane veins with up to 25 cm thickness cut an unusual Cr-Ba-Fe-Cu stratabound mineralization. Minerals associated with the large (up to 10 cm, weighing close to 5 kg) waterclear hyalophane are as follows: magnetite, zincian chromespinel, ferrichromite, pyrite, chalcopyrite, enargite, bornite, siegenite, siderite, quartz, albite, muscovite, chromium chlorite and manganoan ankerite. Composition of hyalophane: SiO_2-49.88, Al_2O_3-22.43, FeO-0.05, BaO-18.52, Na_2O-1.44, K_2O-6.87, TiO_2-0.08, NH_4^+-0.10. It appears in euhedral, prismatic, pseudo-orthorombic crystals with regularly grown faces of (110), (010) and (201) forms. Various twinning of crystals was also observed.

Hyalophane is rich in H_2O-NaCl-CO_2 F inclusions, often with rutile and some anisotropic dm (accidentally trapped solids? - F.M.) Solid inclusions of hematite, chlorite and other opaque dm are common. Microthermometry data of these I are as follows: T first M CO_2 from -60.0 to -57.2; T M CO_2 from -58.1 to 56.5; Tm ice from -11.7 to -4.0; Tm clath. from +2.5 to +6.2; Th CO_2 from 14.6 to 29.2 (into L or V?; not indicated - F.M.); Th tot 320. Calculated salinities are between 6.6 and 13.5 NaCl eq. wt% and calcluated CH_4 contents are between 0.55 and 8.8%. P at Th tot is estimated to be around 2250 bars. Micro-Raman spectroscopy detected the presence of CO_2, H_2O, NO_2 and carbonates as dm.

K/Ar age for muscovite associated to hyalophane is 38.7+/-1.6 Ma. and whole rock samples yielded K/Ar ages between 38.6+ / -1.5 and 40.3+ / -1.6 Ma. However, hyalophane samples yielded younger ages from 25.3 to 16.7 Ma. due to the assumed Ar-loss by the reordering of mineral structure or the weak argon retentivity. (Abstract by F. Molnar)

PALINKAS, L.A. and **JURKOVIC, Ivan**, 1994, Lanthanide geochemistry and fluid inclusion peculiarities of the fluorite from the barite deposits south of Kresevo (Bosnia and Herzegovina): Geol. Croat., v. 47, no. 1 (1994) p. 103-115. Authors at Faculty of Mining, Geol. and Petroleum Engineering, Univ. of Zagreb, Pierottijeva 6, 4100 Zagreb, Croatia.

"Strata-bound" barite deposits occur in Devonian dolomites, situated in the Mid-Bosnian Palaeozoic Schist Mountains. These contain barite as the main ore mineral (5.9 wt% $SrSO_4$ on average and $\delta^{34}S = +8.3‰$) which comprises 90-99 wt% of the bulk ores. The subordinate components are calcite, fluorite, Hg-Sb-tetrahedrite, pyrite and quartz.

Analysis of REE by INAA revealed an extremely low content of lanthanides (1.584 ppm), negative Eu anomalies (Eu^{3+} / Eu^+ = 0.7398), and $(Tb)_N/(La)_N = 6.2$ indicating late-stage mineralization.

Primary FI show a uniform number of infilling phases (L+V+S), and persistent volume ratio. This indicates homogeneity of the hydrothermal ore-forming F and an absence of boiling phenomena at the time of fluorite formation. T_h is between 200° and 310°C, with a distinctive maximum at 250°C. T_{fm} -20.3°C predominates but careful examinations of the early melting behaviour of the I warrants the existence of T_{fm} - 51°C, and the presence of $CaCl_2$. High sal between 25 and 26 wt% eq. NaCl was determined from the hydrohalite melting temperature (T_{mh}). Some additional dm are also present. Fluorite, barite and calcite formed from the high saline waters probably originated by mixing of heated hydrothermal F with the highly evolved post-Variscan Upper Permian formation waters. This is supported by the study of the isotopic composition of the carbon, oxygen and sulphur of the paragenetic carbonates and sulphides. (Authors' abstract)

PALMER, D.A.S. and **WILLIAMS-JONES, A.E.**, 1996, Genesis of the carbonatite-hosted fluorite deposit at Amba Dongar, India: evidence from fluid inclusions, stable isotopes, and whole rock-mineral geochemistry: Economic Geol., v. 91 (1996) p. 934-950. Authors at Dept. of Earth and Planetary Sci., McGill Univ., 3450 University Street, Montreal, Quebec, Canada H3A 2A7.

The Amba Dongar carbonatite complex consists of a carbonatite ring dike and a number of syenitic intrusions. Hydrothermal activity associated with intrusion of the carbonatite was responsible for fenitization of the surrounding sandstones, and deposition of economic quantities of fluorite (11.6 Mt of 30% CaF_2). Fluorite mineralization occurs as veins and vug fillings, localized along fractures within the calcite carbonatite, near its contact with the sandstone.

FI in fluorite indicate a low T-low sal (<160°C and 0.6-0.3 wt % NaCl eq.) ore F, which decreased in T and sal as it evolved. Crushing experiments performed on FI in both fluorite and quartz indicate the presence of 0.08 *m* of dissolved CO_2, and analyses of leachates and decrepitate residues from FI show significant concentrations of Ca, A [?], Na, Cl, and S. Oxygen and hydrogen isotope compositions of F inclusions suggest that the ore F was dominantly meteoric and that it had equilibrated with sedimentary carbonate-bearing rocks. Log $\ddot{u}_{O_2}$, and pH conditions of the F, at the time of ore formation, are interpreted to have been >-42 and <3.5, respectively. The presence of Al and S in the F, the molar eq. of Na and Cl, and the positive deviation of ^{18}O and D from the meteoric water line point to a small contribution from orthomagmatic F.

A model is proposed in which the intrusion of a carbonatite magma at high crustal levels was accompanied by the release of orthomagmatic F, expressed as extensive K and Na metasomatism of the surrounding sandstones. With the decline of orthomagmatic activity, a meteoric water-dominated hydrothermal system was initiated by the heat of the intrusion. The interaction of Ca-bearing meteoric F with the last vestiges of F-bearing orthomagmatic NaCl brines caused deposition of large quantities of fluorite at the site of mixing. (From authors' abstract by E.R.)

PAN, Yuanming and **FLEET, M.E.**, 1996, Rare earth element mobility during prograde granulite facies metamorphism: significance of fluorine: Contrib Mineral Petrol, v. 123 (1996) p. 251-262. First author at Dept. of Geological Sci., Univ. of Saskatchewan, Saskatoon, Saskatchewan S7N 5E2, Canada.

A granulite zone of the Quetico subprovince, Ontario, Canada, is characterized by significant amounts of rare earth element (REE)-bearing fluorapatite (1-10 vol. %) and other REE-rich minerals (allanite, monazite and zircon). The presence of high F contents in the REE-rich minerals and their associated minerals (e.g. biotite and hornblende) suggests that REE and high field strength elements may have been transported as fluoride complexes during the granulite facies metamorphism. This conclusion is supported by previously published results of hydrothermal experiments on the partitioning of REE between fluorapatite and F-rich fluids at 700°C and 2 kbar. (From authors' abstract by E.R.)

PAN, Zhong-Hua, 1996, Veined barite deposits in southeast Sichuan and vicinity and bedded barite depostis in eastern Guizhou and western Hunan: a comparative study (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 712. Author at China Univ. of Geosci., Wuhan, China.

The veined barite (VB) deposits in southeast Sichuan occur as open-space fillings in the Upper Cambrian carbonate rock to the Lower Silurian siltstone and consist mainly of barite, fluorite, calcite, and quartz with minor pyrite. Th of P FI in the VB deposits are mainly 160° to 260°C; compositions of the I are rich in NaCl and H_2O, δD_{H_2O} values are -8.9 to -42.9‰ (SMOW). $\delta^{34}S$ values of barite in the VB deposits, ranging from +23 to +42.1‰ (CDT), are close to those reported in Cambrian evaporitic gypsum of southeast Sichuan and vicinity ($\delta^{34}S$ = +23.1 to +29.7‰) or significantly higher. These FI and H and S isotope data suggest that mineralization of the VB deposits was related to a NaCl-rich hot brine, and that sulfur originated from the Cambrian evaporites in this district. (From author's abstract by E.R.)

PANG, Zhonghe, 1996, Whole-system geochemical modeling and the study of water-rock interaction: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 119-123. Author at Inst. of Geol., Chinese Acad. of Sci., Beijing, 100029.

Whole-system geochemical modeling is a quantitative approach in water-rock interaction studies. A whole-system usually contains minerals, G and an aq phase. Based on the description of individual phases, simultaneous equilibrium equations are formed according to the principles of mass balance, mass action and enthalpy balance. Then the water-rock interaction processes under different conditions (change of composition, change of T, change of P) can be modeled. Examples of whole-system geochemical modeling studies on geothermal systems, epithermal ore-forming systems and sedimentary basins are included in the paper. (From author's abstract by E.R.)

PANI, Daniela and **VALERA, R.G.,** 1996, F-bearing hydrothermal fluids in the Tertiary rift fracture system of West Sardinia (Italy) (abst): 30th Int'l Geog. Cong., Abstracts, v. 1, p. 425. First author at Centro Studi Geom. e Mineralurgici del C.N.R., Cagliari, Italy.

Fluorite indications associated with volcanics and small fluorite concentrations occur in the area.

The fractures are filled by an association of fluorite-quartz-(barite) in small veins, lenses and stockworks. The mineralization may be hosted at the contact between Paleozoic and Tertiary rocks, or within the Tertiary rocks themselves at a short distance from the tectonic contact. A typical ribbon texture of fluorite-chalcedony is frequent in the veins, and barite may appear in groups of small platy crystals.

Fluorite characteristics (habit, colour, FI) witness a wide range of T in the mineralizing process. It normally shows perfectly cubic crystals, or fibrous-radiated texture and pale yellow to pinkish colour. In some places, probably corresponding to a deeper position in the mineralization environment, the fluorite crystals are perfectly octahedral and colourless. The Th of the FI range from an average of 150°C (cubic, coloured fluorite) to an average of 250°C (octahedral, colourless fluorite).

Fresh and mineral waters from springs connected with the Alpine rift fracture system show a still existing strong positive F anomaly, whereas waters collected from wells drilled in alluvials, close to the same springs, do not show any. (From authors' abstract by E.R.)

PANIAGUA, A., RODRIGUEZ PEVIDA, L.S., LOREDO, J., FONTBOTÉ, L., and **FENOLI HACH-ALI, P.,** 1996, A carbonate-hosted Au deposit of the Hercynian belt: the Salamon district (N Leon): IV Spanish Geological Congress, Universidad de Alcalá, 1-5 July, 1996, published in Geogaceta, v. 20, no. 7, p. 1605-1608 (in Spanish; Engl. abst.). First author at Departamento de Geologia, Universidad de Oviedo, E-33005, Oviedo.

The Salamon gold prospect constitutes an example of carbonate-hosted gold deposit formed during the last events of the Hercynian orogeny. It is formed by a complex paragenetic sequence of Au-As-Sb-Hg-Cu-Ni-Co-Pb-Zn-U minerals in jasperoid and quartz-dolomite host rock. Au correlated positively with As at single crystal scale in pyrite and arsenopyrite, of FI study and arsenopyrite geothermometry show T in the range 140-280°C at 350-400 bars. Stable isotope data suggest reduction of sulfur from marine evaporites and buffer of carbon in the F by the host carbonates. The age of the deposit is 269 ± 5 m.y., U-Pb determination on uranite grains gires and which is consistent with on uranite age from Villamarin and with age determinations of intrusive rocks spatially associated to several ore deposits in the area. (Authors' abstract.)

PANINA, L.I., USOLTSEVA, L.M. and **VLADYKIN, N.V.,** 1996, Lamproite rocks of the Yakokut Massif and Upper-Yakokut depression (Central Aldan): Geol. and Geophys., v. 37, no. 6 (1996) p. 16-28 [in Russian; Engl. abst.]

This paper deals with the geologic setting of the Yakokut lamproite rocks, their geochemistry and genesis. MI study of olivine and pyroxene phenocrysts has shown that the rocks crystallized from M heated to more than 1300°C. In their chemistry, the M were rather close to the rock composition, but in the process of crystallization the ratio (K+Na) /Al in them changed considerably, and as a result the M acquired alternatively either miaskitic or agpaitic character. The M were moderate in ratio

$$\frac{100\ FeO}{FeO + Mg + TiO_2} \qquad (< 50\ mol\%),$$

with SiO_2 much predominant over Al_2O_3 (> 5 molar quantities).

During olivine crystallization the F contained 41 mol% CO_2 and 58.9 mol.% N_2; during diopside crystallization they contained 100 mol% nitrogen.

The features, distinguishing the Yakokut rocks from typical lamproites, may be related either to melting of mantle substrate under low-P conditions, or to mixing of ordinary lamproite magmas with derivatives of high-alumina K-basaltoid M. (From authors' abstract by E.R.)

PANOVA, E.G., 1996, Thermobarogeochemical investigation of quartzs from tin and tungsten ore deposits (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A72. Author at Dept. of Mineral., S. Petersburg Univ., Universitetskaj Nab. 7/9, S. Petersburg, 199034, Russia.

Quartz is the constant companion of tin and tungsten minerals of greisen ore deposits. It crystallizes before, together with, and after ore minerals. In that case it carries the tracks of modification by hydrothermal solutions and thus characterizes the conditions of minerogenesis. The composition of G-FI of quartz from tin and tungsten ore deposits of Far East, Kazakhstan, Transbaykalian area were investigated. Quartz were collected from different parts of orebodies, from ore and non-ore associations.

Decreptophonic investigation has shown that the most informative characteristic is sum G-saturation (amount of impulses at the heating before 700°C). Quartz from ore paragenesis have a G-saturation (2000-3000 imp.) 5-10 times more than the same from non-ore paragenesis.

Chemical compositions of quartz I marked on the three angles diagrams. Points of ore quartzs are settled down in the center parts and non ore quartz points are in the angles of triangles.

Differences between ore-quartz from different regions are less than between ore and non-ore quartz from one deposit. (Author's abstract)

PARILOV, Y.S., 1996, Physical-chemical parameters of pyrite-polymetallic, lead-zinc and copper deposits forming in Kazakstan: Geology of Kazakstan, v. 1, no. 343, p. 53-59 (In Russian, Engl. abst.).

FI data on T, content and features of the mineral-forming F flows in principal types of the copper, lead and zinc deposits of Kazakstan are presented. Some ideas on ore objects and ore-forming F flows sources are discussed. (Author's abstract)

PARK, Hee-In, LEE, Insung, and **PARK, Kye-Hun,** 1996, Hydrogen and oxygen isotope compositions of ore fluid in the Dongyang talc deposit, Korea (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 684. First author at Isotope Research Group, Korea Basic Sci. Inst., Korea.

O and H isotopic data of talc shows that $\delta^{18}O$ and δD range from 8.6 to 15.8‰ (vs SMOW), and from -65 to -90‰ respectively. Water content of talc extracted in the H analysis is near 4.0 wt% and agrees with that calculated from chemical formula. δD values of tremolite and chlorite talc schist are in the similar range to those of talc. $\delta^{18}O$ and δD values of the metamorphic rocks near the area have quite different range of values compared with those of talc. Based on the FI and mineral assemblage data, the T and P of talc formation are estimated as 450°C and 2000 bar, respectively, with the CO_2 P of 0.4 (X_{CO_2}). O and H isotope data of talc reported are not abundant yet, but the isotopic composition of the F involved in talc formation can be estimated assuming that talc behaves similarly as monmorillonite. The isotopic composition of the F related to the talc formation fall in or very close to those of magmatic water in $\delta^{18}O$ and δD. These data imply that the ore F was from the hydrothermal solution of igneous origin and the talc formed in much higher T compared to the clay minerals of the low T environment. (From authors' abstract by E.R.)

PARNELL, J., 1996, Alteration of crystalline basement rocks by hydrocarbon-bearing fluids; Moinian of Ross-shire, Scotland: Lithos, v. 37, no. 4 (1996) p. 281-292. Author at Queen's Univ. of Belfast, School of Geosci., Belfast, UK.

Moinian (Proterozoic) gneisses in Easter Ross-shire, Scotland, exhibit pronounced alteration where they have been subjected to the flow of hydrocarbon-bearing F from an adjacent Devonian sedimentary basin. Comparison of the petrography of altered and unaltered gneiss indicates that element redistribution accompanied the alteration process. The alteration involved creation of S porosity by dissolution of P minerals in the gneiss, chloritization of biotite and orthoclase, albite, monzite and titanium oxides, attesting to redistribution of all the major components of the gneiss. Evidence for bitumen being coeval with albite/ quartz, and an association of high porosity with bitumen indicate that hydrocarbon-bearing F were present during the alteration process. Bitumen also penetrated beyond the visible alteration zone and accreted around radioelement-bearing accessory minerals. Organic geochemical data indicate that there is a local source for the bitumen in the Devonian sequence. Bitumen veining also occurs within the Devonian sequence. FI data from quartz associated with bitumen in the gneiss and the Devonian indicate minimum Tt of 120-140 and 100-120°C, respectively. The alteration was probably a result of a F flow episode relating to fault movement during basin subsidence. (Author's abstract)

PARNELL, J., CAREY, P.F. and **MONSON, B.,** 1996, Fluid inclusion constraints on temperatures of petroleum migration from authigenic quartz in bitumen veins: Chemical Geol., v. 129 (1996) p. 217-226. Authors at School of Geosci., Queen's Univ., Belfast BT7 INN, UK.

Solid bitumens in fracture systems commonly contain microscopic crystals of authigenic quartz which were precipitated coevally with the bitumen early in the paragenesis of the fracture-fillings. The quartz contains P FI (both aq and hydrocarbon), yielding Th particularly in the range of 95-130°C, indicating minimum Tt during petroleum migration. Volumes of up to 50% entrained quartz, and a predominance of aq I, indicate that the petroleum F had a substantial aq component. (Authors' abstract)

PARNELL, J., MONSON, B. and **GENG, A.,** 1996, Maturity and petrography of bitumens in the Carboniferous of Ireland: International J. of Coal Geol., v. 29, no. 1-3 (1996) p. 23-28. Authors at Queen's Univ. of Belfast, School of Geosci., Belfast, UK.

A set of bitumen samples from the Carboniferous of Ireland shows a general trend of increasing maturity southwards across the island. Bitumen reflectance is the most sensitive parameter and ranges up to 3.6%. Most of the bitumens occur in hydrothermal mineral veins and were generated locally by the passage of hot F through Carboniferous shales and limestones. Some bitumens contain I of metalliferous and other inorganic minerals. Anisotropy is exhibited by all bitumen samples with reflectances of 2.0% or over; mesophase textures occur in bitumens with reflectances over 3.0%, including one case where FI Th in coeval minerals (calcite and fluorite) are less than 200°C. (From authors' abstract by E.R.)

PASAVA, J., HLADIKOVA, J. and **DOBES, P.,** 1996, Origin of Proterozoic metal-rich black shales from the Bohemian Massif, Czech Republic: Economic Geol., v. 91 (1996) p. 63-79. Authors at Czech Geological Survey, Klarov 131/3, 118 00 Prague 1, Czech Republic.

Proterozoic metal-rich black shales (metasiltstones) in the Bohemian Massif are always closely associated with submarine mafic volcanic rocks and occur in (semi)isolated basins. Sulfur isotope results suggest the dominant source of sulfur to have been seawater sulfate, reduced by bacteria under different conditions. The $\delta^{13}C$ values of the organic matter (-24.2 to -37.5‰) reflect the combination of the carbon isotope composition of dissolved HCO^-_3, its high concentration, and the type of organisms. The results of Rock-Eval pyrolysis as well as laser Raman spectroscopy show a high maturity, close to that of well-crystallized graphite. FI and stable isotope data from quartz and carbonate veinlets of very low grade regionally metamorphosed metal-rich black shales at Kamenec and highly metamorphosed facies at Hromnice indicate that they resulted from the interaction between ^{18}O-rich F, volcanics, and metasediments. The interaction could have occurred during subsea-floor or later regional metamorphism. (From authors' abstract by E.R.)

PASTERIS, J.D., 1996, Mount Pinatubo volcano and "negative" porphyry copper deposits: Geology, v. 24, no. 12 (1996) p. 1075-1078. Author at Dept. of Earth and Planetary Sci., Washington Univ., Campus Box 1169, St. Louis, Missouri 63130-4899.

A major concern in the analysis of the volatile systematics of the 1991 eruption of Mount Pinatubo in the Philippines is the explanation for the release of such large amounts of SO_2 into the atmosphere. The author uses an ore-deposit model. Several variables are significant to the evaluation of the Mount Pinatubo eruption, the most important of which is the partitioning behavior of sulfur among the solid and aq F (liquid + gas) phases of the system. For example, one reason for the release of such large quantities of sulfur from Mount Pinatubo may be that--in contrast to many other oxidized calc-alkalic volcanoes--its M reached saturation with an SO_2-bearing aq F before the solid phase anhydrite began to precipitate. (From author's abstract by E.R.)

PASTERIS, J.D., WOPENKA, Brigitte, WANG, Alian and **HARRIS, T.N.,** 1996, Relative timing of fluid and anhydrite saturation: another consideration in the sulfur budget of the Mount Pinatubo eruption, *in* Fire and Mud, C.G. Newhall & R.S. Punongbayan, eds., Philippine Inst. of Volcanol. & Seismology, p. 875-891. Authors at Dept. of Earth and Planetary Sci., Washington Univ., Campus Box 1169, St. Louis, MO 63130-4899.

Raman microsampling spectroscopy and petrographic analysis were done on four major types of I in quartz and plagioclase phenocrysts in phenocryst-rich dacite from the June 15, 1991, eruption of Mount Pinatubo, Philippines: (1) glass I, typically containing one or more bubbles, (2) V-dominated I, (3) aq I consisting of L and V±solids, and (4) solid I. In quartz-hosted glass I with bubbles, Raman analysis revealed only CO_2 in some enclosed bubbles, but not SO_2 or H_2S (below detection limit of 1 bar partial P); dissolved H_2O, but not CO_2 (less than the detection limit of 900 ppm) was detected in the glass phase. The observed bubble:glass ratios in such I, the Raman-inferred CO_2 P in some bubbles, the documentation by Raman spectroscopy of G leakage from bubbles over time, and the petrographic documentation of physical breaching of many glass I suggest that these I may represent the two-phase entrapment at depth of coexisting M and supercritical F but that the F was not retained. No volatile species were detected in the V-dominated I, so very low GP are indicated. Raman spectroscopic analysis revealed anhydrite among the solid phases in fracture-lining aq I that are found only in quartz, implying an elevated sulfate content in late-stage aq F. Solid I of apatite, zircon, and amphibole were identified spectroscopically. Of note is the lack of anhydrite I in our samples. This observation, coupled with reports of high SO_3 in apatite I, lack of sulfur isotopic zonation in anhydrite phenocrysts, and relatively low bulk-sulfur contents in Mount Pinatubo dacites (only 25% of those in El Chichon eruptive rocks), suggests that the Mount Pinatubo dacitic magma may have reached saturation with respect to a CO_2-SO_2-H_2O F before anhydrite saturation occurred. Since sulfur strongly partitions into a F over a M phase, early saturation of the magma with a supercritical aq F could have effectively stripped sulfur from the M. In this case, neither the bulk-sulfur content nor the abundance of anhydrite crystals in eruptive rocks could be used as an indicator of the original sulfur content of the system. If F saturation indeed occurred early in Mount Pinatubo's magmatic history, then the $(H_2O+CO_2)/SO_2$ ratio in the M may have controlled the timing of the removal of sulfur from the M via F exsolution and the proportion of the available sulfur that ultimately reached the atmosphere. (Authors' abstract)

PATI, J.K. and **MAMGAIN, V.D.,** 1996, A note on the occurrence of orbicular rocks in Bundelkhand granitoid complex: J. of the Geological Soc. of India, v. 48, no. 3, p. 345-348.

Indexed under FI (E.R.)

PATIÑO DOUCE, A.E., 1996, Effects of pressure and H_2O content on the compositions of primary crustal melts: Transactions of the Royal Soc. of Edinburgh: Earth Sci., v. 87, p. 11-21 (also in: The Third Hutton Symposium, Geol. Soc. Amer. Special Paper 315).

PAUER, Frank, KIPFSTUHL, Josef, and **KUHS, W.F.,** 1996, Raman spectroscopic study on the spatial distribution of nitrogen and oxygen in natural ice clathrates and their decomposition to air bubbles: Geophys. Research Lett., v. 23, no. 2 (1996) p. 177-180. First author at Alfred-Wegener-Institut für Polar-und Meeresforschung, Bremerhaven, Germany.

We present the results of Raman spectroscopic scans to determine the N_2 / O_2 ratios on different planes through a clathrate in the Greenland Ice Core Project (GRIP) deep ice core, in which the two axes of the scans are perpendicular to one another. The spectra of the individual focal planes do not point to fractionation effects of the N_2/O_2 concentrations within a clathrate specimen in the range of the precision of Raman spectroscopy. In a second study, the frequency shift of the N_2 and O_2 peaks due to decomposition of a clathrate to an air bubble is shown qualitatively. From their peak integrals, there is no indication of different retransformation rates to air bubbles between the oxygen and the nitrogen contents of clathrates. The N_2 / O_2 ratios we observe in clathrates and on clathrate decomposition at different stages are retained in our measurements of air bubbles resulting from clathrate decomposition. (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 (1994) p. 525-527 (in Russian, translated in Trans. (Doklady) Russian Acad. Sci., Earth Sci. Sect., v. 343, no. 5 (1996) p. 167-170). Authors at Inst. for Ore-Deposit Geol., Petrography, Mineral., and Geochem., Russian Acad. of Sci., Moscow, and Fedorovskiy All-Russia Mineral Raw Material Inst., Moscow.

Abst. in FIR, v. 28, p. 124 (E.R.)

PEDERSEN, Mikael, 1996, Use of gas analyses in modelling mineralising events in the Jameson Land Basin, East Greenland: Bull. Greenlands Geol. Unders., Bull. 172 (1996) p. 74-77.

The Blyklippen Pb-Zn occurrence in the Mesters Vig area is the only ore deposit that has so far been exploited; other important ore mineral concentrations include the Malmbjerget porphyry Mo deposit, the Karstryggen Sr deposit and extensive sediment-hosted Pb, Zn, Ba and Cu mineralisation within the region. FI hosted-G were extracted from the samples either by crushing or thermal decrepitation, and were analysed using a quadropole mass spectrometer.

The G data show that different types of F have been involved in ore formation. Samples from Bredehorn and Blyryggen, both located near the western fault-bounded basin margin, show the influence of two F: a hot (> 250°C) component with relatively low sal and high in CO_2, and a cooler (130-150°C) F with higher sal and lower CO_2 content. The hot F is interpreted as being a deep crustal F that has been mobilised by the intrusion of the alkaline Werner Bjerge complex, while the cooler F is considered to be a local sedimentary brine. The role of the Werner Bjerge complex in the generation of the hot F is indicated at Blyryggen, where the gas data show a trend towards higher T, lower sal and higher CO_2 / N_2 ratios the closer the samples were taken to the intrusive complex. At Bredehorn, samples in general show higher CO_2 / N_2 ratios than at Blyryggen, which is consistent with their position closer to the Werner Bjerge. The two-component mixing at Bredehorn and Blyryggen shown by the FI data has also been demonstrated by lead isotope data, which suggests that lead from two different sources is present.

The presence of two F with different G components is also seen in Devondal at the eastern basin margin. One of the components is similar to the low T component at Blyryggen, and is interpreted as a sedimentary brine, while the other is very rich in hydrocarbons. There seems to be a geographical pattern with H_2S / CH_4 ratios increasing eastwards towards the vicinity of the Tvekegledal fault. This might indicate an increased dominance of sedimentary brine component in that direction. The hydrocarbon-rich nature of samples from the west end of Devondal can be explained by the presence of pure hydrocarbon I.

The G analyses show no evidence of CO_2-enrichment, which is seen in areas where magmatic activity has clearly played a role in ore deposition, suggesting that the mineralising F in Devondal are heated sedimentary brines. This is consistent with the lead isotopes that suggest a local source for the lead. Thus, a model for the mineralising event in the area envisages sedimentary brines, probably enriched in SO_4^{2-} and base metals, to be mobilised by a thermal event in the Tertiary and introduced to the Devondal area along the Tvekegledal fault. The F then migrated laterally from the fault zone through permeable layers and some entered the overlying carbonate buildups, where hydrocarbons were already trapped. The meeting between hydrocarbons and sulphate bearing brines resulted in thermochemical sulphate reduction and precipitation of sulphide minerals. The barite and quartz veining which is widespread in the area was probably formed by precipitation from cooling sedimentary brines. (From author's abstract by H.E.B.)

PEIFFERT, Chantal, NGUYEN-TRUNG, Chinh, and **CUNEY, Michel,** 1996, Uranium in granitic magmas: Part 2. Experimental determination of uranium solubility and fluid-melt partition coefficients in the uranium oxide-haplogranite-H_2O-NaX (X = Cl, F) system at 770°C, 2 kbar: Geoch. Cosm. Acta, v. 60, no. 9 (1996) p. 1515-1529. Authors at Centre de Recherche sur la Géologie des Matiéres Premiéres Minérales et Energétiques and GDR CNRS-CREGU 77, BP 23, 54501 Vandoeuvre-lés-Nancy, Cedex, France.

Data obtained show that F/M partition coefficients higher than one, favorable for the genesis of magmatic U mineralization, can be reached for peraluminous leucogranites in equilibrium with chloride-rich solutions. (From authors' abstract by E.R.)

PENG, S.L. and CHEN, Zilong, 1996a, Experimental study on liquation of tungsten- and tin-bearing granitic melt supersaturated with water at 850°C, 150 Mpa (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 631. Author at Dept. Geol., CSUT, Changsha 410083, China.

PENG, Shenglin and CHEN, Zilong, 1996b, New experimental evidence for liquation mineralization of W and Sn in granitic magmatic system (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 634. Authors at Dept. of Geol., Central South Univ. of Tech., Changsha, China.

Since the latest two decades, some researchers have paid attention to the phenomena of the L separation and its probable mineralization in the intermediate acid magma systems. Two series of experiments have recently been completed by us that involve (I) partitioning of W and Sn between granitic M and F-H_2O and Cl-H_2O F, and (II) partitioning of W and Sn between the two immiscible phases in granitic M, [i.e.] "melt-melt" (M-M) partitioning experiments. (From authors' abstract by E.R.)

PENNACCHIONI, G., 1996, Progressive eclogitization under fluid-present conditions of pre-Alpine mafic granulites in the Austroalpine Mt. Emilius Klipe (Italian Western Alps): J. of Structural Geol., v. 17, no. 5 (1996) p. 549-561. Author at Univ. di Padova, Dipartimento di Geologia, Paleontologia e Geofisica, Padua, Italy.

Indexed under FI (E.R.)

PERELLÓ, José, URZÚA, Felipe, CABELLO, José and **ORTIZ, Francisco,** 1996, Clustered, gold-bearing Oligocene porphyry copper and associated epithermal mineralization at La Fortuna, Vallenar Region, northern Chile: *in* "Andean copper deposits: new discoveries, mineralization, styles and metallogeny," Soc. Econ. Geologists Special Publication No. 5, Camus, F., Sillitoe, R.H. and Petersen, R., eds., 1996, p. 81-90. Authors at Minera BHP de Chile Inc., Apoquindo 4499, Piso 12, Santiago, Chile.

The high-sulfidation epithermal gold mineralization at Cantarito consists of a core of vuggy and massive silica with abundant alunite, which is bordered outward by zones dominated sequentially by kaolinite, sericite, smectite, and chlorite. The mineralization is contained in the siliceous core, where native gold grains are associated with quartz-alunite in hairline fractures, veinlets, and breccias. Pyrite, barite, and scorodite are present locally.

The style of the mineralization in the La Fortuna cluster displays many of the features that characterize the gold-rich porphyry copper deposits of the Philippines and Indonesia, as well as the porphyry gold deposits of northern Chile. (From authors' abstract by E.R.)

FI data are quoted from Skewes, 1993, showing some Th values over 600°C. (E.R.)

PERTHUISOT, V. and **ROUVIER, H.,** 1996, Pb-Zn deposits associated with Triassic evaporites in the diapirs of the eastern Maghreb (Tunisia) (abst.): 16th Earth Sciences Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 158 (in French). First author at ESEM, Univ. Orléans, France.

Numerous Pb-Zn concentrations occur in a close relationship with salt-bearing diapiritic cores. Analyses of FI show that at least part of the mineralization is due to the presence of a hot F, saturated in NaCl, comparable to the F involved in the emplacement of the classic MVT deposits. The age of the emplacement of the mineralizations is problematic. The sulfides are generally epigenetic, but their age remains uncertain, regardless of their host rocks. The only certainty concerns the very recent age of emplacement of a part of the mineralizations, necessarily Neogene in view of the age of their host rocks.

The most recent depositions could be the result of a F circulation caused by the compressive tectonics. Older mineralizations could have been emplaced in an essentially extensive regime, due to a spontaneous circulation of F. The origin of these F can be found in the Post-Triassic cover or in the sedimentary series below the salt levels. (From authors' abstrac,t translated by E.A.J. Burke.)

PERTOLD, Zdenek and **PUNCOCHAR, Milan,** 1996, The Kasperske Hory ore district: *in* Gold Deposits in Bohemia, Petr Moravek, ed., Czech Geological Survey, 1996, p. 79-91.

Indexed under FI (E.R.)

PETERSEN, S., HERZIG, P., FÖRTSCH, P. and HANNINGTON, M., 1996, Fluid temperature history of the TAG hydrothermal mound, Mid-Atlantic Ridge, 26°N (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F763, November 12, 1996. First author at TU Bergakademie Freiberg, D-09596 Freiberg, Germany; e-mail (petersen@mineral.tu-freiberg.de)

In 1994, ODP Leg 158 drilled into the active TAG hydrothermal mound at the Mid-Atlantic Ridge, 26°N. FI measurements were conducted on quartz and anhydrite from a complex assemblage of sulfide-anhydrite-silica breccias drilled at different areas of the mound.

FI are generally two phase L/V I and homogenize into the L phase. Tt for quartz and anhydrite from the TAG mound are generally high and range from 212-390°C. Their sal vary from 1.9 to 6.0 eq. wt.% NaCl averaging 4.5 eq. wt.% NaCl. The TAG-1 drilling area is located next to the central Black Smoker Complex with exit T of 363°C. Tt fall within a narrow range between 327-384°C. TAG-1 is characterized by a central anhydrite-rich zone (20-35mbsf) which is underlain by pyritic and siliceous breccias, marking the beginning of the subseafloor stockwork. A comparison of the Tt of the anhydrite-rich zone with the stockwork shows a moderate T increase with depth. The anhydrite zone is characterized by a mode of 350°C which is slightly lower than the exit T at the Black Smoker Complex, whereas the stockwork samples show a mode around 370°C. FI measurements in quartz and anhydrite from breccias underlying white smokers in the Kremlin area (TAG-2; exit T between 260 and 300°C) give Tt around 340°C, somewhat lower than results for the Black Smoker Complex, but clearly above those of the presently venting white smokers. The west side of the mound (TAG-4) is characterized by both low and high Tt, showing a heterogeneous distribution. Samples from the northern side of the mound are lithologically similar to the TAG-1 area, but Tt show a wider range and a stronger T increase with depth. (Authors' abstract)

PETFORD, N., MILLER, J.A., and RANKIN, A., 1996, Confocal scanning laser microscopy imaging of fluid inclusions in quartz: USA Microscopy and Analysis, September 1996, Issue 20, p. 7-8. First author at School of Geological Sci., Kingston Univ., Kingston-upon-Thames, U.K.

The technique reveals minute G I invisible in transmitted light, and other details pertinent to FI studies (E.R.)

PETTKE, Thomas and DIAMOND, L.W., 1996, Rb-Sr dating of sphalerite based on fluid inclusion-host mineral isochrons: a clarification of why it works: Economic Geol., v. 91 (1996) p. 951-956. Authors at Gruppe Isotopengeologie, Mineralogisch-Petrographisches Inst., Univ. Bern, Erlachstrasse 9a, CH-3012 Bern, Switzerland.

Based on an analogy with the Rb-Sr isotope systematics of synthetic fluid inclusions and on manipulation of published sphalerite data, we propose that the isochron arrays derive from differential partitioning of Rb and Sr between hydrothermal F and sphalerite, with coefficients which are not necessarily those expected at equilibrium. Therefore, complete separation of chemically homogeneous sphalerite (i.e., with a unique Rb/Sr ratio) from its P FI yields a two-phase isochron that carries only apparent age significance a priori, regardless of the number of replicates. However, most sphalerites reported in the literature are inhomogeneous with respect to their Rb/Sr ratios, i.e., they constititute several phases sensu stricto. We interpret this to result from rapid variations in effective element partitioning during sphalerite growth. Hence, the resulting FI-host mineral arrays are multiphase isochrons which indeed date the growth of sphalerite, as assumed by previous workers. (From authors' conclusions by E.R.)

PETTKE, Thomas, and FREI, Robert, 1996, Isotope systematics in vein gold from Brusson, Val d'Ayas (NW Italy), 1. Pb/Pb evidence for a Piemonte metaophiolite Au source: Chemical Geol., v. 127 (1996) p. 111-124. Authors at Mineralogisch-Petrographisches Inst., Gruppe Isotopengeologie, Univ. Bern, Erlachstrasse 9a, CH-3012 Bern, Switzerland.

A lead isotope study reveals a complex isotope geochemistry of petrographically cogenetic vein minerals. It was found that within an assemblage defined as cogenetic on petrographic grounds the Pb isotopic signature is not necessarily uniform and source modeling based on lead isotopes of associated minerals may be inappropriate. (From authors' abstract by E.R.)

PHILIPPOT, Pascal, 1996a, The chemistry of high-pressure fluids (1 to 3 GPa): natural observations vs experimental constraints: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Engl.), p. 39-52. Author at CNRS-URS 736, Lab de Petrologic, T26-E3, Univ. Paris 7, 4 place Jussieu, 75005 Paris, France.

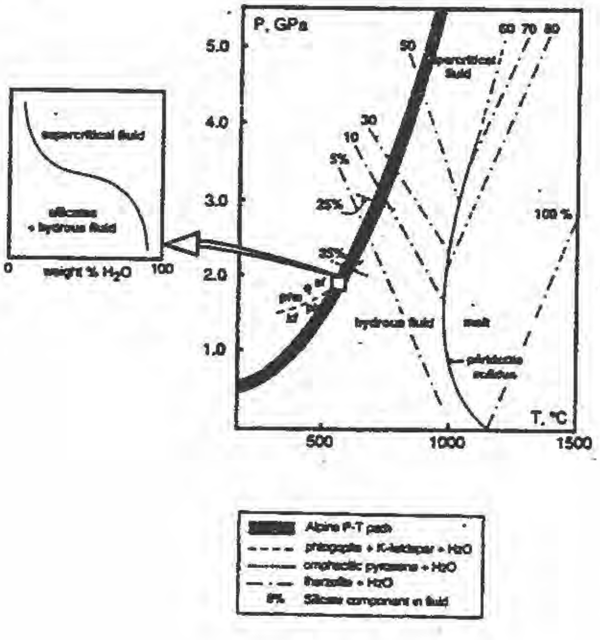
F are active at all levels in the subducted slab during high-P metamorphism. Early episodes of devolatilization of sediments and altered oceanic lithosphere under greenschist and blueschist conditions lead to the evolution of H_2O, CO_2 and CH_4 as a F phase that is commonly of low sal. In contrast, FI in low T eclogitic and high-grade blueschist rocks (1~3GPa and 400~700°C) from the Alps consist of moderately to highly-saline (up to 50 wt.% eq. NaCl) aq brines locally in association with $CO_2 \pm N_2$. These brines are present in segregation veins composed of the same mineral assemblage that the rocks they contact and contain a large variety of dp including silicate (quartz, omphacite, zoisite, kyanite, glaucophane, albite, talc, white mica, sphene), chloride (NaCl, KCl), carbonate (calcite dolomite, magnesite), sulfate (barite, anhydrite/gypsum), sulphide (pyrite), oxide (baddeleyite, rutile, ilmenite, magnetite) and phosphate (monazite, Mg-phosphate, apatite). This argues for the high solubility of a variety [of] (Si, Al, Mg, Fe, Ca, Na, K) and trace (Zr, Ti, Ba, Ce, La, Th, Cu, Zn) elements at high P.

Experimental data on the solubility of silicate material at P > 1 GPa indicates that for a geothermal environment comparable to the one prevailing during subduction of Alpine rocks ($\sim 7^\circ C \bullet km^{-1}$) the total solute content of an aq F in equilibrium with a terrigeneous sedimentary component may reach characteristic values of 50 wt.% readily soluble salts at ~60 km depths. Comparable level of silicate-material saturation can occur in aq F coexisting with lherzolite at a depth of ~150 km. The effect of rising P at constant T or addition of NaCl to H_2O F is to increase the solvent properties of the F and thus the solubility of minerals. Owing to the saline character of natural F and the high-P, low-T regime prevailing in subduction zones, the above solubility values should be considered as minimum values. Not all elements have their solubility dominated by chloride complexes however, and it is likely that the concentration of some metals such as Ti, Cu, Zn, Th and the REE in Alpine F was controlled by the presence of other ligands. These results suggest that the transition from aq solutions to H_2O-rich and siliceous F (or M) can be supercritical in nature during high-P metamorphism. Because the solubility capacity of the F increases with rising P and decreasing T, it is to be expected that supercritical high-density F should form more efficiently in cold slab (subduction of old oceanic lithosphere 100~200 Ma) than in hot slab environments. Whatever the transition may be, volatile phases at $P > 1$ GPa cannot be approximated as pure water of binary $H_2[H_2O?]$-CO_2 mixtures but rather as variably hydrated salty-soup of SiO_2, alkalis and metals. (Author's abstract)

PHILIPPOT, Pascal, 1996b, Composition of high-pressure fluids (1 to 3 GPa) in nature and experiments: a review (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 602. Author at CNRS, Laboratoire de Pétrologie, Université Paris 7, France; e-mail (plp@ccr.jussieu.fr)

Segregation veins are common features of HP-rocks (1-3 GPa and 400-700°C) of the Alps. The veins contain the same mineral assemblage as the rock they contact implying that the material filling veins was derived from the wall rock. P FI in vein minerals consist of mildly- to strongly-saline (0-50 wt% eq. NaCl) aq brines locally in association with $CO_2 \pm N_2$. The brines contain a large variety of daughter phases including silicate (quartz, omphacite, zoisite, kyanite, glaucophane, albite, talc, white mica, sphene), chloride, (NaCl, KCl), carbonate (calcite, dolomite, magnesite) and phosphate (monazite, Mg-phosphate, apatite). Such F are best described in terms of variably hydrated salty-soup of SiO_2, alkalis and metals. The characteristic F composition reflects that of the host rock; Na-, Fe- and Ca-rich fluids are found in eclogites whereas Mg-rich F occur in pyrope quartzites and metaperidotites.

The P-T diagram below shows a compilation of the solubility data from the literature together with a prograde P-T path for the Alpine HP-rocks. The total solute content of an aq F in equilibrium with a sedimentary component (rock composed of 2 micas, K-feldspar and quartz) may exceed 50 weight % at ~60 km depths (phase diagram in inset).



Comparable level of silicate-component saturation should occur in a F coexisting with lherzolite at a depth of ~150 km. A significant difference between these two sys-tems lies in the gradual *vs* abrupt increase in rock solu-bility with rising P. In contrast, burial of omphacite-bearing rocks (typical eclogite) from 60 to 100 km depth should be accompanied by a reversal in solubility of about 10 weight % dissolved solutes. This observation may have some significance for the origin of omphacite veins in eclogitic rocks and jadeite-rich layers in ultra high-pressure rocks. Importantly, the available data argues for a super-critical transition between aq solution and H_2O-rich silicate F (or melts). This is likely to have implications for the redistribution of incompatible trace elements (Nb, Ta) - the subducted slab and the overriding mantle wedge. (Author's abstract.)

PHILIPPOT, P., CHEVALLIER, P., and GIBERT, F., 1996, Synchrotron-radiation X-ray fluorescence applied to the analysis of single fluid inclusions (abst.): 16th Earth Sciences Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 101 (in French). First author at CNRS-URA 736, Université Paris-7, France.

In order to obtain quantitative estimates of the trace-element concentrations in FI, experiments have been carried out at the synchrotron-radiation X-ray fluorescence facilities of the LURE (Orsay) and of the ESRF (Grenoble). The instrument contains a multilayer Bragg-Fresnel elliptical lens which provides a focused image of the incident beam of about 10 μm. This lens also serves as monochromator, and about 10^5 (LURE) or 10^9 (ESRF) 12.4 keV photons.sec^{-1} pass through the focused point. The first results obtained on natural and synthetic I show a great variation of concentrations of dissolved ions, and this within a single I, due to different path lengths. [As has been shown by others, the] intensity ratio of Kα/Kß rays changes with the thickness of the material transversed and can thus be used as an indication of the absorption. To check these calculations in experiments we have developed an order of analyses which comprise: 1) Analysis of a solution with known concentrations (1000 ppm Ni, Cu, Zn, Mn or Sr) for different sal of the F (absorption by the F). An irradiation cell and capillaries of synthetic quartz adapted to these measurements have been constructed. 2) Analysis of a metallic target (Ni, Cu or Sr) with interception of the incident beam by slides of quartz and aluminum of known thickness (absorption by the host mineral). The obtained results are being processed and will be presented orally. From authors' abstract, translated by E.A.J. Burke.

PHILLIPS, G.N., 1996, Fluids and gold deposits (abst.), in Mesothermal Gold Deposits : A Global Overview. Volume of extended abstracts to accompany short course, Perth, 11-12 July, 1996. Pub. No. 27, p. 104-106, Geol. Dept (Key Centre) & UWA Extension, Univ. Western Australia, 135p. ISSN 0156-9287.

PHILLIPS, G.N. and HUGHES, M.J., 1996, The geology and gold deposits of the Victorian gold province: Ore Geol. Reviews, v. 11 (1996) p. 255-302. First author at 1 Coppin Street, East Malvern, Victoria 3145, Australia.

The Palaeozoic succession of Victoria represents a major world gold province with a total production of 2500 t of gold (i.e. 78 million oz), and remains the prime example of a 'slate belt' gold province (also known as 'turbidite-hosted', or 'shale-greywacke' gold province). Most production came from quartz veins (1000 t), Bendigo (697 t), Balarat (408 t) and Castlemaine (173 t) being the largest producers. Wallrock alteration is strongly influenced by host rock: in metasedimentary rocks, it is limited and subtle, but it is more pervasive in mafic and felsic igneous rocks. Carbonates, muscovite and pyrite are the most widespread alteration minerals in these rocks, representing CO_2, K and S addition. Enrichment of As within gold deposits is common, with Sb important in some small deposits, whereas base metals are only abundant locally, and Bi, W, Mo and Te show strong spatial association with granites and are rarely associated with economic gold deposits. Granites are an important component of the Palaeozoic succession in Victoria, but no large deposits are within granites. The limited amount of F chemistry data from Victorian gold deposits suggests low-sal fluids which contained CO_2, and variable methane, with Th from 150 to 300°C. The sulphur isotopic compositions of pyrite are mostly +1 to +5‰, with some values slightly above +10‰. Mineralizing temperatures are inferred to be near 300°C, and pressure around 1-2 kbar. A major advance in scientific understanding of these oft neglected deposits could kindle a major exploration and production revival. (From authors' abstract by E.R.)

PIASZCZYK, David, 1989, The characterisation and genesis of the silica flour deposits at Corinna: Bachelor of Science thesis, Univ. of Tasmania, 105 pp.

Silica flour is a fine grained (90% 30-200 µ) source of high purity (99.99%) silica which occurs as pods. Silica flour is totally granular and unconsolidated, [but] contains larger boulder material in various stages of decomposition. Lacy agate boulders have colloform banding and are the most common type of boulder. Silicified dolomicrite boulders show remnant textures of the original dolomicrite but are now 99.99 silica. Reagglomerated boulders indicate recent cementing of the flour. With analysis of the FI and oxygen isotopes in the flour and lacy agate boulder material, the source solutions for silicification were characterized. FI give Th (lowest F T) of 125.5°C and a sal of 10.5 - 12.7 wt.% (dependent of NaCl-KCl composition). When combined with oxygen isotope data a value for the $\delta^{18}O$ of the F was calculated $\delta^{18}O_{fluid} = 6.26‰$, T, sal and $\delta^{18}O$ values are all characteristic of the source F. F conditions during dolomite replacement can be summarised to F T below 200°C, near neutral pH, only slight super-saturation of silica, and undergoing slow cooling at near equilibrium conditions. Silicification F for the deposits were either derived from a magmatic or metamorphic source with possible mixing with meteoric waters. (From author's abstract by E.R.)

PICHLER, Thomas and DIX, G.R., 1996, Hydrothermal venting within a coral reef ecosystem, Ambitle Island, Papua New Guinea: Geology, v. 24, no. 5 (1996) p. 435-438. Authors at Ottawa-Carleton Geosci. Centre and Dept. of Earth Sci., Carleton Univ., 1125 Colonel By Drive, Ottawa, Ontario K1S 5B6, Canada.

Shallow-water (5-10 m) hydrothermal venting in a nearshore coral reef environment at Ambitle Island in the Tabar-Feni island arc, east of Papua New Guinea, occurs as focused discharge of boiling F from discrete ports 10-15 cm in diameter, and as dispersed discharge of diffuse bubble streams that issue through the sandy mixed carbonate-volcaniclastic sea floor. Abiotic aragonite and microcrystalline ferroan, low-Mg calcite, interlaminated with Fe-oxyhydroxides, are the prominent hydrothermal precipitates. Geochemical attributes of aragonite ($\delta^{18}O$, $\delta^{13}C$, and FI) suggest that cements formed from a solution with sal <5‰ at T of ~100°C, with probable contribution of hydrothermal CO_2. Sr isotope ratios in abiotic (hydrothermal) aragonite (~0.704 15) are similar to those in island-arc basalt and denote considerable subsurface water-rock interaction of meteoric water derived from the adjacent volcanic island. The Sr isotope ratio of a coral sample (0.707 46) collected adjacent to a vent portal suggests coral growth within a mixed seawater-hydrothermal environment. (Authors' abstract)

PIGGOTT, Neil, VEAR, Alwyn, WARREN, E.A., GRAHAM, Rod, HOWE, Spencer, O'LEARY, John and PULHAM, A.J., 1996, The evolution of the Piedemonte Llanero petroleum system, Cordillera Oriental, Colombia; 2, Reservoir petrography and petroleum geochemistry: American Assoc. of Petroleum Geologists Bulletin, v. 80, no. 8, p. 1324. First author at BP Exploration, London, UK.

Detailed quantification of cements and rock texture, FI microthermometry, thermal maturity data, oil-source rock correlations and structural restorations have been integrated to reveal the porosity and hydrocarbon charge evolution of reservoirs in the Piedemonte Llanero thrustbelt of Colombia. For most structures quartz cementation predated major hydrocarbon migration. Average quartz cementation T is uniform within a structure, but varies between thrust sheets. These variations appear to reflect differences in burial depths during quartz cementation rather than variations in timing. Integration of all data reveals a complex but predictable evolution of porosity and hydrocabon charge in both space and time which is being applied to current exploration in the Piedemonte Llanero and is relevant to thrustbelt exploration elsewhere. (From authors' abstract by E.R.)

PITMAN, J.K. and SPÖTL, Christoph, 1996, Origin and timing of carbonate cements in the St. Peter Sandstone, Illinois Basin: evidence for a genetic link to Mississippi Valley-type mineralization *in* Siliciclastic Diagenesis and Fluid Flow: Concepts and Applications, SEPM Special Publication No. 55, p. 187-203. First author at U.S. Geol. Survey, 939 Denver Federal Center, Lakewood, CO 80225, USA.

The Ordovician St. Peter Sandstone in the Illinois Basin has undergone complex diagenetic modification involving (1) early K-feldspar, dolomicrospar, and illite precipitation, (2) late quartz, planar and baroque dolospar, anhydrite, calcite, and illite cementation and (3) carbonate-cement and K-feldspar dissolution. In southern Illinois, burial reconstruction in combination with silicate mineral age dates indicate that late-diagenetic cementation in the St. Peter Sandstone occurred during deep burial (~3,300m) in Late Pennsylvanian and Early Permian time when major ore-forming (MVT) events were taking place in the region. Maturation kinetics suggest that precipitation T at this depth were ~140°C, assuming the major heat source was from the basement. The range of burial T predicted for the St. Peter Sandstone (~65-140°C) compares closely with the T of hydrothermal ore-forming F (~80-180°C) suggesting that the F involved in diagenesis (i.e. dolomitization and quartz and anhydrite precipitation) may have been part of the same (paleo)hydrologic system that caused MVT mineralization. In the shallow northern part of the basin, FI data indicate that dolospar precipitated at higher T (110-115°C) than would be expected in these otherwise low T (<50°C) rocks. Provided these values are reliable, the St. Peter Sandstone was affected by a heat source that was not burial related. Hydrothermal F associated with the Upper Mississippi valley District could account for these T. FI and isotopic data indicate that the F involved in burial cementation throughout the basin were saline and comparable in composition to the brines responsible for MVT mineralization (~20 wt.% NaCl eq.). In the absence of igneous activity, warm topographically driven F (i.e. low T (<200°C) brines) moving updip from the southern tectonic margin of the basin can explain much of the dolospar and the associated mineral cements in the St. Peter Sandstone. ^{18}O-depleted dolospar concentrated along the LaSalle anticline in east-central Illinois suggest that this structural feature was a major conduit for the movement of these hot F through the basin. The ultimate source of the F may have been the Ouachita fold belt or the Reelfoot rift. There also is some evidence that F were expelled from the Arkoma and Black Warrior Basins. (Authors' abstract)

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 (1995) p. 525-527 [in Russian, translated in Trans, (Doklady) Russian Acad. Sci., Earth Sci. Sect., v. 343A, no. 6, p. 143-147, 1996). Authors at Far Eastern Geological Inst., Far Eastern Dept., Russian Acad. of Sci., Vladivostok.

POLLIAND, Marc, and **MORITZ, Robert**, 1996, Structural setting and fluid inclusion characteristics of the polymetallic quartz-barite veins of the "Montagne de Pormenaz," Aiguilles Rouges Massif, France (extended abstract): Schweiz. Mineral. Petrogr. Mitt., v. 76, p. 91-95. Authors at Dépt. de Minéralogie, Univ. de Genève, rue des Maraîchers 13, CH-1211 Genève 4, Switzerland.

The "Montagne de Pormenaz" consists of the pre-Stephanian A Pormenaz porphyric monzonitic Ba-rich intrusion. The quartz-barite mineralized veins are hosted by the monzonite. These mineralized veins have been emplaced during Alpine sinistral transpression as extension fractures fillings, and have been controlled by Hercynian and Alpine structures.

The microthermometric FI study based on (1) quartz and barite crystal intergrowths from the mineralized veins, and (2) barren regional quartz veins shows that the mineralized veins correspond to a thermal anomaly with respect to the regional F. Th indicate minimum T of 200-250°C during the ore formation process. (Authors' abstract)

POLYKOVSKY, V.S., 1996a, Advances and trends in thermobarogeochemistry studies in Uzbekistan (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 15-17. Author at Society of FI Research of Uzbekistan.

A review of the stages in the development of concepts, equipment, and education dealing with FI studies. (E.R.)

POLYKOVSKY, V.S., 1996b, The regularities of the fluoridewear formation's accommodation [sic] in middle Asia (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 32-34.

A review of the many types of deposits (E.R.)

POLYKOVSKY, V.S., AKBAROV, H.A. and **IVANOVA, N.A.**, 1996a, The Aby Raihon Beruny Tashkent State Technical Univ.'s training program on the Practical thermobarogeochemistry (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 47-49. Authors at Soc. of Fluid Inclusion Researches of Uzbekistan, Tashkent State Tech. Univ.

An advertisement for a FI training course costing $3000 to $6000 plus food and housing.

See next entry (E.R.)

POLYKOVSKY, V.S., AKBAROV, H.A., and **IVANOVA, N.A.**, 1996b, The Aby Raihon Beruny Tashkent State Technical Univ.'s training program on the practical thermobarogeochemistry (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 6. (Note: this abstract was distributed at the I.G.C. Workshop/Shortcourse, but was not printed in the official 30th I.G.C. Abstracts volumes. E.R.) Authors at The Soc. of FI Researches of Uzbekistan, Tashkent State Technical Univ.

The intensive development of Thermobarogeochemistry (TBG) as one of the sciences about the Earth branch to no small degree is caused by the combination of the theoretical investigations in this sphere with practical use on all stages of the geological survey works.

In the tine of working out of the Training program "Applied thermobarogeochemistry" the experience of the Moscow, Lvov Universities (N.P. Ermakov, F.P. Melnikov, N.V. Piznur, U.V. Lyahov on the training of the geological specialities' students and the experience of the specialised trade-improvement courses of educational and scientifically industrial center of Republic of Uzbekistan's State Geological Committee (V.S. Polykovsky) and Fluid Inclusion User school in USA (David Norman) were taken into account.

The program envisages the acquaintance of the students with [various] problems, for the solution of which the TBG investigations are directed.

Purposeful use of the methods and methodics of the TBG for the exposure and definition of the prospects of regions and areas on the definite types of the fossils as the specific deposits, ore field and ore bodies, is based on the results of the systematical analysis of all investigations.

The 195-hour training process given in Engl., Uzbek and Russian, is realised by the leading specialists-scientists-thermobarogeochemists of Republic Uzbekistan and Moscow, Sankt-Peterburg, Lvov and Novosibirsk. For the characteristics of the most actual part of the Program the scientists from USA, Great Britain, France, Germany, China and Japan are invited.

The approximate cost of training from 3000$ up to 6000$, the cost of accommodation in the hotel from 10 up to 50$/24 hours, the cost of nourishment from 3 up to 30$/day (according the Circular of the Organizing Committee). (From authors' abstract by E.R.)

POLYKOVSKY, V.S., FINKELSHTEIN, Y.I., and **IVANOVA, N.A.**, 1996a, Thermobarogeochemical peculiarities of the gold mineralisation display in the carbonate rocks in south Uzbekistan (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug.10-11, p. 5. (Note: this abstract was distributed at the I.G.C. Workshop/Short-course, but was not printed in the official 30th I.G.C. Abstracts volumes. E.R.) Authors at Goscomgeo, Uzbekistan.

Thermobarogeochemical methods establish the possibilities of use in exploration.

The gold in the breccia and the veinlet calcite is associated with pyrites and cinnabar, plus rare antimonite.

On their composition the majority of all I founded in the calcites of all studied formations of the investigated region (the calcites of the grey and brown breccias, calcite veins with cinnabar and gold, semi-transparent calcite from vein formations, nests and pollings) are two phase with 5-30 vol.% G, and some dm halite is present.

The homogenization of the I constantly happen in L phase under Ts 250-75°C.

Aq extracts [from two stages?] showed:

$$\frac{\text{C155 HCO}_3\ 41}{\text{Ca}_2 + 50\ \text{Mg}_2 + 28}\ ;\quad \frac{\text{HCO}_3\ 83}{\text{Ca}_2 + 73}$$

The G composition of the I in calcite showed Z.I. Kovalishin in the time of analysis of these components, extracted CO_2 - 1.4, N_2 - 84.5, CH_4 - 0.0, H_2 - 0.0.

The investigations define the hydrothermal character of mineral-forming solutions, and in connection of this fact, conduct the amend of the geologo-surveying works' direction. [sic] (From authors' abstract by E.R.)

POLYKOVSKY, V.S., FINKELSHTEIN, Y.I. and **IVANOVA, N.A.**, 1996b, Thermobarogeochemical peculiarities of the gold mineralisation's display in the carbonate rocks in south Uzbekistan (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 43-46. Authors at Soc. of Fluid Inclusion Researches of Uzbekistan.

After a discussion of the crystallographic shapes of FI in calcites (from unspecified ore deposits) the G/L ratios are shown to vary widely, as do the values of Th. The ratios of solutes and of G were also determined. (E.R.)

PORTNYAGIN, M.V., MAGAKYAN, R., and **SCHMINCKE, H.-U.**, 1996, Geochemical variability of boninite magmas: evidence from magmatic inclusions in highly magnesian olivine from lavas of southwestern Cyprus: Petrologiya, v. 4, no. 3, p. 228-239, (in Russian, translated in Petrol., v. 4, no. 3, p. 209-220). First author at Vernadsky Inst. of Geochem. and Analytical Chem., Russian Acad. of Sci., ul. Kosygina 19, Moscow, 117975 Russia.

Detailed geochemical, mineralogical, and experimental studies of an Ol-phyric boninite from the Mavrokolimbos area, southwestern Cyprus are presented. Olivine phenocrysts have a primitive composition ($Fo_{87\text{-}92}$). They contain crystalline I of magnesian orthopyroxene (Mg# = 0.90-0.92), chromian spinel of variable composition (Cr/(Cr+Al) = 0.79-0.60), and syngenetic M and FI. The M I, which were quenched experimentally, were analyzed for major elements (using electron microprobe), trace elements, and H_2O (by ion microprobe). The detected compositional variations of the M I suggest a wide chemical diversity of the primary boninitic magmas and the involvement of at least four independent components in their composition. According to the proposed model, the boninite M formed by partial mantle melting in an open system, at an effective restite permeability of approximately 2%, a fact evident from the occurrence of an ultradepleted M [$(Ce/Yb)_n$ = 0.07]. The incipient mantle melting began under the effect of the aq component. The P F was characterized by a low content of the most incompatible elements (H_2O/K_2O > 150). Its origin was related to the dehydration of a subducted slab. The enrichment of the boninite in LREE and LILE was due to the presence of an independent component [$(La/Sm)_n > 2$, $(K/La)_n \sim 5$, $(K/Sr)_n \sim 5$, $(Sr/Ce)_n \sim 1$], which could be introduced in the mantle source by the aq component percolating through the heterogeneously metasomatized mantle. Alternatively, the enriched component may have locally occurred in the mantle in the form of M films before the melting. The genesis of this component is related to potassic mantle metasomatism. The boninitic magmas interacted with silicic rocks/melts during the crystallization and produced hybrid M with anomalously high contents of HREE [Yb > 2.5 ppm, $(Dy/Ti)_n > 5$], Y, and Na, and low CaO/Al_2O_3 ratios (<0.75). (Authors' abstract.)

POULSON, S.R., 1996, Equilibrium mineral-fluid stable isotope fractionation factors in graphitic metapelites: Chemical Geol., v. 131, p. 207-217. Author at Dept. of Earth Sci., Dartmouth College, Hanover, NH 03755, USA.

The stable isotopic composition (C,O,H and S) of a F in equilibrium with the common metapelite assemblage graphite + sulfide has been calculated using a modified Redlich-Kwong equation of state at 500°C, 3.5kbar, and 700°C, 6kbar, for a range of fO_2 and fS_2 conditions.

The results have implications for studies using stable isotopic methods to investigate interaction between a F and a graphitic metapelite during metamorphism, especially during devolatilization and F-rock interaction. Equilibrium values of $\Delta_{\text{mineral-}\Sigma\text{fluid}}$ during metamorphism are dependent upon the composition of the F, which in turn is dependent upon fO_2 and fS_2. (From author's abstract by E.R.)

POUTIAINEN, M. and **GRÖNHOLM, P.**, 1996, Hydrothermal fluid evolution of the Paleoproterozoic Kutemajärvi gold telluride deposit, southwest Finland: Econ. Geol., v. 91, no. 8 (1996) p. 1335-1353. Authors at Dept. of Geol., Univ. of Helsinki, P.O. Box 11, Helsinki FIN-00014, Finland.

The Kutemajarvi gold telluride deposit is located about 200 km north of Helsinki in southwestern Finland. It occurs in the continental island arc-type Paleoproterozoic volcano-sedimentary Tampere schist belt situated in the central part of the Svecofennian domain (2.0-1.75 GA) of the Fennoscandian Shield. The deposit, consisting of four distinct vertical ore pipes, is associated with a strongly hydrothermally altered zone in the northern part of the Tampere schist belt. The most common host rocks are intensively deformed sericite-quartz schist, quartz rock, and quartz veins. Very fine grained native gold occurs mainly along quartz grain boundaries but also in late fractures and often as symplectites with tellurides. Also, the host rocks contain minor Fe-Cu-Zn-Pb-As sulfides-sulfosalts and abundant Fe-Pb-Bi-Ag-Au tellurides. In 1994, the proven ore reserves were about 0.36 million Mt averaging 7 g/t Au.

Postpeak metamorphic sulfide ± gold deposition (380°-320°C/2.8-2.0 kbars) resulted from the interaction between the wall rocks and a low-sal (<7 wt% NaCl eq.) H_2O-CO_2 ± CH_4 hydrothermal F, which percolated through permeable zones developed during the syn- to late-stage deformation (i.e., ductile to brittle). Phase separation (effervescence) due to local P fluctuations may have caused gold telluride ± sulfide deposition at 330° to 270°C 1.6 to 0.7 kbars. Late brittle deformation and hydraulic fracturing opened pathways for large volumes of CO_2-CH_4 ± N_2 F, allowing a possible G-phase transport of tellurium (and gold?). Later reheating of the deposit resulted in remobilization of early gold associated with sulfides by diluted aq solutions at lowered T (<380°C) and P (<1 kbar). (Authors' abstract)

POWELL, W.G. and **GHENT, E.D.**, 1996, Low-pressure metamorphism of the mafic volcanic rocks of the Rossland Group, southeastern British Columbia: Canadian J. of Earth Sci., v. 33, no. 10, p. 1402-1409.

Indexed under FI (E.R.)

PRESNELL, R.D. and **PARRY, W.T.**, 1996, Geology and geochemistry of the Barneys Canyon gold deposit, Utah: Economic Geology, v. 91 (1996) p. 273-288. Authors at Kennecott Exploration Company, and Dept. of Geol. and Geophys., Univ. of Utah, Salt Lake City, Utah 84112-1183.

Barneys Canyon is a sediment-hosted, disseminated gold deposit located 7 km from the large, gold-rich, Bingham prophyry copper deposit. Host rocks for gold mineralization are dolomite, siltstone and sandstone.

FI measurements from barite and jasperoid show a mean sal of 1.7 wt% NaCl eq. and Th of 130° to 393°C with weak modes at 350 and 230°C, suggesting that two F have interacted with rocks at Barneys Canyon. Kaolinite-bearing assemblages formed below 280°C. Pressure correction at hydrostatic pressure is 12°C.

FI measurements, geochronology, structure, trace elements, and distance from Bingham are inconsistent with genesis of the Barneys Canyon deposit as part of the Bingham porphyry copper system. It is unlikely that genesis of the Barneys Canyon gold deposit involved igneous activity. (From authors' abstract by E.R.)

PRIETO, Manuel, PANIAGUA, Andres and **MARCOS, Celia,** 1996, Formation of primary fluid inclusions under influence of the hydrodynamic environment: European J. of Mineral., v. 8, no. 5, p. 987-996.

Full paper for previous abstract (E.R.)

When crystals grow under convection conditions, the hydrodynamic environment can promote the formation of I in the rear side of the crystals, downstream in relation to the F flow. An experimental study of this mechanism of F trapping is presented, and the conditions under which hydrodynamics influences growth behaviour are discussed. Crystal growth experiments have been carried out with aq solutions in a convection system under controlled conditions of T, solution velocity V_S, and supersaturation σ_∞. Growth rates of 011) faces of ADP crystals have been measured for different orientations, in relation to tthe solution flow and for different values of σ_∞ and V_S. It is concluded that hydrodynamics can produce an anisotropy in the con-tribution of material to crystallograhically equivalent faces. At low solution velocities and moderate supersaturation, the growth rate depends on the flow "impact" angle. In contrast, at high solution velocities ($V_S > 3$ cm.s^{-1} for $\sigma_\infty = 2.45\%$) the hydrodynamic configuration has no influence on the growth kinetics.

Hydrodynamics can also plan an important role in the formation of FI during crystal growth. However, this effect only occurs at low solution velocities, when the growth kinetics is controlled by the hydrodynamic configuration. Crystals grown at low solution velocities ($V_S < 3$ cm.s^{-1} for $\sigma_\infty = 2.45\%$) show large FI in the rear zone. At high solution velocities the mass-transfer is high enough to avoid the hydrodynamic control of growth, and no I are generated by this mechanism.

PROKOFIEV, V. Yu. and **ZORINA, L.D.,** 1996, Fluid regime of the Darasun ore-magmatic system based on fluid inclusion studies: Scientific Journal–Geologiya I Geofizika, v. 37, no. 5, p. 50-61 (in Russian; translated in Russian Geol. & Geophysics, v. 37, no. 5, p. 48-59).

As a result of investigation of individual FI in granodiorite-porphyry minerals and paragenetically associated gold-bearing sulfide-quartz veins of the Darasun deposit, geochemical features of the F regime at various stages of development of ore-magmatic system have been established. A two-stage scheme of formation of hydrothermal ore veins is proposed: (1) heterogenization and boiling out of hydrothermal solutions in a thermal field of intrusion with formation of chloride brines which extract and accumulate ore components; (2) tectonic opening and supply of weakly-mineralized waters into ore-forming system, whose mixing with hydrotherms resulted in deposition of productive gold-ore mineralization. A high informativeness of S FI in quartz of granodiorite porphyries has been established for revealing potentially ore-bearing intrusive bodies. (Authors' abstract).

PROKOFYEV, V. Yu., 1996, The main principles of classification of hydrothermal ore deposits based on a study of fluid inclusions (on the example of gold) (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 752. Authors at Vinogradov Inst. of Geochem., Irkutsk, Russia.

Our experience in detailed analysis of FI in minerals of 18 large and unique gold deposits from different regions (Russia, Kazakhstan, Uzbekistan, Armenia, Slovakia) led us to the following hierarchy of their features:

The degree of openness of ore-forming hydrothermal systems, i.e. the character of their contact with the atmosphere is the fundamental factor for classification of hydrothermal deposits, as it influences the strongest both composition and parameters of F as well as the magnitude, rate and range of their variations. The ratio (water P + easy-boiling G P)/water P called further "baric index of system-closed" (BISC) is proposed as a discriminating parameter. Three major groups of gold-bearing hydrothermal systems can be distinguished on this basis, which are principally different in the sense of physical and chemical setting and the character of FI in minerals with different discriminating parameters within each group: open systems; half-open systems; and closed systems. (From author's abstract by E.R.)

QI, Jinzhong and **LI, Li,** 1996, Geochemistry study of fluid inclusions of gold deposits connected with alkalic rocks in China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 739. Authors at Gold Geological Inst. of MMI, China.

FI studies of 5 gold deposits (e.g. Dongping gold deposit, Hebei province, Hadamen gold deposit, Inner Mongolia, etc.) connected with alkalic rocks show that quartz of auriferous quartz veins contain abundant three-phase CO_2-NaCl-H_2O I and two-phase CO_2-rich ones, which are 5~20 µm in diameter. Th of the FI are mostly 150 to 300°C, the sal are mainly 0.2 to 12 wt% NaCl, and the mineralizations occur at depth of 1.4 to 2.8 km. The most striking character of F composition is that in cations, Na^+ is dominant, followed by K^+, Ca^{2+} and in anions Cl^- is slightly more than SO_4^{2-}. In G phase, H_2O is dominant, followed by CO_2. The pH values are mainly 6.5~8.5, indicating that the ore solutions are alkaline. The isotope compositions of H and O indicate that the ore-fluids are mainly composed of magmatic water. With the dropping of T of the ore-F, the contents of CO_2 decrease while the sal increase. In the report, authors have also discussed the relations between Au and other components of the ore-F, and concluded that in these deposits, chloride, H_2S, SiO_2, CO_2 of the F all together participated in the migration and concentration of Au. (Authors' abstract.)

QIAN, Weihong, 1996, The motion of the earth interior liquid and global tectonics: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 152-160. Author at Dept. of Geophys., Peking Univ., Beijing 100871.

This paper deals with the angular momentum exchange between the solid inner core and magmatosphere in different periods. The results show that the higher gravity potential surface was located in two poles (palaeocontinents) by the end of astronomical evolution period, and that the first stage of geological evolution period the crust split and drifted. During the geological evolution period, the split plates moved many times in different directions and formed today's global tectonics. (From author's abstract by E.R.)

QICHENG, Fan, RUOXIN, Liu, ZHUORAN, Lin, XUELEI, Chu, RUI, Zhao, and **WEIGUO, Huo,** 1996, Preliminary study of carbon isotope in mantle CO_2 Fluid inclusion from eastern China: Geochimica et Cosmochimica Acta, v. 25, no. 3, p. 265-269. (in Chinese, Engl. abstract)

CO_2 in xenoliths containing CO_2-rich FI (including twelve peridotites and one granulite) in Cenozoic basalt from eleven regions of eastern China has been extracted using method of decrepitation through step heating, and its carbon isotopes have been determined. The results show that $\delta^{13}C$ at 800°C mainly ranges from -16.0‰ to -22.0‰, while that at 1100°C from -21.0‰ to -29.0‰. There exist low $\delta^{13}C$ and inhomogeneity of carbon isotopic composition in mantle F from eastern China, and high T carbon has an even lower $\delta^{13}C$. No significant correlation has been shown between carbon and oxygen isotopes. (Authors' abstract)

QIN, Jianxiong and **ZENG, Yunfu,** 1996, Genesis and development of porosity in carbonate reservoirs–fluid inclusion evidence: Chinese J. of Geochem., v. 15, no. 4, p. 364-373 (in Engl.). Authors at Chengdu Inst. of Tech., Chengdu, 610059.

FI in minerals filled in pores of reservoir rocks can be used as a good indicator of pore genesis and development so as to shed light on oil generation, migration and accumulation. The relationship between pore evolution and oil generation has been established based on FI studies on the Lower Ordovician carbonate reservoir strata in the Ordos Basin, Northwest China. Seven stages of porosity development can be recognized, i.e., the penecontemporaneous, the early and middle-late diagenetic, the supergene, the early, middle and late reburying stages. The dissolution pores and fissures formed in the supergene and middle-late reburying stages and the structural fractures formed in the late reburying stage constitute the major traps of oil and G. The major phase of oil migration and accumulation took place between Late Jurassic and Cretaceous, corresponding to the middle and late reburying stages. The generation and accumulation of oil can be closely related to Yenshanian tectonics. (Authors' abstract)

QIN, Shan and **WANG, Pu,** 1996, Mineralization-alteration and genesis of Lejiawan antimony deposit: Acta Scientiarum Naturalium Univers. Pekinensis (Beijing Daxue Xuebao Ziran Kexue Ban), v. 32, no. 4 (1996) p. 448-455 (in Chinese; Engl. abst.). First author at Dept. of Geol., Peking Univ., Beijing, 100871.

Lejiawan antimony deposit is a typical deposit in the antimony mineralization zone in northern Guang Dong Province. Zoning of mineralization and alteration in Lejiawan antimony deposit is very distinct, from orebody to country rock there are antimony mineralization, silification and pyritization zones, respectively. Based on analyses of the ore-forming process, isotopic data and FI data, the authors suggest that the genesis of Lejiawan antimony deposit belongs to stratabound epithermal transformation deposit. (Authors' abstract)

QING, Hairuo, 1996, Fluid flow during the tectonic thrusting and formation of dolomite reservoirs in the Western Canada Sedimentary basin: evidence from regional geochemical trends (abst.): 30th Int'l Geol. Cong., Abstracts, v. 1, p. 347. Author at Dept. of Geol., Royal Holloway, Univ. of London, UK.

From northeastern British Columbia to Pine Point, over a lateral distance of 400 km, saddle dolomites show general trends of decreasing $^{87}Sr/^{86}Sr$ ratios (0.7106 to 0.7081) and Th (178°C to 92°C) with corresponding increase in $\delta^{18}O$ values (-16‰ to -7‰ PDB). These regional trends suggest that hotter and more radiogenic basinal F moved eastward updip along the Presqu'ile barrier and mixed with cooler ambient formation waters. These movements of basinal F were probably related to tectonic thrusting and compression, sedimentary loading, and tectonic uplift on the western margin of the Western Canada Sedimentary Basin. The Middle Devonian Presqu'ile barrier appears to have acted as a deeply buried regional conduit system that played a role in focusing and channeling these basinal F. These regional F flows were responsible for extensive burial dolomitization and also played a role in MVT mineralization at Pine Point.

One or more orogenic events appear to [have] provided the driving mechanism for large-scale migration of basinal F leading to mineralization at Pine Point. However, the low δD (-80 to -100 permil SMOW) of Pine Point dolomite FI can be interpreted as a mixing of some syn- to post-Laramide meteoric water with basinal brines during dolomitization, supporting a Late Cretaceous to early Tertiary dolomitization and mineralization at Pine Point. (From author's abstract by E.R.)

QIU, Hua-Ning, 1996, ^{40}Ar - ^{39}Ar dating of the quartz samples from two mineral deposits in western Yunnan (SW China) by crushing in vacuum: Chemical Geol., v. 127, no. 1-3 (1996) p. 211-222. Author at Guangzhou Inst. of Geochem., Chinese Acad. of Sci., P.O. Box 1131, Guangzhou 510640, People's Republic of China.

The primary aim of this study is to investigate the possibility of dating fluid inclusions of quartz samples using the ^{40}Ar - ^{39}Ar method by crushing in vacuo. The samples are from the Lushui tin-tungsten deposit and the Shangmanggang gold deposit in western Yunnan, SW China. Coexisting muscovite S-90MS and quartz S-90Qw in a piece of tungsten ore from the former deposit were selected, and the isochron age of S-90Qw by crushing (38.6±1.9 Ma) shows excellent coincidence with that of S-90MS by stepped heating (38.6±0.8 Ma). The isochron age and plateau age by crushing of the quartz SMG-8Qz from the latter deposit indicate that the gold mineralization occurred at ~144 Ma. These ages are respectively agreeable with the evaluated ages from the geologic facts. In addition, since the postassium concentration (calculated from ^{39}Ar released by crushing) in the quartz sample SMG-9Qz was as high as 0.24%, electron-probe analysis was applied to investigate the occurrence of potassium, and the results reveal that the majority of potassium scattered in the microcrystal quartz grains. (Author's abstract)

QIU, Y.M., WANG, J.G., YANG, H.Y., McNAUGHTON, N.J. and **GROVES, D.I.,** 1996, Geological and geochemistry constraints on the genesis of the Yixingzhai gold mine in the Archaean Mt Wutai-Hengshan granite-greenstone belt, North China Craton (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 624. First author at Key Centre for Strategic Mineral Deposits, Univ. of Western Australia, Nedlands 6907, Perth, Australia.

About 20 gold deposits/prospects have been discovered in the late-Archaean Mt Wutai-Hengshan granite-greenstone terrain in the central North China Craton (NCC) during the last decade. This paper documents gold mineralization in the Yixingzhai gold mine, the largest gold mine in the area, and provides constraints on the genesis of this deposit based on field investigations, FI and isotope studies.

The main ore minerals include native gold, electrum, pyrite, chalcopyrite, galena, sphalerite and arsenopyrite, with minor native bismuth, pyrrhotite and molybdenite. The gangue minerals are dominated by quartz, sericite, feldspar and calcite. Gold-associated wall-rock alteration includes pyritization, silicification, sericitization, chloritization and carbonatization. FI in gold-rich quartz veins are similar to those of the granitic porphyries and the diorite complex, but different from those of Archaean rocks. The sal and T of the F determined from FI in quartz veins hosted by granitic porphyry, polymetallic sulfide quartz veins, and gold-bearing quartz veins decreases from 9.5-12.5 wt% and 329-391°C, 6.6-11.2% and 300-340°C, to 5.4-10.8% and 240-380°C, respectively. The relatively high sal of the ore F suggests that it is magmatic in origin. The $\delta^{34}S$ contents of gold associated sulfides (-0.3 to +3.5‰) are within error of those of pyrite in the Mesozoic granitic intrusion (+0.2 to +4.4‰). $\delta^{18}O$ of the ore F calculated from $\delta^{18}O$ of quartz in gold-bearing quartz veins (+8.21 to +8.26‰), is also close to the $\delta^{18}O$ value of the granitic intrusion (+9.1‰). Available Pb isotopic compositions, determined from gold-related galena and K-feldspars from Mesozoic granitic intrusions and Archaean rocks, suggest the Pb was derived from the Mesozoic granitic intrusion. Available data suggest that ore-F and ore metals for gold mineralization were derived from the Mesozoic granitic intrusions. (From authors' abstract by E.R.)

RAGAN, V.M., 1996, Evidence for extensive hydrothermal events in the genesis of the Mississippi valley-type (MVT) deposits of eastern Kansas and the Tri-State zinc-lead mining district of Kansas, Missouri, and Oklahoma: Doctoral thesis at Univ. of Missouri, Kansas City, MO, USA, 169 pp.

Indexed under FI (E.R.)

RAGER, Helmut, AMTHAUER, Georg, BERNROIDER, Manfred and SCHURMANN, Kay, 1996, Colour, crystal chemistry, and mineral association of a green sphalerite from Steinperf, Dill Syncline, FRG: European J. of Mineral., v. 8, no. 5, p. 1191-1198.

Full paper for previous abstract (E.R.)

RAHMAN, A.H.A., 1996, Refining models of hydrocarbon migration and entrapment using stable isotope and fluid inclusion analysis: Case studies in carbonate reservoirs (abst.): Warta Geologi [Malaysia], v. 22, no. 2, p. 76.

Carbonate grainstone successions provide significant reservoir facies for hydrocarbons on a global scale and it is clear that their reservoir potential often depends largely on the interplay between burial cement emplacement and the arrival of hydrocarbons. Mesozoic carbonates in south England provide insights into the timing of both cementation and hydrocarbon migration that may have more general application. Bathonian carbonate grainstones in the southern UK accumulated as a set of stacked calcitic oolite shoals on a homoclinal ramp. Although they suffered early diagenesis under marine, and more significantly, meteoric conditions, later diagenetic cements such as saddle dolomite and, more particularly, mildly ferroan calcite are volumetrically more important in causing the occlusion of porosity on a regional scale. Maximum burial was achieved in the Cretaceous, the basin undergoing mid-Tertiary inversion and uplift.

We have analysed systematically the late cements employing: standard petrography (including CL and UVL); C and O isotopes; Sr isotopes and FI studies. Integration of the results of these approaches constrains both the pore-F composition and the T regime at the time of cement precipitation. Saddle dolomite was emplaced before the mildly ferroan calcite and at T between 75 and 85°C and from highly saline brines (18-19.5 wt.% NaCl eq.). Five types of FI have been recognised: (1) monophase aq (L); (2) monophase oil (L); (3) two-phase aq (L-V); (4) two-phase oil (L hydrocarbon-V); (5) three-phase aq-oil (L-hydro-carbon-aq L-V). Dolomites do not contain hydrocarbon I but reflect maximum burial T and precipitation from the densest brines. Mildly ferroan calcite competed for pore spaces with hydrocarbons. Oil-filled pores did not become cemented. Mildly ferroan calcite continued to be precipitated over a wide range of falling T (and falling sal) during inversion uplift (locally in excess of 1.4 km). The Sr isotopic studies suggest that Early Jurassic shales contributed water to the brine system in the basin. These same shales are the main source rocks for hydrocarbons.

Fluorescence responses of hydrocarbon I show that oil was migrating as a distinct phase during cementation of the reservoirs. Fluorescence response identifies a regional trend in source rock maturity with an increase in maturity occurring toward the basin centre. Application of these techniques to other basins could help to refine maturation, migration and porosity modelling. (Author's abstract)

RAJESH, H.M. and SANTOSH, M., 1996, Fluorapatite from alkaline pegmatites of the Kerala Khondalite Belt: a petrologic and fluid inclusion study: J. Geological Soc. of India, v. 48 (1996) p. 637-646. Authors at Centre for Earth Sci. Studies, PB 7250, Akkulam, Thuruvikkal Post, Trivandrum - 695-031.

We report the occurrence of P apatite crystals in association with graphite within alkaline pegmatite dykes in the Kerala Khondalite Belt (KKB). Petrologic and X-ray diffraction studies identify the mineral to be fluorapatite. FI studies show that the fluorapatites contain abundant CO_2-rich I with densities in the range of 0.85-0.72 gcm^{-3}. A subsequent generation of trail-bound CO_2-H_2O I with low sal were entrapped along hydraulic cracks. The abundance of CO_2-rich I, and the intimate association of fluorapatite with F-precipitated graphite suggest that the pegmatite dykes hosting fluorapatite were rich in CO_2-dominated F. We indentify that among the magmatic conduits proposed for the transfer of CO_2-rich F in granulite processes in the KKB, the fluorapatite and graphite bearing pegmatites reported in this study form important examples. (Authors' abstract)

RAKOTONDRAZAFY, M.A.F., MOINE, B. and **CUNEY, M.**, 1996, Mode of formation of hibonite ($CaAl_{12}O_{19}$) within the U-Th skarns from the granulites of southeast Madagascar: Contrib. to Mineral. and Petrol., v. 123, no. 2, p. 190-201.

Indexed under FI (E.R.)

RAMANA MURTHY, K.V., SHOBHITA, K., GORIKHAN, R.A. and BHATTACHARYA, A.K., 1993, A note on fluid inclusion study of quartz from uraniferous migmatites from Sirsoti area, Sonbhadra District, Uttar Pradesh, India: J. of Atomic Mineral Sci., v. 1, 1993, p. 33-39. First author at Atomic Minerals Div., Dept. of Atomic Energy, Hyderabad-500 016.

FI study has been carried out on quartz from uraniferous migmatitic rocks of Sirsoti area of Sonbhadra District, Uttar Pradesh. The FI in quartz are of two types viz. (i) H_2O L + V and (ii) H_2O L + CO_2 L + CO_2 G. Th of H_2O L + V type I indicate that the T of formation varied between 150-350°C. Tm ice indicate that the hydrothermal solutions were CO_2-bearing with a sal of 6-8% eNaCl. A common range of Th for both L-rich as well as V-rich I provides evidence for the boiling of the ore F. (Authors' abstract)

RAND, S.W., 1988, The geology and mineralisation of the Mt. Charter prospect: Bachelor of Science thesis, Univ. of Tasmania, 96 pp and appendices.

The Mt. Charter barite prospect occurs in Cambrian rhyodacitic to dacitic lavas, lava breccias and volcaniclastics. Hydrothermal alteration has variably affected the volcanic rocks. Strong sericite - pyrite - silica alteration occurs in a 'central core' beneath the barite outcrop, surrounded by carbonate and chlorite alteration. Mineralisation within the 'central core' comprises common barite and pyrite in veins and disseminations. Ore minerals include pyrite, sphalerite, tennantite, galena and minor chalcopyrite. Trace minerals occurring include gold as electrum, tetrahedrite and proustite. Sulphur isotope studies indicate that seawater was a significant component of mineralising F. P FI in barite from the 'central core' indicate that the F were low T (< ≈ 250°C). (From author's abstract by E.R.)

The most important conclusion to be gained from this study is that P FI can be recognised within the barite. A T of ≈ 245°C for the original hydrothermal F can still be determined despite the effects of metamorphism. The presence of P I which differ markedly from seawater (zero chloride content) is problematical and has important implications for the source of the F and their metal transporting capacity. (From author's text by E.R.)

RAO, U., FEHN, U., TENG, R.T.D., and **GOFF, F.,** 1996, Sources of chloride in hydrothermal fluids from the Valles caldera, New Mexico: a ^{36}Cl study: J. of Volcanol. and Geothermal Research, v. 72 (1996) p. 59-70. First author at Dept. of Earth and Environmental Sci., Univ. of Rochester, Rochester, NY 14627.

$^{36}Cl / Cl$ ratios were measured in waters from high-T drill holes and from surface springs in this region. The results suggest that brines are meteoric waters which penetrated into the basement where they derive chloride from leaching of basement rocks and/or from saline pore F trapped there, along with likely addition of chloride from Paleozoic strata. Although these F have since come to reside in the intracaldera volcanic sequence after convective upwelling, they do not derive much Cl^- from the volcanic strata; and residence times of F in the volcanics are < 100,000 years. (From authors' abstract by E.R.)

RED'KO, L.R. and **NAOUMKO, I.M.,** 1996, Fluid inclusions in quartz of granitic pegmatites from basic rocks, north-western region of the Ukrainian Shield (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 488. Authors at Inst. of Geol. and Geochem. of Combustible Minerals of the Ukrainian Nat'l. Acad. of Sci., Lviv, Ukraine.

The felsic pegmatites within rocks of basic composition are widespread in the north-western region of the Ukrainian Shield. Golovinskiy Massif. PFI are found in quartz crystals from pegmatites that occur within anorthosites and gabbro-labradorites. FI include 1) multiphase ones with dm occurring as individual groups in crystal matrix without visible relations to filled fractures suggesting their P (early-secondary?) nature, phase ratios and compositions are rather variable, Th 420-450°C L, and 2) tube-like FI situated immediately close to crystal surface, predominantly two-phase diverse-filled FI of CO_2 (from 81 L_1 + 19 G to 7.5 L_1 + 92.5 G), rarely complex of type L + L_1 + G, Th CO_2 (15 L_1 + 85 G) - 24.9°C G. Other types of FI also [exist]. As a whole concentration of FI solutions change from 4 to 23 wt.% of NaCl. Kirov-Kocherivska structure-metallogenic zone. In quartz from pegmatite veins early-secondary V-L FI predominate having almost constant filling, with form close to negative crystals and composition of 60-65 L + 35-30 G, Th = 260-280°C L, rarely 340-350°C L (if insoluble up to T-380°C solid phases present).

In both cases content of CO_2 (vol.%) in FI increase from early to late units: pegmatite of graphic structure (59.1) ->internal crystal zone (84.4) -> external crystal zone (93.1) or of graphic (50.0) -> pegmatoid (87.2) -> micro-block-structure (91.5) pegmatite.

Conclusions:

1. Quartz of pegmatites in basic rocks were formed in unstable environments, preferentially under F heterogenization when the T decreased and F concentration increased.
2. The T and geochemical parameters of post-magmatic stage of vein-type felsic pegmatites in basic rocks development in general are close to those in felsic rocks.
3. The similarity of mineral-forming F regime most readily prominent [is] in carbon dioxide behavior (Naoumov et al, 1972). Its concentration [and?] stability permits the conclusion that the most important controlling influence in the regulation of the mineral-forming medium pH also has been played by CO_2.
4. The latter fact could facilitate the geochemical methods for searching and evaluations of the granite pegmatite fields within basic rocks based on investigations of numerical distribution of CO_2 variability in the inclusions of mineral-forming F. (From authors' abstract by E.R.)

REED, M.H., 1996, Geochemical control of epithermal ore fluid composition by alteration mineral equilibria and mineral-buffered dilution (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A19. Author at Dept. of Geological Sci., Univ. of Oregon, Eugene, OR 97403; e-mail (mhreed@oregon.uoregon.edu)

Among the three principal epithermal ore types, the genetic distinction between two of them, vein Pb-Zn-Cu-Ag-Au (e.g. Creede, Comstock), and adularia-silica-Au (e.g. Sleeper, Hishikari), depends on F sal., pH and sulfide concentration. Published FI data and compositions of active geothermal systems show that the vein base metal-Ag-Au ores precipitate from saline F (e.g. 1-8 wt.% NaCl) whereas the adularia-silica-Ag-Au ores generally form from more dilute F, although some gold-rich ores apparently precipitate from moderately saline F with large sulfide concentration. The genetic significance of these differences is addressed using heterogeneous equilibrium calculations with program CHILLER. (From author's abstract by H.E.B.)

REN, Bingchen, 1996, Discussion on the mantle fluid mineralization in metasomatism of crust and mantle: A Baiyinchang Cu-polymetallic deposit: Acta Geoscientia Sinica–Bull. of the Chinese Acad. of Geol. Sci. (Diqiu Xuebao), v. 17 (1996) p. 57-63 (in Chinese; Engl. abst.)

In this paper, it is considered that the Baiyinchang ore field is formed in a structural setting of paleorifting that cuts the sial on the basis of deep-seated structure, volcanic formation and bimodal volcanism with basic and calk-alkalic, intermediate as well as acidic volcanic rocks, among them, two times of mineralization events in Xiaotieshan, Tongchanggou and so on ore deposits; together with Zheyaoshan, Huoyanshan ore deposits are contemporaneous with the bimodal volcanic activity, that is to say, ore-forming process is spatiotemporally consistent with acidic volcanic rocks. Composition of CO_2 FI in ore is consistent with those of upper mantle, except that H_2O

is higher in content. Ore is characterized by rich large ion lithophile element and by bearing the assemblage of mineralization alteration rich in Mg and K. S and Pb derives from lower crust or from upper mantle. Sr isotope initial values of exhalation silicalite show that ore-forming materials originated from an imhomogeneous mantle. S/Se, Co/Ni and Se/Te imply that ore-forming materials come from deep-seated as well.

In this paper, it is set out that the ore deposit formed in a strong extensional rifting, which made away with the volatile component, from deep-seated mantle due to extending of rift. Mantle released plenty of CO_2, containing metallic elements, together with basic magma of upper mantle, was intruded upwards in crust, thus resulted in melting of lower crust to form acidic magma. In the meanwhile, hot brine rich in volatile component and metallic element, being high in sal, upswings along the rift, and then flows into sea floor to form ore deposit. (Author's abstract)

REN, Qijng, XU, Wenyi, LU, Xiancai, LIU, Hongying, and SUN, Xiaomin, 1996, Genesis of the super-large porphyry molybdenum deposit at Jinduicheng, Central China (abst.): 30th Int'l Geol. Con., Abstracts, v. 2, p. 789. Authors at Dept. of Earth Sci., Nanjing Univ., China.

The super-large Jinduicheng molybdenum deposit is associated with a Mesozoic granite porphyry. The hydrothermal ore-forming system is characterised by high content of CO_2. The average P ranges from 124 to 418 bar and fluctuated between hydrostatic and lithostatic P. The highest P was reached during the major ore-forming stage. The average T ranges from 142.5 to 276.4°C. The ore-forming T could be ascribed to the enrollment of plenty of relatively cool meteoric water. The sal of mineralizing solutions manifests bimodal distribution pattern with two ranges from 28 to 41 and from 1.9 to 15 wt% NaCl eq., indicating that magmatic F is also one of the major constituents. Oxygen, hydrogen and sulphur isotope data lean towards the same conclusion. Compared with the Henderson deposit, mineralizations at Jinduicheng are characterised by the following facts . . . (4) The hydrothermal ore-forming system had relatively low T and sal. (5) Meteoric water played a more important part during ore-forming process. (6) V-rich FI are absent in quartz veins and no evidence for boiling is found in the hydrothermal system. (7) Very high CO_2 contents in ore-solution and abundant type IV FI in vein-quartz indicate that F immiscibility may have contributed to the formation of molybdenite deposit at Jinduicheng. (From authors' abstract by E.R.)

RENMIN, Hua, PEIHONG, Wu, and KERONG, Chen, 1996, A discussion on the origin of ore F of the Yinshan polymetallic deposit, Jiangxi, China: Geological J. of Universities, v. 1, no. 2 (1996) p. 37 [in Chinese; Engl. abs.]. Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing 210093.

On the basis of geological and geochemical characteristics of the Yinshan polymetallic deposit, Jiangxi province, and from the view point 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. Oxygen isotope compositions of altered rocks and F (FI) 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 down going meteoric water and phyllitic wall rocks which 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)

RÉQUIA, K.C.M., XAVIER, R. P. and FIGUEIREDO, Bernardino, 1995, Textural and paragenetic evolution of the fluid phases in the Salobo polymetallic deposit, province Mineral de Carajás, Pará (Brazil): Bol. Mus. Para. Emílio Goeldi, sér. Ciênc. da Terra, v. 7, 1995, p. 27-39 (in Brazilian Portugese; Engl. abst.). First author at Université de Genève, Département de Minéralogie, 13, Rue de Maraîchers, 1211 Genève 4 Switzerland.

The Salobo polymetallic ore deposit, Pará, consists of a P Cu (Au, Ag, Mo) mineralization, hosted by Archean iron formations. The Cu mineralization is mostly formed by bornite-chalcopyrite and bornite-calcosite [chalcocite] disseminations, in association with magnetite-rich levels. During the tectonic-metamorphic evolution of the deposit, under high amphibolite facies conditions, the sulfide assemblage was probably represented by a Cu-rich cubic solid solution (i.s.s.). At retrograde amphibolite facies conditions, the i.s.s. originated the bornite solid solution and the tetragonal chalcopyrite. The evolution of the bornite solid solution to bornite and calcosite occurred at the greenschist facies retrograde event. FI studies showed that two types of FI occur in the Salobo ore deposit: monophase carbonic I ($CH_4 < 10$ mol%) and aq I, subdivided into highly saline aq I (34.9 - 52.1 wt.% NaCl eq.) and low to moderate saline aq I (1.2 - 21.1 wt.% NaCl eq.). The carbonic F are interpreted as F generated or re-equilibrated under high amphibolite facies conditions. The saline aq F, present during the amphibolite and greenschist facies retrograde events, are probably related to the metamorphic-hydrothermal alterations or syn- to late-tectonic granites in the study area (e.g. Salobo Velho granite) and seem to be responsible for both Cu and Au remobilization. The isochores corresponding to the saline aq 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, consistent with T around 350°C indicated by the compositional characteristics of Au. (Authors' abstract)

See also FIR, v. 28, p. 137 (E.R.)

REZAEE, M.R. and TINGATE, P.R., 1996, Precipitation temperatures and origin of quartz cement and its influence on the Tirrawarra Sandstone reservoir quality, southern Cooper Basin, South Australia: Geological. Soc. of Australia Abstracts, v. 41, p. 362.

Indexed under FI (E.R.)

RICHARD, Denis, MARTY, Bernard, CHAUSSIDON, Marc, and ARNDT, Nicholas, 1996, Helium isotopic evidence for a lower mantle component in depleted Archean komatiite: Science, v. 273 (1996) p. 93-95. First author at CNRS, Centre de Recherches Petrographiques et Geochimiques, Rue Notre-Dame des Pauvres, B.P. 20, 54501 Vandoeuvre Cedex.

Archean magnesium-rich komatites require hot and presumably deep mantle sources, but their trace-element composition and radiogenic isotope composition are similar to those of modern mid-ocean ridge basalts, which originate in the upper mantle. The isotopic composition of helium extracted by sequential crushing of fresh olivines separated from two Archean and one mid-Proterozoic komatiites varies over three orders of magnitude, between a radiogenic end-member rich in helium-4 and a component rich in helium-3. Such helium-3 enrichment suggests the presence of a lower mantle component in Archean komatiites. (Authors' abstract)

Includes discussion of S FI (footnote 14) and also analysis of a MI for K and U. (footnote 15) (E.R.)

RIDLEY, J.R. and HAGEMANN, S.G., 1996, Fluid inclusions in Archean high-temperature gold deposits: Can we evaluate post-entrapment modification? (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 104-106. First author at Inst. for Isotope Geol. and Mineral Resources, ETH, Zürich, CH 8092, Switzerland.

FI studies of syn-metamorphic lode- and vein-style gold deposits in greenschist-facies terrains have shown the importance in these hydrothermal systems of a low-sal, H_2O–CO_2 ($X_{CO_2} \approx 0.1$–0.2) F, with in some instances minor CH_4 (Ho et al., 1985; Gebre-Mariam et al., 1995). Vein and proximal hydrothermal alteration assemblages equilibrated at the T, X_{CO_2} and f_{O_2} of this F, confirming its dominance of the system chemical evolution.

In the Archean Yilgarn Block of Western Australia, a number of syn-metamorphic lode- and vein-type gold deposits occur in amphibolite and lower-granulite facies terrains. Formation conditions for these deposits are estimated to range between 450 and 700°C at 3 to 5 kbar (for details see Groves et al., 1995). That these high-T deposits are genetically related to those in greenschist-facies terrains is indicated by their closely similar timing, structural controls on siting, and ore and alteration chemistry. Ore and alteration assemblages poorly constrain X_{CO_2} to within the broad range of $0.05 < X_{CO_2} < 0.5$, but importantly indicate a value of f_{O_2} such that CO_2 would be the dominant carbonic phase in the F.

At each deposit investigated, three or four types of FI are present in vein quartz and clinopyroxene (this study; Bloem and Brown, 1991; Ridley et al., 1995).

Isochores for type (i) and type (iv) inclusions project generally to slightly too high P whereas those for type (ii) I project with T to P as little as a half those inferred for mineralisation on petrological grounds, with generally lower P for CH_4-richer I.

At face value, the F-I record thus indicates a complex hydrothermal history, with F trapped under very variable conditions, with very variable H_2O:CO_2:CH_4 ratios, and also with f_{O_2} generally significantly lower than would be in equilibrium with the alteration and ore assemblages. Large variations in F P during trapping are considered unlikely given the high T of mineralisation.

There is, however, a general trend that FI populations have less variable compositions, and their compositions and densities are closer to those predicted from alteration petrology in deposits formed at lower-amphibolite facies conditions than those formed at higher T. This suggests T-dependent compositional, and also potentially mechanical, re-equilibration with ambient conditions after entrapment. Three processes of I re-equilibration have been suggested recently on theoretical grounds and from the results of experiments on synthetic FI: hydrogen diffusion (e.g. Hall and Bodnar, 1990); wicking of water, most likely through diffusion (Qiu et al., 1992), and mechanical re-equilibration of I to ambient P changes (e.g. Vityk and Bodnar, 1995).

If combinations of the above three re-equilibration mechanisms operated, post-entrapment re-equilibration of an initially near uniform population is an allowable explanation of the variability of I composition and molar volume. (From authors' abstract by E.R.)

RITTER, Ulrich, DUDDY, Ian, MORK, Atle, JOHANSEN, Harald and ARNE, Dennis, 1996, Temperature and uplift history of Bjornoya (Bear Island), Barents Sea: Petrol. Geosci., v. 2, no. 2, p. 133-144.

Indexed under FI (E.R.)

ROBB, L.J., 1996, The Witwatersrand gold-uranium deposits (abst.): Geological Soc. of Australia Abstracts, v. 41, p. 367.

Indexed under FI (E.R.)

ROBERTS, Sheila, SPENCER, Ron and YANG, Wenbo, 1996, Climatic response in Death Valley, California, during glacial termination II. First author at Environmental Sci. Dept., Western Montana College of the Univ. of Montana, Dillon, Montana.

A core from Death Valley, California, USA, provides new evidence that the climatic response to a global transition from glacial stage 6 to interglacial stage 5 (Termination II) in this continental desert region does not readily fit global models. Th of FI in P halite from the lower half of the 186 m core indicate that maximum summer T were generally about 10 to 18°C cooler during a long saline lacustrine interval (186 ka to 120 ka) than they are today. The presence of halite pseudomorphs after hydro-halite (stable only below 1°C) suggests similarly colder winter T. Nearly 15 m of rhythmically bedded P halite preserve a T record from about 128 to 120 ka. Data indicate cold T throughout this interval, which marks the desiccation of the lake. In contrast to other climate records that use stable isotopes as proxies for T, we do not see a rise in T in this interval, which correlates with Termination II (stage 5e). (From authors' abstract by E.R.)

ROBINSON, J.P., 1995, Structurally-controlled, igneous-hosted, disseminated Au mineralization near Nelson, Nevada (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A68.

FI and isotopic data indicate that mineralization occurred in meteoric F at T near 100°C. This contrasts with many detachment-associated precious metal deposits in the region that commonly formed from ascending hydrothermal F at T>150-300°C. (From author's abstract by H.E.B.)

ROBINSON, J.P., 1996, Structurally-controlled, igneous-hosted, disseminated Au mineralization near Nelson, Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 567-579. Author at 476 East South Temple, Suite 166, Salt Lake City, UT 84111.

A disseminated gold deposit contains anomalous gold primarily in the Nelson monzonite. FI and isotopic data indicate that mineralization occurred in meteoric F at T near 100°C. The shallow level of mineralization of this deposit distinguishes it from many detachment-associated precious metal deposits in the region.

Propylitic alteration is widespread throughout the host rocks. Gold mineralization appears to be associated with an event of quartz-calcite veining that is younger than the propylitic alteration. Anomalous gold also occurs in zones of local silicification, argillic alteration, and quartz-alunite veining. (From author's abstract by E.R.)

ROCHOLL, A., HEUSSER, E., KIRSTEN, T., OEHM, J. and **RICHTER, H., 1996,** A noble gas profile across a Hawaiian mantle xenolith: coexisting accidental and cognate noble gases derived from the lithospheric and asthenospheric mantle beneath Oahu: Geoch. Cosm. Acta, v. 60, no. 23 (1996) p. 4773-4783. Authors at Max-Planck-Inst. für Kernphysik, Saupfercheckweg 1, 69120 Heidelberg, Germany.

A noble G profile across a garnet pyroxenite xenolith from Salt Lake Crater, Oahu, Hawaii, provides information about the scale and origin of noble G heterogeneities within such rocks. Variations in both absolute and relative noble G concentrations are large and comparable to those observed between individual Salt Lake Crater pyroxenite xenoliths. Overall, the observed noble G compositions reflect a derivation from depleted MORB-type mantle sources.

The spatial distribution of noble G signatures within the xenolith and the observed correlation between helium and argon isotopes suggest the presence of two different noble G components which are trapped in different phases and are unevenly distributed within the xenolith. ^{40}Ar / ^{36}Ar and 1 / ^{36}Ar correlate inversely, indicating that atmospheric contamination is insignificant. Hence, the observed isotopic variations reflect mixing of two mantle-derived noble G components. Correlations between He-Ar isotopes and CO_2 / H_2O in different pyroxenites from Salt Lake Crater, including our sample, reveal that the first component is characterized by highly radiogenic helium and argon isotopes and related to abundant secondary CO_2-rich FI. Given the high diffusivity of He at mantle temperatures (Hart, 1984), the observed helium isotope heterogeneities on a sub-mm scale require that the F were introduced concurrently with eruption. This interpretation is supported by the low entrapment depths of FI in Salt Lake Crater pyroxenites (<30 km; Murck et al., 1978). This implies that the F are genetically related to the host magma itself and reflect its composition. The second noble G component is interpreted as being magmatic, i.e., cognate to the basaltic magma from which the pyroxenite precipitated within the mantle. It is proposed that this component resides inside the mineral lattices and was trapped during magmatic crystallization. (From authors' abstract by E.R.)

ROEDDER, Edwin, 1996, Modern techniques of fluid inclusion studies–9th CMR lectureship: Center for Mineral Resources Research, Korea Univ., Seoul, Korea, 111 pp.

A series of six review lectures, covering (or reprinting) recent published studies by the author. (E.R.)

ROEDDER, E., WHELAN, J.P. and **VANIMAN, D.T.,** 1994, Fluid inclusion studies of calcite veins from Yucca Mountain, Nevada, tuffs: Environment of formation: International High Level Radioactive Waste Management Proceedings, American Society of Civil Engineers and American Nuclear Society, Fifth International Conference, Las Vegas, Nevada, p. 1854-1860.

Calcite vein and vug fillings at four depths (130-314 m), all above the present water table in USW G-1 bore hole at Yucca Mountain, Nevada, contain P FI with variable V/L ratios: most of these I are either full of L or full of V.

The L-filled I show that most of the host calcite crystallized from F at <100°C. The V-filled I provide evidence that a separate V phase was present in the F during crystallization. Studies of these V-filled I on the microscope crushing stage were interpreted in an earlier paper as indicating trapping of an air-water-CO_2 V phase at "<100°C". Our new studies reveal the additional presence of major methane in the V-filled I, indicating even lower Tt, perhaps at near-surface T. They also show that the host calcite crystals grew from a flowing film of water on the walls of fractures open to the atmosphere, the V-filled I representing bubbles that exsolved from this film onto the crystal surface. (Authors' abstract)

ROELOFSEN, J.N. and **MARTIN, R.F.,** 1996, Arfvedsonitic amphibole from the Strange Lake peralkaline complex, Quebec-Labrador Border: Origin and relationship to mineralization (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A80. Authors at Dept. of Earth and Planetary Sci., McGill Univ., Montreal, Quebec, H3A 2A7.

Variations in composition of the arfvedsonitic amphibole in units of peralkaline granite of the Strange Lake complex on the Quebec-Labrador border have a direct relationship to the nature of the ore minerals in the associated Zr, Y, REE, Nb, Be deposit. The mafic minerals, predominantly arfvedsonitic amphibole (with up to 0.4 wt.% Li_2O and 2.9 wt.% F), but with minor and variable amounts of aegirine, comprise 7 to 15 vol.% of the various units. Our results, combined with published FI studies, indicate replacement of arfvedsonitic amphibole by aegirine above 350°C, followed by Ca-metasomatism below 200°C. The breakdown reactions involving P arfvedsonitic amphibole are significant in the development of mineralization in the Strange Lake complex and, by implication, in other peralkaline felsic complexes. (From authors' abstract by H.E.B.)

ROGGENSACK, Kurt, WILLIAMS, S.N., SCHAEFER, S.J. and **PARNELL, Jr., R.A.,** 1996, Volatiles from the 1994 eruptions of Rabaul: understanding large caldera systems: Science, v. 273 (1996) p. 490-493. First author at Dept. of Geol., Box 871404, Arizona State Univ., Tempe, AZ 85287-1404.

The 1994 eruption of Rabaul, in Papua New Guinea, involved a small plinian eruption at Vulcan and a vulcanian eruption on the opposite side of the caldera at Tavurvur. Vulcan's ash leachates indicate seawater interaction that is consistent with earlier obervations of low sulfur dioxide emissions and the presence of ice crystals in the initial plinian eruption cloud. In contrast, Tavurvur ash leachates indicate no seawater interaction, and later sulfur dioxide emissions remained high despite low-level eruptive activity. Silicic M I indicate that the andesitic M contained about 2 wt% water and negligible carbon dioxide. Mafic M I in Tavurvur ash have water and carbon dioxide contents that vary systematically over the course of the eruption. The mafic M I suggest that a mafic dike intruded from below the silicic chamber and provide further evidence that mafic intrusions drive caldera unrest. (Authors' abstract)

ROMANO, Claudia, LECHTENBERG, Frank and **DINGWELL, Donald,** 1996, Synchrotron X-ray fluorescence analyses of gas bubbles in glass (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F803, November 12, 1996. First author at Bayerisches Geoinstitut, Univ. Bayreuth, Bayreuth, 95440 Germany; e-mail (claudia.romano@uni-bayreuth.de)

The origin of included bubbles, the physics of their incorporation and the simulation of their transport through the M has received considerable attention in the geosciences, because of the importance of the transport of volatile phases under P for volcanic processes. Methods for the detection of bubbles, identification of their contents and the determination of chemical partitioning between them and their host glasses are thus important goals. Here we prsent the first results of a synchrotron-based investigation of the contents of G and V bubbles trapped in glass M under conditions of elevated T and P. The I-bearing glass samples were analysed in SYXRF facility at Hasylab beamline L with white line excitation from a bending magnet source at the storage ring DORIS-III. The synchrotron-based XRF (SYXRF) method is non-destructive and does not result in significant heating of the sample. Additionally, the possibility exists of mapping the distribution of solid, L and gaseous phases in more complex multiphase I in glasses. (From authors' abstract by E.R.)

ROMANO, C., MUNGALL, J.E., SHARP, T. and **DINGWELL, D.B.,** 1996, Tensile strengths of hydrous vesicular glasses: An experimental study: American Mineralogist, v. 81 (1996) p. 1148-1154. Authors at Bayerisches Geoinstitut, Univ. Bayreuth, D-95440 Bayreuth, Germany

We have measured the pressures of decrepitation of vesicles in synthetic glasses of feldspar compositions ($NaAlSi_3O_8$ - $KAlSi_3O_8$). Vesicles filled with Xe do not decrepitate at internal pressures of 160 MPa, indicating that the unflawed surface of the vesicle wall has an intrinsic strength >80 MPa. Vesicles containing CO_2 escaped decrepitation and displayed ductile deformation when the T_g was reached at the maximum P of 200 MPa (indicating an intrinsic strength higher than 100 MPa). Vesicles containing H_2O showed dramatically reduced strength, decrepitating at internal P on the order of 1-5 MPa. The H_2O-filled vesicles leaked slowly over periods of several weeks or months. The relative stability of the inclusions is strongly dependent on the quench rate, with rapidly quenched inclusions showing greater stability over long periods of time. Microscopic examination revealed the presence of radial microfractures in the walls of H_2O-filled vesicles. We account for the microfracturing with reference to recent studies of chemical-gradient stress. Our observations may account for a variety of phenomena, which occur wherever hydrous vesicular glasses are formed, including explosive decompression of vesicular glassy rock in near-surface volcanic environments, spontaneous decrepitation of vesicular basaltic glass dredged from the seafloor ("popping rocks"), and rapid loss of H_2O from synthetic vesicular glasses produced in laboratory experiments investigating F-M phase equilibria. (Authors' abstract)

RONA, P.W. and **VON HERZEN, R.P.,** 1996, Introduction to special section on measurements and monitoring at the TAG hydrothermal field, Mid-Atlantic Ridge 26°N, 45°W: Geophy. Research Lett., v. 23, no. 23 (1996) p. 3427-3430. First author at Inst. of Marine and Coastal Sci. and Dept. of Geological Sci., Rutgers Univ., New Brunswick, NJ.

RONCHI, L.H., TOURAY, J.C., and **DARDENNE, M.A.,** 1996, Evolution of two similar stratabound fluorite ore deposits in the Ribeira Valley, southern Brazil: Explor. Mining Geol., v. 5, no. 3 (1996) p. 231-240. First author at Univ. do Vale do Rio dos Sinos–UNISINOS, Dept. de Geologia, Caixa Postal 275, 93.022-000 São Leopoldo-RS, Brazil.

Mato Dentro and Sete Barras are two stratabound fluorite ore deposits that show contrasting ore types: a microcrystalline facies predominates at Mato Dentro, while macrocrystalline ore is the most common type at Sete Barras. The Mato Dentro ore results from replacement of marble and collapse breccias, whereas the Sete Barras ore represents recrystallization and/or remobilization of pre-existing ore. Sr and Nd isotopic data suggest a crustal source for the fluorite ore. FI results indicate that the mineralizing F at Mato Dentro differed significantly from that at Sete Barras. At each deposit, however, ore types with different textures (macro- and microcrystalline) have similar REE patterns and contain the same type of FI, probably due to complete recrystallization and/or remobilization of fluorite by one main F type (at each deposit). A complex hydrothermal history from late Proterozoic to Mesozoic is recorded by these two fluorite deposits. Initial fluorite deposition in the Ribeira district occurred in the late Proterozoic, in response to F circulation related to granitoids of the Brasiliano cycle (450 Ma to 750 Ma). (Authors' abstract)

ROSE, T.P. and **DAVISSON, M.L.,** 1996, Radiocarbon in hydrologic systems containing dissolved magmatic carbon dioxide: Science, v. 273 (1996) p. 1367-xxxx. Authors at Isotope Sci. Div., L-231, Lawrence Livermore National Laboratory, Livermore, CA 94550.

ROSENBAUM, J.M., ZINDLER, Alan, and **RUBENSTONE, J.L.,** 1996, Mantle fluids: evidence from fluid inclusions: Geoch. Cosm. Acta., v 60, no. 17 (1996) p. 3229-3252. Authors at Lamont-Doherty Earth Observatory and Dept. of Geological Sci. of Columbia Univ., Palisades, NY 10964.

A total dissolution technique has been developed and used to identify and quantify the incompatible element contents of F trapped in I in minerals from peridotite xenoliths using "fluids" in the generic sense (i.e., C-O-H fluids and melts). F from lherzolites, a wehrlite, and a harzburgite host important quantities of alkalis, Ba, U., Th, Pb, and contain Sr and Nd as well. Quantitative application of the technique shows that the CO_2-rich F in a lherzolite from Nunivak Island, AK USA and the CO_2-poor M in a lherzolite from San Carlos, AZ, USA, have incompatible element compositions similar to each other differing only in their K and Ba contents. With the exception of their K contents, the trace element compositions of these F resemble those of carbonatites and kimberlites. Major and radiogenic isotope data from the lherzolite and a phlogopite harzburgite from Nunivak suggest that the F trapped in the lherzolite is associated with a carbonatite M, linked to hydrous metasomatism in the region. A more dilute CO_2-bearing M was identified in a wehrlite from Salt Lake Crater, HI, USA resembling Hawaiian alkali basalt in its incompatible element composition. The strontium, neodymium, and lead isotope composition of the fluids resemble those of the surrounding mantle and do not reflect their parent/daughter ratios. Lead isotope data for F-bearing clinopyroxene in the wehrlite suggest F influx was recent. Conventional and laser oxygen isotope analyses show that most FI-bearing xenoliths examined are out of oxygen isotope equilibrium. Diffusion-based arguments suggest that F infiltration in these xenoliths occurred over the last 1-10 My. The F identified in this study will dominate the incompatible element budget of typical mantle peridotite if presented in greater than sub-weight percent quantities. (Authors' abstract)

ROWAN, E.L. and **GOLDHABER, M.B.,** 1996, Fluid inclusions and biomarkers in the Upper Mississippi Valley zinc-lead district; implications for the fluid-flow and thermal history of the Illinois Basin: U.S. Geological Survey Bulletin, B 2094-F, p. F1-F34.

A combination of data and calculations from the traditionally separate disciplines of hydrology, petroleum geology, and economic geology is used to provide insight into the thermal and hydrologic history of the Illinois Basin and adjacent areas. Thermal considerations, the timing of fluorite mineralization in southern Illinois, and the northward-decreasing pattern of fluorine enrichment in sediments are used to show that the principal flow direction was northward through the Cambrian and Ordovician aquifers of the Illinois Basin. This basin-scale flow system resulted in mass transport and energy transport that in turn drove chemical reactions within the Illinois Basin and at its margins. (Authors' abstract)

ROWAN, E.L., HATCH, J.R. and **GOLDHABER, M.B.**, 1996, Constraints on the thermal and burial history of the Illinois basin from fluid inclusions and thermal maturity of organic matter (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A387. First author at U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025; e-mail (erowan@octopus.wr.usgs.gov)

Measurements of thermal maturity in the Illinois basin using coal vitrinite reflectance and biomarkers significantly exceed values that can be accounted for by present day burial depths. An interval of additional sedimentary section, now removed by erosion, has long been suggested to account for the discrepancy. While deep burial could indeed account for the observed maturity levels of organic matter, FI T provide a stringent additional constraint on the thermal and burial history of the basin. On the northwestern margin of the Illinois basin T of FI hosted by sphalerite veinlets filling cleats in Pennsylvanian coals range from 75-113°C; at the basin's northern margin in the Ordovician-hosted sphalerite ore of the Upper Mississippi Valley (UMV) district, FI T are predominantly in the range 90-140°C. The UMV ores and the coal cleat hosted sphalerites very likely formed during the same hydrogeologic episode.

In 2-D numerical modeling of a N-S cross-section through the basin we tested several scenarios both with and without regional F flow. To account for FI T by burial alone would require > 2.5 km of post-Pennsylvanian sedimentary section that must have been present in the Permian at the time of mineralization in the UMV district. Rapid erosion would be required to prevent the thermal maturities of coal and biomarkers from exceeding their observed values. Alternatively, the amounts and rates of post-Pennsylvanian sedimentation and erosion may have been far more modest with a significant contribution of heat from northward regional F circulation. The period of relatively high T recorded by FI and the short duration of the thermal event required by the maturity of organic matter are more easily explained by the effects of F circulation combined with burial than by burial alone. A relatively high F flow rate (m/yr) would be required by mass balanace as well as thermal considerations in forming the UMV ores. (Authors' abstract)

ROY, J. and **LAPP, J.**, 1996, A novel dual laser microprobe system for high resolution in situ sampling of rocks and minerals: applications to noble gas, stable isotope and ICP-MS analysis (abst): 30th Int'l Geog. Cong., Abstracts, v. 1., p. 482. Authors at Merchantek Inc., Carlsbad, CA 92008.

We have designed an ultra-compact frequency-quadrupled Nd:YAG laser (the uLUV) to optimize the critical parameters that determine laser microprobe performance: frequency of 266 μm in the deep UV; spot size from 3 - 200 μm, pure TEM100 mode beam; perfect Gaussian beam profile with no hot spots; UV power output to 10 mJ; extremely stable pulse-to-pulse power output, elimination of green light arising during frequency doubling; extremely small base size; and robustness. The UV laser and a specially designed CO_2 laser (MIR) have been integrated into a highly flexible, high-performance laser microprobe system, the MIR-LUV, which has extremely favorable characteristics for analysis of geological materials. In addition to the two lasers, the microprobe system includes the following modules: beam delivery, beam and sample observation, automated XYZ stage, sample chamber, mass spectrometer interface, and computer. ALL operational aspects are automated and under computer control, including laser power output, laser repetition rate, focus of laser beam, sample illumination, and sample positioning. Because of the modular design of the system, it is possible to configure a microprobe for very specific needs, including access to other wavelengths from the Nd:YAG (primary or doubled), integration of a polarizing microscope, integration of a FI stage, placement of the laser onto the translation stage to allow immobilization of the sample chamber, and choice of an appropriate sample chamber. Initial applications of the MIR-LUV laser microprobe are evenly divided between noble G, stable isotope, and elemental analysis. Noble G applications have focused on argon release from mineral grains for ^{40}Ar - ^{39}Ar studies. Stable isotope applications include in situ decarbonation of carbonates and phosphates, oxidation of organic material, and fluorination of silicates. Elemental and isotopic analysis is accomplished by using the system to produce a monodisperse unfractionated aerosol that is introduced into the ICP torch of an ICP-MS. (From authors' abstract by E.R.)

RUBIN, J.N., 1996, Skarn formation and ore deposition at the Gunung Bijih Timur (Ertsberg East) Complex, Irian Jaya, Indonesia: Doctoral thesis at Univ. of Texas, Austin, TX, US. 311 pp.

Indexed under FI (E.R.)

RUGGIERI, G., CATHELINEAU, M., BOIRON, M.C., MARIGNAC, Ch. and **GIANELLI, G.**, 1996, Fluids and P-T-X conditions related to chlorite formation in the Larderello Geothermal field (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 107-109. First author at 1-IIRG, Piaza Solferino 2, Pisa, Italy.

Preliminary FI studies on the deepest part (2500-4000 m b.g.l.) and on the shallow/intermediate levels of the Larderello system show a complex series of fluid trapping, in relation with the space-time evolution of the P-T-X in the field and the existence of several F sources.

The physico-chemical conditions have been investigated on the basis of microthermometric and Raman spectrocopy data, and chlorite crystal-chemistry.

The authors conclude that the F in the shallow part of the Larderello geothermal field have a low to moderate sal (<10 wt% NaCl eq.) suggesting a prevalently meteoric origin. Some of the I trapped small amounts of CO_2 (± CH_4 and N_2). More saline F were also found, and document more occasional F flows. A characteristic of all the samples is the evidence that boiling occurred sometimes during quartz-chlorite crystallization.

T and P of the vein formation were estimated to be in the 325-370°C range. P has probably changed with time, and P drop may have promoted boiling process (case of C2B and MV1 samples). The comparison between present-day estimated T and data from I indicate that a cooling process occurred at Monteverdi and Sasso 22 at the sampling depth. In the Capannoli 2B well in-hole T is comparable with the formation T indicating a long-lived thermal regime from the time of FI trapping. (From authors' abstract by E.R.)

RUSSELL, D.W., BAILEY, G.M., van MOORT, J.C. and COHEN, D.D., 1996, Chemical composition and paramagnetism of vein quartz from the Tasmania gold mine, Beaconsfield, northern Tasmania: Nuclear Instruments and Methods in Physics Research B, v. 109/110, 1996, p. 598-600. First author at The Don College, Watkinson Street, Devonport, TAS 7310, Australia.

Spot samples of gold bearing quartz from reefs at Beaconsfield have higher Ge, Li, As, Mn, Fe and Al contents, and lower K, S, Na and Cl than barren quartz samples. The gold bearing samples are also more paramagnetic. (Authors' abstract)

RUSSELL, D.W. and van MOORT, J.C., 1992, Mineralogy and stable isotope geochemistry of the Beaconsfield, Salisbury and Lefroy goldfields: Bull. Geol. Surv. Tasm., v. 70, p. 208-226. First author at The Don College, Devonport.

The quartz veins of the Tasmania Reef at Beaconsfield consist of auriferous microcrystalline quartz with a central core of ankerite. [Petrography shows] eight phases of vein development of the Tasmania Reef. Most of these phases have been preceded by a period of brecciation. Quartz and pyrite developing phases precede, or are simultaneous with, two gold depositing phases and are followed by chalcopyrite-sphalerite-galena-ankerite veins, annealing quartz veins, and finally 'vuggy' ankerite veins. Beaconsfield arsenopyrite geothermometry indicates that the T of formation was between 370° and 440°C. The $\delta^{34}S$ of pyrite ranges from +7 to +24.7‰ and the average $\delta^{18}O$ values of the reef quartz is 17.9 ± 0.8‰.

The Beaconsfield and Lefroy reefs are the result of precipitation from deep-seated F ascending through faults associated with the Devonian Tamar Fracture System. (From authors' abstract by E.R.)

The PhD dissertation of D.W. Russell, from Univ. of Tasmania, 1995 (335 pp) has more details, but no FI studies. (E.R.)

RUTHERFORD, M.J. and **DEVINE, J.D.**, 1996, Preeruption pressure-temperature conditions and volatiles in the 1991 dacitic magma of Mount Pinatubo, *in* Fire and Mud, C.G. Newhall & R.S. Punongbayan, eds., Philippine Inst. of Volcanol. & Seismology, p. 751-766. Authors at Dept. of Geol. Sci., Brown Univ., Providence, RI 02912.

The pumice erupted from Mounta Pinatubo June 14-15, 1991, is composed of approximately 80 to 90% white phenocryst-rich dacite and approximately 10 to 20% tan, finer grained, fragmental-looking dacite of the same bulk composition. The compositions of phenocrysts in contact with matrix glass (M) are relatively uniform. Microprobe analyses of MI trapped in plagioclase, hornblende, quartz, and cummingtonite crystals indicate that they are all volatile-rich (H_2O=5.1 to 6.4 wt.% by the difference method), high-SiO_2 rhyolite glasses similar to the matrix glass on an anhydrous basis. Ion proble analyses confirm the H_2O content of 5.5 to 6.4 wt.% for these preeruption M, and infrared spectroscopic analyses indicate that dissolved CO_2 is less than 20 ppm. The average sulfur content of the MI ranges from 55 to 77±28 ppm, which is 19 to 40 ppm in excess of the matrix glass concentration.

The preeruption magma is required to be very H_2O-rich in order to stablize cummingtonite, and to explain approximately 6.4 weight percent volatiles in the MI. The composition of the M in equilibrium with the natural phenocrysts is reproduced at approximately 200 MPa under H_2O-saturated conditions and is not reproduced at higher T, or H_2O P; it is produced in 300-MPa experiments at X_{H_2O} in the F equal to 0.7. It is concluded that the 1991 dacitic magma of Mounta Pinatubo was essentially volatile saturated with an H_2O-rich F just prior to the eruption. (From authors' abstract by E.R.)

RYABCHIKOV, I.D., 1996a, Mantle metasomatism and generation of kimberlite magmas: Geochem. International, v. 33, no. 4 (1996) p. 84-94. Author at Inst. for Geol. of Ore Deposits, Russian Acad. of Sci.

An attempt was made to test the model that is capable of explaining the extreme differentiation of REE in kimberlites and lamproites. This model presumes the formation of small fraction M in the diapir rising in sublithospheric mantle, transfer of this M into lower continental lithosphere, and second stage melting of this enriched lithospheric material. This mechanism is similar to the one proposed for the posterosional Hawaiian magmas.

The estimated M fractions at various stages of the considered complex process were used to access the behavior of CO_2, K_2O, P_2O_5, and H_2O. The balance of CO_2 during this process implies that primary kimberlite magmas are likely to be generated as carbonate-saturated M. (From author's abstract by E.R.)

RYABCHIKOV, I.D., 1996b, Diamond-bearing potential of carbonate-rich partial melts generated in the mantle (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 660. Author at Inst. for Geol. of Ore Deposits, Russia.

An attempt was made to test the model which is capable of explaining the extreme differentiation of REE in kimberlites and lamproites. This model invokes the formation of small fraction M in sublithospheric mantle, its tranfer into continental lithosphere and second-stage melting of this enriched lithospheric material.

The estimated M fractions at various stages of the considered complex process were used to access the behavior of CO_2, K_2O, P_2O_5 and H_2O. The balance of CO_2 during this process implies that P kimberlite magmas are likely to be generated as carbonate-saturated M. In this case CO_2 contents in them may approach 30 wt%. After rising to the depths with P below ca 50 kbar such M should evolve gas, and this may trigger fast transportation of the magma to the surface due to the hydraulic fracturing and crack propagation. Because in the case of relatively CaO-poor kimberlites it should happen in the depth range where diamond is still stable it may provide for its survival due to the very rapid ascent. By contrast, CaO-rich lherzolite-derived magmas will retain dissolved CO_2 until decompression well beyond the diamond stability field, and they are not likely transporting agents of this mineral. Such M may be, however, parent magmas for crustal carbonatites. (From author's abstract by E.R.)

RYABCHIKOV, I.D., SOLOVOVA, I.P., BABANSKII, A.D. and **FAUZI, Kh.**, 1996, Fluorine mobilization and bonding at magmatic and postmagmatic stages in rare-metal granites: evidence from the Homrat Akarem deposit (Egypt): Geokhimiya (1996) no. 5, p. 391-395 (in Russian, Engl. abstract). First author at Inst. for Geol. of Ore Deposits, Russian Acad. of Sci.

We studied the behavior of F at the magmatic and postmagmatic stages of rare-metal granite evolution and the possible genetic relations between rare-metal granites and fluorite mineralization by means of thermobarogeochemistry and thermodynamic calcuations based on the data for the Homrat Akarem (Egypt) rare-metal granite and vein fluorite. Topaz is shown to be stable in assemblage with quartz, microcline, and low-Ca plagioclase at T higher than 350°C, to give way to fluorite at lower T. The mineralogic peculiarity of the granite in question and our study of I in quartz and fluorite corroborate the data we obtained by calculations. (Authors' abstract)

RYCHAGOV, S.N., GLAVATSKIKH, S.F. and **SANDIMIROVA, E.I.,** 1996, Ore and silicate magnetic spherules as indicators of structure, fluid regime, and mineral-ore formation in active hydrothermal system of the Baranskii Volcano (Iturup Island): Geol. Rud. Mesto., v. 38, no. 1, p. 31-40 (in Russian).

SACHAN, H.K., 1996, Cooling history of subduction related granite from the Indus suture zone, Ladakh, India; evidence from fluid inclusions: Lithos, v. 38, no. 1-2, p. 81-92. Author at Wadia Inst. of Himalayan Geology, Dehra Dun, India.

The P-T history of the subduction related Ladakh granite in northwestern Himalaya has been recorded from silicate-M I show initial melting from 650°C-705°C. These I have compositions similar to calc-alkaline granitic magma which is supported by the trace and major element chemistry of the granite. The earliest F (75 eq. wt.% NaCl) circulated at subsolidus conditions from 625°C down to 425 °C, whereas invasion of dilute solution (<8 eq. wt.% NaCl) in the granite took place from 300°C down to 165°C. On the basis of the above observations it is inferred that the cooling history of the Ladakh granite started at 705°C and continued up to [down to?] 650°C in the range of 1.2-2.8 kbar. This, therefore, suggests a shallow emplacement of granitic magma. The hydrothermal processes involved during the cooling reveals simultaneous drop in T and P along with the introduction of dilute solution (very low saline) through microfractures. (Author's abstract)

SACHAN, H.K. and **GHOSH, S.K.,** 1996, Fluid inclusion study of the Neoproterozoic Nagthat siliciclastic sediments, NW Kumaun Lesser Himalaya: Implications to quartz cementation history: J. Geological Soc. of India, v. 47, p. 107-114. Authors at Wadia Inst. of Himalayan Geol., Dehradun - 248 001.

The FI study in quartz overgrowth in the siliciclastics of Neoproterozoic Nagthat Formation reveals that the quartz cementation took place in the range of 80°C to 130°C with a sal range of 0.82 to 9.18 wt.% NaCl. The microthermometric data, combined with petrographic and geologic evidences permitted to constrain the nature of cementing F and source of cement. The silica for quartz cementation was derived partly from both the internal source (quartz and feldspar dissolution) and external source (pore F). It can be further suggested that the quartz cementation in the lower stratigraphic level (near the Chandpur Formation) is mainly by marine water while in the upper stratigraphic level (near the Blaini Formation), meteoric water has played an important role for the same. (Authors' abstract)

SALVI, Stefano and **WILLIAMS-JONES, A.E.,** 1996, The role of hydrothermal processes in concentrating high-field strength elements in the Strange Lake Peralkaline complex, northeastern Canada: Geoch. Cosmo. Acta, v. 60, no. 11, p. 1917-1932. Authors at Dept. of Earth and Planet. Sci., McGill Univ., Montreal, QC H3A 2A7, Canada

The middle-Proterozoic peralkaline pluton at Strange Lake, Quebec/Labrador, comprises hypersolvus to subsolvus phases which are unusually enriched in Zr, Y, REEs, Nb, Be, and F, as exotic alkali and alkaline-earth silicate minerals. The highest concentrations of these elements are in subsolvus granite, which underwent intense low T (≤200°C) hydrothermal alteration involving hematization and the replacement of alkali high-field strength element (HFSE) minerals by calcic eq. This alteration is interpreted to have been caused by meteoric or formational waters. High T (≥350°C) alteration, attributed to orthomagmatic F, is evident in other parts of the subsolvus granite by the replacement of arfvedsonite by aegirine. Comparisons of the chemical compositions of fresh and altered rocks indicate that rocks subjected to high T alteration were chemically unaffected, except for depletion in Zr, Y, and HREEs. These elements were appreciably enriched in rocks that underwent low T alteration. Other elements affected by low T alteration include Ca and Mg, which were added and Na, which was removed. Available data on HFSE speciation in aq F and the chemistry of the pluton, suggest that the HFSEs were transported as fluoride complexes. If this was the case, the low T F could not have been responsible for HFSE transport, because the high concentration of Ca and low solubility of fluorite would have buffered F– activity to levels too low to permit significant complexation. We propose that HFSE mineralization and accompanying alteration were the result of mixing, in the apical parts of the pluton, of a F-rich, essentially Ca-free orthomagmatic F containing significant concentrations of HFSEs, with an externally derived meteoric-dominated F, enriched in Ca as a result of interaction with calc-silicate gneisses and gabbros. According to this interpretation, the latter F was responsible for the exchange of Ca for alkalis, mainly Na, in HFSE-rich minerals and, by sharply reducing F– activity in the mixed F through fluorite precipitation and/or increasing pH, destabilised the HFSE-fluoride complexes, causing deposition of HFSE-bearing minerals. An important implication of this study is that major HFSE enrichment may be restricted to those rare cases where F-rich, Ca-free, metal leaching environments and Ca-rich depositional environments are juxtaposed. (From authors' abstract by E.R.)

SALVIOLI-MARIANAI, Emma and **VENTURELLI, Giampiero,** 1996, Temperature of crystallization and evolution of the Jumilla and Cancarix lamproites (SE Spain) as suggested by melt and solid inclusions in minerals: Eur. J. Mineral., v. 8, p. 1027-1039. Authors at Istituto di Petrografia, Univ. di Parma, Viale delle Scienze 78, I-43100 Parma, Italy.

Rocks from Jumila and Cancarix exhibit extreme compositions among the Spanish lamproites; the rocks of Jumilla have the highest MgO, P_2O_5, REE, Ba, Th and the lowest SiO_2 contents, while the rocks from Cancarix have the highest SiO_2 and K_2O contents as well as high MgO, Cr, Ni, and Zr. Both groups of rocks are derived from peralkaline magmas. Microthermometric measurements on glass I occurring in olivine, clinopyroxene, apatite, sanidine, K-richterite and phlogopite indicate T of crystallization from about 1200°C to about 650°C at Jumilla and from about 1200°C to about 800°C at Cancarix. The chemical composition of the glass forming I in olivine, clinopyroxene, apatite, sanidine, K-richterite and pseudobrookite as well as in late intercrystalline multiphase aggregates (Cancarix) indicates that the (Na + K)/Al ratio of the residual M increased substantially during the cooling and crystallization of the magmas, reaching very high values. Solid I of leucite and/or leucite accompanied by analcime within high T minerals, and rims of sanidine around analcime show that analcime is a S mineral after leucite. (Authors' abstract)

SAMPLE, J.C., 1996, Isotopic evidence from authigenic carbonates for rapid upward fluid flow in accretionary wedges: Geology, v. 24, no. 10, p. 897-900. Author at Dept. of Geological Sci., California State Univ., Long Beach, California 90840-3902.

A comparison of pore F and authigenic carbonates sampled by the Ocean Drilling Program from the Nankai, Peru, Barbados, and Cascadia accretionary wedges illustrates significant disequilibria in oxygen isotopes, which in some cases may be related to rapid incursions of F along fault conduits in the past. The Peru, Barbados, and Cascadia carbonates have lower than expected $\delta^{18}O_{PDB}$ (Peedee belemnite) values for the measured downhole T and isotope compositions of the pore F. In the Peru wedge the lower values may have resulted from past incursion of meteoric water, but in the Barbados and Cascadia wedges, the low $\delta^{18}O_{PDB}$ values were caused in part by past incursion of F with higher T, probably along fault conduits. The T of F in the Cascadia wedge may have exceeded 100°C, which is 90°C higher than measured current downtole T. The required high F-flow rates suggest a mechanism of seismically induced F migration to bring F rapidly from depths of greater than 2 km to the surface (Author's abstract)

SANDERS, C.A.E., BERTOTTI, Giovanni, TOMMASINI, Simone, DAVIES, G.R. and **WIJBRANS, J.R.**, 1996, Triassic pegmatites in the Mesozoic middle crust of the southern Alps (Italy); fluid inclusions, radiometric dating and tectonic implications: Eclogae Geologicae Helvetiae, v. 89, no. 1, p. 505-525. First author at Free Univ., Inst. Earth Sci., Amsterdam, Netherlands.

SANO, Y. and WILLIAMS, S.N., 1996, Fluxes of mantle and subducted carbon along convergent plate boundaries: Geophys. Research Letters, v. 23, no. 20, p. 2749-2752.

SASADA, Masakatsu, SAWAKI, Takayuki, TSUKIMURA, Katsuhiro, SASAKI, Munetake, YAGI, Masahiko, HYODO, Masami, OKABE, Takashi, and **SHIGA, Takahiro**, 1996, Application of synthetic fluid inclusions to geothermal logging (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p., 10-11. First author at Geol. Survey of Japan.

Same as previous abstract (E.R.)

SASADA, Masakatsu, SAWAKI, Takayuki, TSUKIMURA, Katsuhiro, SASAKI, Munetake, YAGI, Masahiko, HYODO, Masami, OKABE, Takashi, and **SHIGA, Takahiro**, 1996, Application of synthetic fluid inclusions to geothermal logging (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 550. First author at Geol. Survey of Japan.

FI can be synthesized in cracked quartz in geothermal boreholes. High-T F trapped in fracture planes of cracked quartz results in FI through healing. Since quartz is mostly stable in geothermal systems, a synthetic FI logging tool can be applied to high T boreholes whose T cannot be measured by conventional tools, and whose F cannot be sampled by conventional equipments.

A preliminary borehole experiment was conduced in the NEDO's hole WD-1 at the Kakkonda geothermal field, northern Honshu, Japan. A proto-type equipment consisting of several carriers and a slick line was applied. Several pieces of thermally cracked I-free quartz were placed at five levels of the well from 360 m to 1485 m, where the T was between 200°C and 271°C. They were put both in a sealed metal tube with silica-saturated alkaline solution and in a non-sealed tube which is open to the borehole F after break of a rapture disk. Microcracks of quartz soaked in alkaline solution in the sealed metal tube were turned into a number of small FI after the 24 day's run. The Th of the synthesized I agreed with the boreholes T measured by a platinum resistance thermometer. However some T ranges were also detected in Th probably because of necking down at lower T. One of the alternative starting materials to reduce necking-down I is heated natural quartz in which all the FI are decrepitated and very thin cracks are developed around the vacant I. (Authors' abstract.)

SASAKI, M., SAWAKI, T. and **SASADA, M.**, 1996, Gas compositions of fluid inclusions from a well of HJ-4 in Hachijojima (abst.): Newsletter of the Japanese Assoc. of Geothermal Fluid Inclusionists, 1996, no. 7, p. 25 (in Japanese)

See FIR, v. 28, p. 146 (E.R.)

SATISH, K.M., SANTOSH, M., HARLEY, S.L. and **YOSHIDA, M.**, 1996, Calc-silicate assemblages from the Kerala khondalite belt, southern India; implications for P-T-F histories: J. of Southeast Asian Earth Sci., v. 14, no. 3-4, p. 245-263.

Indexed under FI (E.R.)

SAUNDERS, J.A., COOK, R.B. and **SCHOENLY, P.A.**, 1996, Electrum disequilibrium crystallization textures in volcanic-hosted bonanza epithermal gold deposits in northern Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Soc. of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 173-179. Authors at Dept. of Geol., 210 Petrie Hall, Auburn Univ., AL 36849.

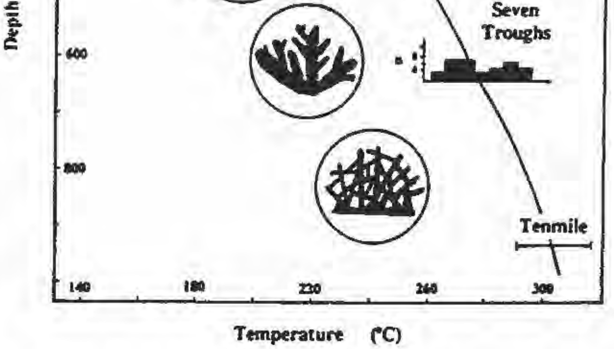


Figure 3–Diagrammatic illustration of changes in dendrite morphology with temperature. Histograms (10°C increments) show fluid-inclusion homogenization temperatures determined in this study, dashed temperature ranges are estimated from silica textures, and the solid line for the Tenmile district is based on data from Nash (1972). Also shown for reference is the boiling curve for pure water, which represents the maximum temperature possible at a given depth. Depths scale shown assumes hydrostatic pressure conditions.

Dendritic electrum is the principal ore mineral in a number of volcanic-hosted high-grade ("bonanza") epithermal Au-Ag deposits in northern Nevada. Dendrites generally form as a consequence of rapid precipitation from supersaturated solutions, and are indicative of disequilibrium ore-forming processes. Both the character of electrum dendrites and the associated silicate minerals change with increasing T of formation. Dendrites formed at T <-180°C formed by aggregation of colloidal electrum particles and commonly occur in opal. Higher-T dendrites are intergrown with coarse quartz and adularia and show a progressively greater influence of internal crystal structure on the resulting dendrite shapes. (Authors' abstract) The relation between electrum dendrite morphology and FIT are shown in Fig. 3.

SAUNDERS, J.A. and **THOMAS, R.C.**, 1996, Origin of 'exotic' minerals in Mississippi salt dome cap rocks: Results of reaction-path modeling: Applied Geochem., v. 11, p. 667-676. Authors at Dept. of Geol., Auburn Univ., Auburn, AL 36849, USA.

Shallow salt domes in central Mississippi pierce Mesozoic formations hosting regionally extensive metal-rich brines. This association, coupled with the multiple F-migration pathways around salt domes, suggests that these brines were the source of Fe and base-metal sulfide, Sr, and Ba minerals in salt dome cap rocks. FI in barite and celestite indicate that the brines had a relatively constant average composition of approximately 200,000 mg/l total dissolved solids, which is similar to present-day oil field brines from central Mississippi. Geochemical reaction-path modeling indicates that the suite of observed cap rock minerals can be produced by alternating periods of biogenic SO_4 reduction with inorganic anhydrite dissolution (or by mixing with seawater). Sulfide-rich portions of cap rock at Hazlehurst salt dome have molar Fe:Pb and Fe:Zn ratios similar to present-day oil field brines, indicating that mixing of brines with abundant amounts of H_2S produced by biogenic SO_4 reduction led to rapid precipitation of virtually all dissolved metals is relatively insoluble sulfide minerals. (Authors' abstract)

SAWAKI, T., 1996, Synthesis of fluid inclusions–preliminary experiments for synthetic fluid inclusion logging system (abst.): Newsletter, Japanese Assoc. of Geothermal Fluid Inclusionists, 1996, no. 7, p. 1-21 (in Japanese; translation courtesy of the author).

Synthethic FI logging systems are being developed by the Geological Survey of Japan in cooperation with the New Energy and Industrial Technol. Development Organization (NEDO) in the "New Sunshine Project", in order to measure T of high-T (>350°C) geothermal wells. Laboratory experiments to synthesize FI are needed for planning of borehole experiments of the synthetic FI logging. Synthesis of FI has been established (e.g. Bodnar and Sterner, 1987). This paper briefly describes how FI were synthesized at the Geological Survey of Japan based on previous works. FI were synthesized in quartz and calcite through crack-healing. The mineral crystals were cut into small pieces. The pieces were heated by a furnace and then were quenched by water, in order to make microcracks in the crystals. The cracked crystals were sealed in Teflon vessels, gold and/or platinum capsules with solutions saturated in SiO_2 or $CaCO_3$. The capsules were set in autoclaves at 200-350°C for 1 day to 2 weeks. After the experiments, FI were formed in some crystals. These results helped planning the borehole experiments. (Author's abstract)

SAWAKI, T., SASADA, M., and **SASAKI, M.**, 1996, Geochemistry of fluid inclusions in granites and pegmatites from Japan: Abstracts of the 103rd Annual Meeting of the Geological Society of Japan, p. 276 (in Japanese).

SAWAKI, T., SASAKI, M., KOMATSU, R. and **MURAMATSU, Y.**, 1996, Geochemical features of fluid inclusions from the shallow geothermal reservoir of the Kakkonda geothermal system (abst.): Newsletter of the Japanese Assoc. of Geothermal Fluid Inclusionists, 1996, no. 7, p. 24 (in Japanese).

See FIR v. 28, p. 147. (E.R.)

SAWAKI, T., SASADA, M., TSUKIMURA, K., MURAOKA, H., UCHIDA, T., SASAKI, M., KAMENOSONO, H., HYODO, M., TAKAHASHI, W., DOI, N. and **IKEUCHI, K.**, 1996, Temperature logging of WD-1a by synthetic fluid inclusions of various compositions–results of short- and long-term experiments in 1995: 1996 Annual Meeting of the Geothermal Research Soc. of Japan, Abstracts with Programs, p. 24 (in Japanese).

SCAILLET, S., CUNEY, M., LE CARLIER DE VESLUD, C., CHEILLETZ, A. and **ROYER, J.J.**, 1996, Cooling pattern and mineralization history of the Saint Sylvestre and western Marche leucogranite pluton, French Massif Central: II. Thermal modelling and implications for the mechanisms of uranium mineralization: Geoch. Cosmo. Acta, v. 60, no. 23, p. 4673-4688. First author at Centre de Recherches Pétrographiques et Géochimiques, CRPT-CNRS, 15 rue Notre Dame des Pauvres, BP 20, 54501 Vandœuvre-lès-Nancy Cedex, France.

The genetic relationships between the F circulations, the mineralization, and the cooling history of the pluton are discussed with particular emphasis on the tectonic process driving exhumation (extension). The initiation of the regional uplift at ~320 Ma triggered at depth the circulation of in situ derived low-density aq F that reacted with the granite to form large vertical dissolution conduits (episyenites) characterized by the strong leaching of SiO_2. The hydrothermal alteration was further enhanced during uplift by the structurally focused throughput of large volumes of aq F along brittle faults cutting across the laccolith. These conduits acted more than 20-30 m.y. after the trap formation as preferential channelways for the U-ore deposition at 270-280 Ma, due to sustained hydrothermal circulation adjacent to the high-heat producing terminal injections emplaced along the vertical fault zones and the metasomatic columns. (From authors' abstract by E.R.)

SCHIANO, Pierre, CLOCCHIATTI, Robert, LORAND, Jean-Pierre, MASSARE, Dominique, DELOULE, Etienne and **CHAUSSIDON, Marc**, 1996, Normal MORB-type melts included in podiform chromites from the Oman ophiolite (abst.): 16th Réunion des Sci. de la Torre, Orleans, 10-12 avril 1996, program, p. 93 (in Engl.). First author at Lab. de Géochimie-Cosmochimie (CNRS-URA 1758), IPG Paris, 4 place Jussieu, Paris.

In an attempt to characterize the composition of the parental M of ophiolitic chromitites, we have undertaken a study of polymineralic solid I trapped in chromites from the Oman ophiolite (Sumail nappe). High-T experiments (1000-1300°C) performed on these I show that they result from post-entrapment crystallization of homogeneous basaltic M with primary compositions (Mg# = 63.8 to

65.8). The primary nature of the I, evidenced by their form and orientation, indicates that the trapped M represent small amounts of the parental L of the host chromites. The M have primary undersaturated olivine tholeiite to alkali basalt compositions, close to those of basalts erupted in seamounts near modern oceanic spreading centres. Moreover, they show regular depeted trace element patterns remarkably similar to those of typical mid-ocean ridge basalts. The patterns differ clearly from those for ocean-islands, and they also lack the negative high-field-strength element anomalies (e.g. Nb) that would characterize an island-arc or a supra-subduction zone origin. These observations indicate that chromite deposits from harzburgitic ophiolites may have formed in a geodynamic setting akin to present-day spreading-ridge centres. (Authors' abstract)

SCHMETZER, Karl, HANNI, H.A., BERNHARDT, H-J and **SCHWARZ,Dietmar,** 1996, Trapiche Rubies: Gems and Gemology, v. 32, no. 4, p. 242-250. First author at Gübelin Gemmological Laboratory, Lucerne, Switzerland.

Ruby crystals from southeast Asia with a fixed six-rayed star, similar in effect to trapiche emeralds from Colombia, are described. They consist of six transparent-to-translucent ruby sectors separated by nontransparent yellor or white planes. Most samples also have a hexagonal tapered yellow, black, or red core. In the yellow or white arms of the star and in the boundary zones between the core and the six ruby sectors, a massive concentration of tube-like I is seen. These I are oriented perpendicular to the morphologically dominant dipyramidal crystal faces; they contain L, two-phase (L/G), and solid fillings identified as magnesium-bearing calcite and dolomite. A trapiche-type sapphire is also described. (Authors' abstract)

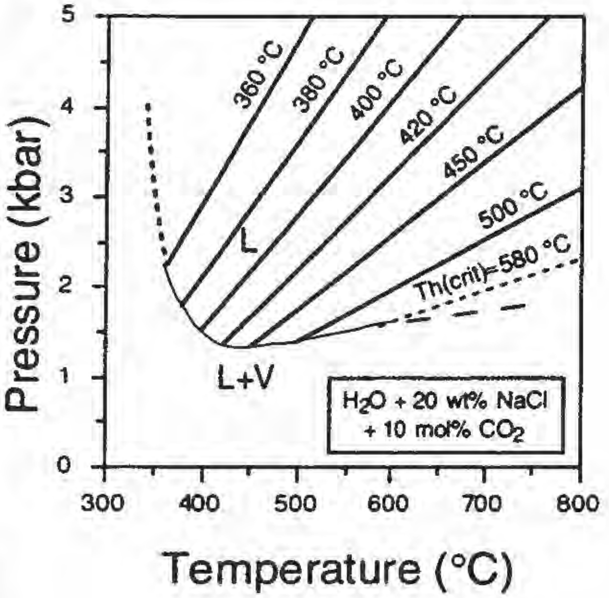
SCHMETZER, Karl, PERETTI, Adolf, MEDENBACH, Olaf and **BERNHARDT, H-J,** 1996, Russian flux-grown synthetic alexandrite: Gems and Gemology, v. 32, no. 3, p. 186-202. First author at Gübelin Gemmological Laboratory, Lucerne, Switzerland.

Synthetic alexandrite is being flux-grown in Russia in a molybdenum-, bismuth-, and germanium-bearing solvent by means of the reverse-T gradient method. Characteristic properties include habit, twinning, growth patterns, residual flux I, trace-element contents, chemical zoning, color zoning, and spectroscopic features in the visible and infrared ranges. The relationship between production technique and characteristic properties is discussed, and diagnostic properties that can be used to distinguish these synthetics from natural alexandrite are disclosed. (Authors' abstract)

SCHMIDT, C. and **BODNAR, R.J.,** 1996, Volumetric properties and solvus locations in the Ternary System H_2O - NaCl - CO_2 at elevated temperatures, pressures, and salinities up to 20 wt% sodium chloride (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 110. Authors at Fluids Research Laboratory, Dept. of Geological Sci., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061-0420, USA.

FI having compositions of 6 or 20 wt% NaCl and 10, 20 and 30 mole% CO_2, both relative to H_2O, were synthesized in cold-seal P vessels at P from 2 to 5 kbar and T between 400 and 700°C. The solvus locations and the P-T slopes of iso-Th lines were determined for bulk F densities above the critical density based on microthermometric analysis. For solvus P above about 2 kbar, the L + V → L boundary was delineated in P-T space using microthermometrically determined sal. Molar volumes were calculated from microthermometric and Raman spectroscopic data for the density of the CO_2 phase.

For H_2O + 20 wt% NaCl + 10 mol% CO_2, the high density portion of the bubble-point curve shows a P minimum at about 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 above 440°C. Addition of CO_2 to an aq 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 kbar for a 20 mol% CO_2 content. The immiscibility field extends into granulite-facies conditions at a CO_2 concentration of 30 mol% relative to water. With the possible exception of the 700°C, 5 kbar run, no FI formed in the one-phase field even at 5 kbar P. The slopes of the iso-Th lines for a constant composition of H_2O + 20 wt.% NaCl + 10 mole% CO_2 decrease nonlinearly from about 20 bars/°C for Th(L-V) of 360°C, to approximately 3 bars/°C for Th(L-V) = 600° C (see figure). The bulk molar volumes, isochores and solvus locations along the pseudobinary (H_2O + 6 wt.% NaCl) - CO_2 are consistent with the data of GEHRIG (1980).



Measured clathrate melting T of H_2O - NaCl - CO_2 I which have formed in the one-phase field are in excellent agreement with the equation of DIAMOND (1992). (Authors' abstract)

SCHMIDT, Christian, CHOU, I-M., BODNAR, R.J. and **BASSETT, W.A.,** 1996, Application of the hydrothermal diamond-anvil cell for microthermometric analysis of volatile-rich fluid inclusions (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F775, November 12, 1996. First author at Dept. of Geol. Sci., Virginia Tech, Blacksburg, VA 24061 USA; e-mail (schmidtc@vt.edu)

During heating of volatile-rich FI, particularly those with high sal, high P are generated inside the I. As a result, the I often decrepitate or stretch before the Th is reached. This behavior has limited the acquisition of isochores and high-T phase equilibria from synthetic FI to compositions having L-V curve P less than about 2 kbar, if conventional FI heating stages are used. In this study, the hydrothermal diamond-anvil cell (HDAC) has been used as a pressurized FI stage to prevent decrepitation. The HDAC was loaded with a polished 100 µm thick quartz chip containing FI. Water was used as the P medium. The P inside of the I at the Th was estimated based on previous measurements, and the confining P on the sample was adjusted so that it was equal to or up to 2 kb higher than the internal P in the I at homogenization.

Using this technique, L-V Th [Th(L-V)] and halite dissolution T [Tm(NaCl)] were determined for synthetic FI in the pseudobinary (H_2O + 40 wt.% NaCl) + CO_2 for compositions of 10 and 20 mol% CO_2 relative to water. Using these data, the P-T locations of the high-P portion of the L-V curves and isochores for H_2O + 40 wt.% NaCl + 10 mol% CO_2 were calculated. For this composition, the P of the bubble-point curve is nearly independent of Th(L-V) and increases sharply at Th(L-V), 490°C. The solvus P is around 2.5 kbar for Th(L-V) between 500 and 650°C. The calculated isochore slopes are steep and decrease from about 35 bar/deg. C at Th(L-V) = 500°C, to 15 bar/deg. C for Th(L-V) = 650°C. The Tm(NaCl) average 342°C (range 6 deg. C) for samples containing 10 mol% CO_2 relative to water, and are approximately 375°C for the 20 mol% CO_2 composition. These halite dissolution T are significantly elevated compared to previously determined V-saturated liquidus T in the 40 wt.% NaCl pseudobinary at lower carbon dioxide concentrations. Tm(NaCl) = 323°C for H_2O + 40 wt.% NaCl and Tm(NaCl) = 332°C for H_2O + 40 wt.% NaCl + 5 mol% CO_2. Compared to the one-atmosphere heating stage data, the total Th for the same samples obtained using the HDAC technique are generally lower (up to several tens of degrees) due to the absence of stretching and/or the suppression of the thermal expansion of the I host material (quartz). Halite dissolution T from both methods are in very good agreement, suggesting that the halite liquidus for this composition shows very little P dependence. (Authors' abstract)

SCHMIDT-MUMM, A., 1996, Application of fluid inclusion studies to the reconstruction of the thermal evolution of sedimentary basins (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 111-112. Author at Institut fuer Geologische Wissenschaften und Geiseltalmuseum, Domstr. 5, D-06108 Halle Wittenberg; e-mail (gfoj8@mlucom2.urz.uni-halle.de)

A review of the procedures used, and the precautions to be taken in both the experimental work and in the interpretation of the data. (E.R.)

SCHRAUDER, Marcus, KOEBERL, Christian and **NAVON, Oded,** 1996, Trace element analyses of fluid-bearing diamonds from Jwaneng, Botswana: Geoch. Cosmo. Acta, v. 60, no. 23, p. 4711-4724. First author at Inst. of Geochem., Univ. of Vienna, A-1090 Vienna, Austria.

Fibrous diamonds from Botswana contain abundant micro-I, which represent syngenetic mantle F under high P. The major element composition of the F within individual diamonds was found to be uniform, but a significant compositional variation exists between different diamond specimens. The composition of the F varies between a carbonatitic and a hydrous endmember. To constrain the composition of F in the mantle, the trace element contents of thirteen micro-I-bearing fibrous diamonds from Botswana was studied using neutron activation analysis. The concentrations of incompatible elements (including K, Na, Br, Rb, Sr, Zr, Cs, Ba, Hf, Ta, Th, U, and the LREEs) in the F are higher than those of mantle-derived rocks and MI. The compatible elements (e.g., Cr, Co, Ni) have abundances that are similar to those of the primitive mantle. The concentrations of most trace elements decrease by a factor of two from the carbonate-rich F to the hydrous F.

Several models may explain the observed elemental variations. Minerals in equilibrium with the F were most likely enriched in incompatible elements, which does not agree with derivation of the F by partial melting of common peridotites or eclogites. Fractional crystallization of a kimberlite-like magma at depth may yield carbonatitic F with low mg numbers (atomic ratio [Mg/(Mg+Fe)]) and high trace element contents. Fractionation of carbonates and additional phases (e.g., rutile, apatite, zircon) may, in general, explain the concentrations of incompatible elements in the F, which preferably partition into these phases. Alternatively, mixing of F with compositions similar to those of the two endmembers may explain the observed variation of the elemental contents. The F in fibrous diamonds might have equilibrated with mineral I in eclogitic diamonds, while peridotitic diamonds do not show evidence of interaction with these F. The chemical composition of the F in fibrous diamonds indicates that, at *p, T* conditions that are characteristic for diamond formation, carbonatitic and hydrous F are efficient carriers of incompatible elements. (Authors' abstract)

SCHRIJVER, Kees, WILLIAMS-JONES, A.E., BERTRAND, Rudolf and **CHAGNON, Andre,** 1996, Genesis and controls of hydrothermal dolomitization in sandstones of the Appalachian thrust belt, Quebec, Canada; implications for associated galena-barite mineralization: Chemical Geology, v. 129, no. 3-4, p. 257-279. Authors at INRS-Georesources, Sainte-Foy, PQ, Canada.

The Appalachian thrust belt of eastern Quebec hosts six epigenetic barite-galena (-sphalerite) occurrences. Two of these, the St. Fabien and Cap Enrage deposits, consist of veins and disseminations enveloped by dolomitized zones, and contain ankerite as an essential gangue mineral. FI data suggest that dolomitization and mineralization at St. Fabien (and Cap Enrage) were the products of interactions between local sedimentary rocks and minor metabasaltic dikes with hydrothermal brines. (From authors' abstract by E.R.)

SCHUBEL, K.A., HARDIE, L.A. and **VEBLEN, D.R.,** 1996, Heterogeneous microstructures in dolomites from the Triassic Latemar buildup, northern Italy (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A337. First author at Dept. of Geology, Lafayette College, Easton, PA 18042; e-mail (schubop@aol.com)

Three generations of dolomite, formed under subaerial sedimentary to subsurface hydrothermal conditions, partially replace Triassic Latemar limestones. Subsurface hydrothermal dolomite comprises a km-scale mushroom-shaped body that crosscuts platform sediments. Fabric-destructive replacement dominates towards the base, where FI filling T range from 152-177°C, whereas fabric-retentive replacement is more common toward the top, where FI filling T range from 101-152°C. Dolomite rhombs are 10 µm to 1 mm across and are partly ordered calcian phases (42-48 mol% $MgCO_3$), with higher $MgCO_3$ contents where the higher T were reached. This massive replacement dolomite is compositionally and microstructurally heterogeneous at the SEM- and TEM-scales. At the SEM-scale, dolomite rhombs consist of compositionally distinct domains (< 10-100 µm across) which are host to TEM-scale modulated (wavelength 40-200) and mottled microstructures oriented parallel to the growth normal.

Since all of the variants of Latemar dolomite are compositionally and microstructurally heterogeneous, calcian phases, it may be possible to relate the types and scales of heterogeneity to environments of dolomitization and reaction mechanisms (void-filling precipitation, fabric-retentive and fabric-destructive replacement and recrystallization). (From authors' abstract by E.R.)

SCHULTZ, D.J., 1996, The fluid history of the Seabee mesothermal gold deposit, northern Saskatchewan: Master's thesis at Univ. of Saskatchewan, Saskatoon, SK, Canada, 122 pp.

The Seabee deposit is a mesothermal, gold-bearing vein system hosted within mylonitic shear structures in the Glennie Domain of the Proterozoic Trans-Hudson Orogen, northern Saskatchewan, Canada. Field and underground observations indicate that shear structures nucleated at rheological contrasts at the contacts between felsic intrusive dykes, and mafic intrusive lithologies. High-grade ore is located where shear structures intersect to form zones of transtension or dilational jogs. Geochemical patterns for altered mylonites are similar to those of the primary lithologies. Mafic host rocks proximal to the Seabee quartz veins have been altered to biotite, actinolite, epidote assemblages as the result of hydrothermal activity. Two stages of mineralization are present within quartz veins of the Seabee deposit. Stage I consists of quartz, tourmaline, K feldspar, and pyrite. Stage II is confined within microfractures that cut the Stage I assemblage. Stage II is dominated by carbonate, pyrrhotite, chalcopyrite, tellurides, and gold. Quartz adjacent to microfractures was locally recrystallised during the Stage II event. Gold is sited where Stage II microfractures intersect pyrite, whereas the microfractures that transect quartz contain only carbonate with trace quantities of chalcopyrite and tellurides. The occurrence of gold indicates that interaction of an auriferous F with Stage I pyrite resulted in gold deposition. In addition, gold blebs locally occur as linear arrays within pyrite proximal to Stage II microfractures, and are interpreted to represent Stage II gold grains about which Stage I pyrite recrystallized. No P FI have been preserved in Stage I quartz veins, although numerous SI are present. SI consist dominantly of G/L H_2O or G/L CO_2, the occurrence of 3-phase G/L $H_2O + CO_2$ vapor is limited. Microthermometric analysis indicates that G/L H_2O I were trapped at 212°C and at P of approximately 2.0 kb, suggesting that the Seabee vein system was emplaced at depths of 7.0 km. Stage I barren quartz has $\delta^{18}O$ values of 8.4-8.9 per mil, whereas auriferous Stage II quartz has higher values of 10.0-10.6 per mil. Tourmaline is variably altered, particularly adjacent to Stage II microfractures. This alteration is reflected in the O-isotope compositions; in unaltered tourmaline the $\delta^{18}O$ is approximately 6.6 per mil, whereas in altered tourmaline the $\delta^{18}O$ ranges from 7.2 to 7.8 per mil. The O-isotopic compositions of barren quartz and unaltered tourmaline are assumed to preserve them. (Author's abstract)

SCHWALM, A.J. and **BURRUSS, R.C.,** 1996, Fluid inclusion evidence for the migration of anomalously hot fluids in the Silurian/Devonian Hunton Group below the pre-Mississippian unconformity surface, Anadarko Basin, OK (abst.): American Assoc. of Petrol. Geologists Annual Meeting Abstracts v. 5, p. 127. First author at South Dakota School of Mines and Tech., Rapid City, SD, US.

FI assemblages in vug- and fracture-filling diagenetic minerals in the carbonates of the Hunton Group record anomalously high Th and sal. T profiles of single wells display maxima directly below or close to the unconformity with the overlying Woodford Shale, and decrease gradually or abruptly downward. In a few wells, suitable diagenetic minerals directly above the unconformity in the Woodford Shale contain FI with Th comparable to those below the anomaly. Highest T coincide with a high-permeability zone developed towards the top of the Hunton carbonates. The thickness and permeability of this zone depends on the development of a paleokarst after Hunton deposition and are controlled by the paleogeographical position within the basin. Depending on the location within the basin, F evolve generally from meteoric or moderately saline (up to differs from 10 wt.% NaCl eq.) with T of 80-120°C to highly saline (up to differs from 26 wt.% NaCl eq.) with T up to 260°C, followed by a decrease in T with either increasing or decreasing sal. Associated petroleum I suggest that the hottest T coincide with peak petroleum migration. T anomalies are highest in the north near the Hunton subcrop on the basin shelf where the total Hunton thickness is generally <100 ft, and the strongly karsted carbonates are sandwiched in between the Woodford and Sylvan shales resulting in a highly focused flow. (Authors' abstract)

SCHWARTZ, Dietmar, KANIS, Jan and **KINNAIRD, Judith,** 1996, Emerald and green beryl from central Nigeria: J. Gemm., v. 25, no. 2, p. 117-141. First author at Gübelin Gemmological Laboratory, Lucerne, Switzerland.

Mineralogical and gemmological characteristics of emeralds and green beryls from the central Nigerian Kaduna and Plateau States are presented. A genetic model for the occurrence of these gemstones in greisen associations of Mesozoic alkali granite ring complexes has been established. Gemmologists should be able to distinguish between Nigerian emeralds and those from other localities. Distinction is based on the unique I and the chemical features of the Nigerian emeralds and green beryls. For those Nigerian specimens that contain solid I, the mineral association of albite + fluorides (fluorite, boldyrevite, ralstonite) + F-silicate + Fe-rich mica + ilmenite + monazite, is locality-specific. Growth structures and FI are extremely common and the later ones show a large range of features including Colombian-type three-phase I. For Nigerian emeralds that show an I pattern similar to that of Colombian emeralds, the easiest distinction is by absorption spectroscopy. The Nigerian emeralds show 'mixed spectra' with peaks attributable to Cr^{3+}, Fe^{2+}, Fe^{3+} and Fe^{2+}/Fe^{3+}, whereas the spectra of Colombian emeralds, as a rule, are largely free of Fe-components. (Authors' abstract)

SCHWARTZ, Dietmar, PETSCH, E.J. and **KANIS, Jan,** 1996, Sapphires from the Andranondambo region, Madagascar: Gems and Gemology, v. 32, no. 3, p. 80-99.

Indexed under FI (E.R.)

SCHWARTZ, M.O., 1996, Native copper deposits and the disposal of high-level waste: Int'l. Geol. Review, v. 38, p. 33-41. Author at Bundesanstalt fur Geowissenschaften und Rohstoffe, P.O. Box 510153, D-30631 Hannover, Germany.

Highly radioactive, heat-producing waste contains radionuclides and generates daughter products that have half-lives as long as millions of years. This high-level waste must be sealed from the biosphere for a very long period in stable containers stored in deep geological repositories. Copper has been seriously considered as a container material in several waste-disposal projects. Native copper deposits may serve as natural analogues for a chemically stable container-repository system. These deposits formed in terrestrial basalt-conglomerate sequences at T of approximately 100-200°C. The hydrothermal systems possessed oxygen fugacities below the stability limit of cuprite and at least 3 log units above the magnetite-hematite buffer at 100°C, and at least 1 log unit above this buffer at 200°C. This corresponds to an oxygen fugacity range of ≤10 log units. The F were characterized by low total sulfur activities and high Cu-Cl ratios. Similar conditions can be expected to exist in a theoretical repository in subaerially extruded Cu-rich basalts interbedded with terrestrial conglomerates, which have undergone pervasive hydrothermal alteration. (Author's abstract)

SCOTT, A.-M., 1996, Condensation and mixing model for variable salinity in the epithermal fluids of the Hokko low-sulfidation Au system, SW Hokkaido, Japan (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F777, November 12, 1996. Author at Yasushi Watanabe (Mineral Resources Dept., Geol. Survey of Japan, 1-1-3 Higashi, Tsukuba, Lbaraki 305, Japan; e-mail (scott@gjs.go.jp)

The Hokko prospect is located in the Minamikayabe area in the Kameda peninsula of southwestern Hokkaido. The alteration mineral assemblage is typical of a low-sulfidation epithermal system, with the presence of NE-SW trending, Au-bearing quartz veins, with gold-grades of up to 16.5 ppm.

The P FI are generally small in size (5 µm), and are found in both massive, and banded quartz, as well as fine-grained quartz-adularia groundmass. Th from 205 two-phase (L+V) FI range between 150 and 330°C. The Th data shows a normal distribution, with the mode for all of the I at 210°C. Freezing runs were performed on 151 of the same I, which yielded a Tm range between –0.1 and –8.0°C, with 85% of the FI, displaying Tm < –1.0°C (2 wt.% NaCl eq.). However, a distinct group of low Th I had a range in Tm from < –1.0 to –8.0°C (up to 12 wt.% NaCl), particularly in a sample collected at 185.7 m, just below the highest Au concentration (17.7 ppm). Oxygen isotopes from quartz reveal a meteoric water source of $\delta^{18}O$ = –9 to –6, for the hydrothermal F.

We propose a combination of condensation and mixing processes in the epithermal system which resulted in the two-phase entrapment of co-existing F with variable sal at the same time, and in close proximity to each other. The largest range in FI sal is interpreted to reflect the critical level for F boiling and the precipitation of ore minerals within the Hokko system. This observation may be applicable to the investigation of other low-sulfidation gold prospects. (Author's abstract)

SECCOMBE, P.K., and **JIANG, Z.,** 1996, Fluid evolution in shear-zone hosted Cu-Au vein deposits: Examples from the Cobar region, Lachlan fold belt, Australia (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 113-115. Authors at Dept. of Geol., The Univ. of Newcastle, Callaghan, New South Wales, Australia 2308; e-mail (psec@geology.newcastle.edu.au)

Current thinking on the origin of the Cobar ores favors a syntectonic concept, whereby structural focussing of metamorphic F has generated mineralization in shear zones at shallow crustal levels. This paper is aimed at defining the nature and evolution of mineralizing F in two major deposits at Cobar.

Heating/freezing data for FI at the Peak mine indicate that both Th and sal increase during the first four paragenetic stages, corresponding to the introduction of Cu-Au, followed by Pb-Zn ores:

Stage 1 (T_h, $T_{m\ ice}$), mean 270, –0.5 to –2.6; Stage 2, mean 322, –3.7 to –5.5; Stage 3, 205-393, –1.1 to –8.6; Stage 4, ≤ 393, T_m NaCl (?) 277-289°; Stage 5, 190-355, –1.6 to –4.0; Stage 6, (high); Stage 7, mean 233, –0.8 to –2.5°C.

Bulk analysis of I F indicate a dramatic rise in the concentration of CO_2 during the initial Cu-Au event (Stage-2) at Peak and the later Pb-Zn event (Stage-4). F and Cl levels are elevated in the F associated with the Pb-Zn event. By contrast, high CH_4 contents (and low CO_2 / CH_4 ratios) characterize intervening and later stages of barren quartz deposition. G-phase compositions are confirmed by microthermometric data and laser Raman spectroscopy on individual FI.

Evolution of the F system at Chesney is in contrast to that at Peak. P FI from veins of the first four paragenetic stages are modified by subsequent external overpressure, from which we infer that quartz from Stages 1-4 was emplaced prior to D_2 (Early Carboniferous deformation). Additionally, Cu-Au ore deposition at Chesney represents the latest paragenetic event (Stage-7).

Thermal and sal cycles evident in the Cobar deposits are likely to be linked to reactivation on the major thrusts and transient supply of F from basin and basement lithologies. (From authors' abstract by E.R.)

SECCOMBE, P.K., ZHIYU, Jiang, LU, Jianchun and **FOSTER, David,** 1996, Timing of mineralisation in turbidite-hosted gold deposits, Lachlan fold belt, NSW, Australia: A 40 million-year record of vein growth (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A83. First author at Dept. of Geol., The Univ. of Newcastle, Callaghan, New South Wales 2308, Australia.

Structurally controlled mesothermal quartz veins in low metamorphic grade metagreywacke-slate sequences of middle Palaeozoic age in the Lachlan Fold Belt of New South Wales represent a major gold ± copper resource. $^{40}Ar/^{39}Ar$ dating of muscovite from the auriferous veins and metamorphic biotite from the hostrocks of Silurian to Devonian age at the Hill End goldfield defines four major episodes of vein formation. Some veins were initiated during a Middle Devonian orogenic event (380-375 Ma). Major development of bedding-parallel quartz veins is associated with Early Carboniferous regional metamorphism (360 Ma). Gold accumulation commenced after the main stages of quartz deposition, during and after the development of the conspicuous internal vein laminations (about 355 Ma and 345-340 Ma, respectively). In both settings F T range up to 370°C, CH_4 and CO_2 may be major dissolved G species and F mixing is implicated as a control on ore deposition. In the gold-only, mesothermal vein deposits (Hill End), sal are of low sal (<3.6 wt.%) but at Cobar, sal as high as 12.4 wt.% NaCl eq. explain the presence of additional base metals in the Peak ore systems. Linked thrusts and culminations along anticlinal hinges are critical structural elements in localising mineralization in both districts. (From authors' abstract by H.E.B.)

SEDOVA, I.S., SEMENOV, A.P. and **BALTYBAYEV, S.K.,** 1996, Fluid inclusions in quartz veins from low- to medium-grade metamorphic rocks in the Ladoga complex: Geokhimiya, no. 10, p. 1433-

1447, 1996 (in Russian, translated in Geochem Int'l., v. 33, no. 9, p. 93-108, 1996.

FI data are given for 20 polished plates from quartz veins localized in low- and medium-T rocks in the Ladoga zoned complex, which has been metamorphosed in the range 450-780°C with slight rise in P from 3.5-4 up to 5-6 kbar. There are four quartz-vein generations. The generation II veins (V_2) are considered as simultaneous with the culmination of the metamorphism, while the III veins (V_3) are considered as reflecting the start of the regressive stage. There are four main types of I (H_2O with varying sal, H_2O-CO_2, CO_2, and CH_4-N_2 ones) and three additional ones (CH_4-N_2-CO_2, H_2)-CH_4-N_2, and H_2O-NaCl-$NaHCO_3$) in V_2 and V_3. In connection with the progressive metamorphism, the total gas release from the quartz (as indicated by gas chromatography) and the number of CO_2 I are increased relative to the H_2O and CH_4-N_2 I. The molar fraction of CO_2 increases substantially in zone III, where the first migmatites appear. The H_2O:CO_2 ratios are estimated as 0.8-0.2 for V_2 from the zone of low-T metamorphism (zone II) and 0.6:0.4 for zone III. Use has been made of solid-state thermometry, the densities of the CO_2 I of various ages, and the Th of the aq I to propose an evolutionary trend for the progressive and regressive metamorphism in the complex. (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: Dok. Ross. Akad. Nauk, 1995, v. 342, No. 2, p. 226-229 (in Russian, translated in Trans. (Doklady), Russian Acad. Sci., Earth Sci. Sect., v. 344, p. 203-207, 1996) Authors at Inst. for Precambrian Geol. and Dating, Russian Acad. of Sci., St. Petersburg.

Abst. in FIR 28, p. 151 (E.R.)

SEGALSTAD, T.V., 1996a, The distribution of CO_2 between atmosphere, hydrosphere, and lithosphere; minimal influence from anthropogenic CO_2 on the global greenhouse effect: in The Global Warming Debate, John Emsley, Editor, 1996, The Report of the European Science and Environment Forum; ISBN 0952773406; published by Bourne Press, Ltd., Dorset, UK, 288 pp., p. 41-50.

The global climate is primarily governed by the enormous heat energy stored in the oceans and the latent heat of the ice caps, not by the small amount of heat that can be absorbed in atmospheric CO_2. Human contribution to atmospheric CO_2 from the burning of fossil fuels is small (4% at most), according to carbon isotope mass balance calculations. The effect of this contribution to global warming is small and well within natural climatic variability. The amount of fossil fuel carbon is small compared to the total amount of carbon in the atmosphere, hydrosphere, and lithosphere. The lifetime of atmospheric CO_2 is about 5 years. The ocean will be able to absorb the larger part of the CO_2 that humans can produce through burning of fossil fuels. The IPCC CO_2 global warming model is not supported by the scientific data. Based on geochemical knowledge there should be no reason to fear a climatic catastrophe because of human release of the CO_2 gas. (Authors' abstract.)

SEGALSTAD, T.V., 1996b, The ore mineralization at the Kongsberg silver mines, Norway: Fractures, Fluid Flow and Transport in Fractures, 10th Kongsberg Seminar, 8-10 May 1996, Kongsberg, Norway, program, unpaginated. Author at Mineralogical-Geological Museum, Univ. of Oslo, Sars' Gate 1, N-0562 Norway.

The Kongsberg district native silver-bearing calcite veins are known to occur where the fracture system intersects "Fahlbands," i.e. schistose zones in the Precambrian gneisses rich in iron sulfides (mainly pyrrhotite).

FI T of formation range between 200 and 300°C when applying a pressure correction assuming hydrostatic pressure of 350 bar at 3.5 km stratigraphic depth (Segalstad et al., 1986). Sal range from 0-35 equivalent wt.% NaCl. The I data of Johansen (1985) reveal at least 3 different heating and cooling cycles with associated sal cycling.

Native silver has generally been deposited during the heating part of the cycles from 250 to 300°C associated with a decrease in sal from about 27-22 to about 20-15 eq.wt.% NaCl (absolute values different for different mines and different cycles). Mineralizing F which reached T less thatn 250°C and/or reached sal maxima less than 22 eq. wt.% NaCl have not been found to deposit native silver.

Barite is most often found as separate veins; these veins show isotopic $\delta^{34}S$ (vs. CDT) values corresponding to sulfate in contemporaneous Permian sea water (12‰). Fahlband sulfur (0‰) is a likely source for the vein sulfides of the main ore forming stages.

$\delta^{13}C$ (vs. PDB) of carbonaceous material in the veins (coalblende) (-30 to -28‰) points to Oslo Region shales (-29 to -22 ‰) as possible sources for the major part of the carbon in coalblende and calcite (-26 to -1‰) in the silver-bearing veins. G analyses of FI in vein gangue show roughly CH_4 and CO_2 in equal amounts, and the find of petroleum I in vein gangue point out that carbon also could have been present in the L state in the mineralizing F.

$\delta^{18}O$ (SMOW) of whole rocks and vein quartz and vein calcite (7 to 26‰) show that the mineralizing F must have been "crustal water," i.e. mainly meteoric water which has exchanged oxygen isotopes with the crustal rocks.

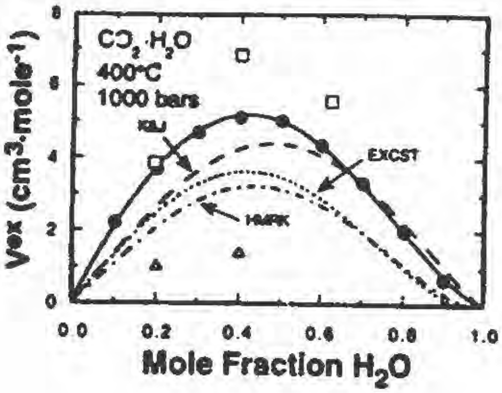
Thermochemical modeling shows that the hydrothermal solution was poor in sulfur ($\Sigma S \leq 0.001$ m) and rich in carbon ($\Sigma C \geq 0.001$ m). Chemical reactions between a saline solution of this kind and pyrrhotite in the Fahlbands at the T of minimum calcite solubility (near 250°C) consumed protons raising the pH of the localized, now closed system F in the tension gashes, leading to the deposition of first argentite and then native silver with coalblende. When pyrrhotite stability had been reached in the mineralizing sequence, equilibrium with wallrocks was reached, and the mineralization of silver minerals ended.

The Kongsberg silver district hydrothermal system could have acquired its silver through leaching of the black shales of the Oslo Region, like it acquired its carbon, either locally from the shales overlying and falling into the opening fractures (Frøyland & Segalstad, 1992), and/or by the hydrothermal F flowing along the sub-Cambrian conglomerate in the Oslo Region (Segalstad & Ohmoto, 1990). In a 50 m thick prism of such black shale, overlying the 5 x 20 km Kongsberg hydrothermal system area, it will just be necessary to leach one tenth of silver available in the shale in order to deposit the 2000 tons of silver exploited from the mines. The solutions would require only some 3 ppm of the available FeS in the Fahlbands to deposit the 2000 tons of known silver once present in the mines (From author's abstract by E.R.)

SEITZ, J.C. and **BLENCOE, J.G.**, Experimentally determined volumetric properties of CO_2 - H_2O mixtures at 400°C and pressures up to 1000 bars (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A159. First author at Chemical and Analytical Sci. Div., Oak Ridge Nat'l. Laboratory, P.O. Box 2008, Bldg. 4500S, MS-6110, Oak Ridge, TN 37831-6110; e-mail (seitzjc@ornl.gov)

Densities of CO_2 - H_2O mixtures were measured at 400°C and pressures up to 1000 bars using a custom-designed, high-T, high-P vibrating-tube densimeter. Precisions achieved were: ± 0.1 bar and ± 0.01°C. Conservative estimates of accuracy are: ±0.2 bar and ± 0.05 kC. Uncertainties for measured densities are < ±0.0010 g/cm^{-3}.

The density data were used to calculate molar volumes (V) and excess molar volumes (V^{ex}). Because the volumetric properties of pure CO_2, pure H_2O, and CO_2 - H_2O mixtures were determined at constant T and P in each experimental session, V^{ex} was determined with high precision from a single, internally consistent set of results. In the figure, our experimentally determined values for V^{ex} at 400°C and 1000 bars are shown as filled circles; open triangles and the open squares represent the experimental data of Franck and Tödheide (1959) and Zakirov (1984), respectively. Also plotted are V^{ex} curves calculated from three equations of state: EXCST represents the extended corresponding states model of Ely and Huber (1990), and K&J and HMRK reprresent the modified Redlich-Kwong equations of Kerrick and Jacobs (1981) and Holloway (1977), respectively. We have also compared our experimentally determined molar volumes with values calculated from equations of state. Maximum discrepancies (V_{exp} – V_{calc} / V_{exp}; 400°C and 1000 bars) between our data and predictions of the EXCST, K&J, HMRK equations are 1.4%, –1.9%, and 5.6%, respectively. (Author's abstract)



SEITZ, J.C., PASTERIS, J.D. and CHOU, I-Ming: Raman spectroscopic characterization of gas mixtures. II. Quantitative composition and pressure determination of the CO_2-CH_4 system: American J. of Science, v. 296, p. 557-600. First author at Chemical and Analytical Sci. Div., Oak Ridge Nat'l. Laboratory, P.O. Box 2008, Bldg. 4500S, Oak Ridge, Tennessee 37831-6110.

`Raman spectral parameters were determined for the v_1 band of CH_4 and the v_1 and $2v_2$ bands (Fermi diad) of CO_2 in pure CO_2 and CO_2-CH_4 mixtures at pressures up to 700 bars and room T. Peak position, area, height, and width were investigated as functions of pressure and composition. The application of these spectral parameters to a suite of natural CO_2-CH_4 I has yielded internally-consistent, quantitative determinations of the F composition and density. (From authors' abstract by E.R.)

SELBY, David and NESBITT, B.E., 1996, A fluid inclusion and stable isotope study of the Endako porphyry molybdenite deposit, British Columbia: Implications for P-V-T-X history of ore and post ore fluids (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 116-117. Dept. of Earth and Atmospheric Sci., Univ. of Alberta, Edmonton, Canada, T6G 2E3.

Mineralized veins are characterized by L-rich and halite-bearing FI. This study has sub-divided these I into 3 types: Type 1, liquid + vapour ± opaque dm and liquid + vapour ± translucent dm; Type 2, liquid + vapour and Type 3, liquid + vapour + halite. Type 1 and 3 I are further sub-divided into sub-populations by microthermometric behavior and are typically P, whereas type 2 are generally S. Type 1 and 3 I characterize veins bordered by potassic selvages and Type 1 I characterize veins bordered by phyllic selvages. Type 2 I are predominant in ribbon veins, especially in those characterized by brecciation and quartz recovery textures. Type 1 I have sal between 5 and 15 wt.% NaCl eq., with modes of 7 to 9 wt.% NaCl eq. The I homogenize by V bubble disappearance and by critical behavior at T between 250 and 550°C, with modes at 360 to 370°C, and 390 and 410°C. Sal of Type 1 I from veins bordered by potassic and phyllic selvages overlap considerably; however, Th of I from veins bordered by phyllic selvages are generally 20 to 50°C lower than those bordered by potassic selvages. Type 2 I have salinities between 0.2 and 5 wt.% NaCl eq. I in calcite have sal between 3.1 and 4.2 wt.% NaCl eq. Homogenization by V bubble disappearance occurs at T between 130 and 285°C, with modes at 150 and 170°C and 190 to 230°C. I in calcite homogenize at T between 208 and 210°C. Type 3 I which homogenize by V bubble disappearance occurs at T between 375 and 420°C and have sal of 30 to 45 wt.% NaCl, and those which homogenize by halite dissolution occur at T between 410° and 550°C and have sal of 45 to 60 wt% NaCl eq (Bloom, 1981).

FI studies of Dawson (1972) and Bloom (1981) and this study suggest that Type 3 I were not generated by aq F immiscibility. If aq F immiscibility had occurred to form these I, sal (L+V+H) I should coexist with a low-sal V-rich I, which have similar final Th. However, the latter population was not observed during this study nor by Dawson (1972) or Bloom (1981). Dawson (1972) suggested trapping P of 530 to 720 bars for a I of 30 wt % NaCl trapped at T of 500 to 550°C and Bloom (1981) suggested P fluctuations between extremes of lithostatic and hydrostatic load.

Stable isotope analyses of potassic, phyllic and argillic alteration phases yield depleted δD and enriched $\delta^{18}O$ values.

Results from FI (types 1 and 3) studies of veins bordered by potassic selvages suggest the involvement of saline (30-60 wt.% NaCl eq., Bloom, 1981) and low sal (6-15 wt.% NaCl eq.) magmatic F (>480°C, Dawson, 1972) in the origin of the Endako molybdenum deposit. However, quartz δD_{FInc} values deviate from generally accepted magmatic isotopic values, suggesting the early involvement of meteoric water in magmatic F and ore genesis. (From authors' abstract by E.R.)

SELBY, David, NESBITT, B.E. and MUEHLENBACHS, Karlis, 1996, Stable isotope characteristics of the Endako molybdenite deposit, British Columbia: Implications for fluid evolution (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A84. First author at Dept. of Earth and Atmospheric Sci., Univ. of Alberta, Edmonton, Canada, T6G 2E3.

The Lower Jurassic, Endako quartz monzonite of the Francois intrusion suite of central British Columbia hosts Canada's largest porphyry molybdenum deposit, the Endako mine. The deposit features potassic, phyllic and argillic alteration zones, with ore mineralization associated with both stockwork and structurally controlled, ribbon textured veins.

Stable isotope analyses of potassic, phyllic and argillic alteration phases yield depleted δD and enriched $\delta^{18}O$ values. Quartz from quartz molybdenite stockwork and ribbon textured veins and hydrothermal K-feldspar and biotite associated with potassic selvages, yield $\delta^{18}O$ values, of 8 to 9.3‰, 4.2 to 6.6‰ and 3.1 to 4.5‰, respectively. Hydrothermal biotites, which have altered to phlogopite and clinochore, yield depleted $\delta^{18}O$ values of 1.8 and −2.1‰. Kaolinite from argillic alteration yields $\delta^{18}O$ values of 6.6 to 6.9‰ and δD values of −156‰. Quartz from quartz molybdenite stockwork and ribbon textured veins yield δD_{FInc} values of −105 to −157‰.

$\Delta_{qtz\text{-}Ksp}$ and $\Delta_{qtz\text{-}bio}$ values suggest isotopic equilibrium T of 440°C and 480°C. These data are in good agreement with FI filling T from quartz-Mo veins with potassic selvages. $\delta^{18}O_{H_2O}$ values for quartz, biotite and K-feldspar calculated at 550°C, 480°C, and 440°C, respectively give values of 6.7, 6.4 and 3.8‰. δD_{H_2O} values of kaolinite calculated at 100°C gives a value of −143‰. Results from both FI and $\delta^{18}O$ studies suggest involvement of magmatic F in the origin of the Endako molybdenum deposit. Quartz δD_{FInc} values deviate from generally accepted magmatic isotopic values, suggesting the early involvement of meteoric water in magmatic F and ore genesis. (Authors' abstract)

SELF, S. and **KING, A.J.**, 1996, Petrology and sulfur and chlorine emissions of the 1963 eruption of Gunung Agung, Bali, Indonesia: Bull. Volcanol, v. 58, p. 263-285. Authors at Hawaii Center for Volcanol., Dept. of Geol. and Geophy., School of Ocean and Earth Sci. and Tech., Uiv. of Hawaii at Manoa, Honolulu, Hawaii 96822, USA.

The 1963 eruption of Gunung Agung provided evidence for magma mixing. Basalt magma mixed with pre-existing andesite magma shortly before eruption to yield basaltic andesite with a T of 1040-1100°C at an assumed pressure of 2 kb, fO_2>NNO, and an average M volatile content ($H_2O \pm CO_2$) of 4.3 wt.%. Magma-mixing end members may have provided some of the S and Cl emitted in the eruption. Glass I in phenocrysts contain an average of 650 ppm S and 3130 ppm Cl as compared with 70 ppm and 2220 ppm, respectively, in the matrix glass. Maximum S and Cl contents of glass I approach 1800 and 5000 pm, respectively. Application of the petrologic method to products of the 1963 eruption for estimating volatile release yields of 2.5×10^{12}g (Mt) of SO_2 and 3.4 Mt of Cl released from the 0.65 km^3 of juvenile tephra. An independent estimate of SO_2 release from atmospheric aerosol loading (11-12 Mt) suggests that approximately 7 Mt of SO_2 was injected into the stratosphere. The difference between the two estimates can be most readily accounted for by the partitioning of S. as well as some Cl. from the magma into a water-rich V phase which was released upon eruption. For other recent high-S-release eruptions of more evolved and oxidized magmas (El Chichón, Pinatubo), the petrologic method gives values two orders of magnitude less than independent estimates of SO_2 emissions. Results from this study of the Agung 1963 magma and its volatile emissions, and from related studies on eruptions of more mafic magmas, suggest that SO_2 emissions from eruptions of higher-S-solubility magma may be more reliably estimated by the petrologic method than may those from more-evolved magma eruptions. (From authors' abstract by E.R.)

SELIVERSTOV, V.A., GORSHKOV, A.I., SHCHEKA, S.A. and **SIVTSOV, A.V.**, 1996, Diamonds and carbonado of the Primorskii Krai: mineralogy, crystal chemistry, and genesis: Geol. Ore Deposits, v. 38, p. 429-441. First author at Russian Acad. Sci., Inst. Geol. Ore Deposits Petrography Mineral & Geoc., Staromonetnyi p, Russia.

The diamonds and carbonado discovered in the Primorskii Krai gold-bearing placers suggest this region is a part of the large north China diamond-bearing province. The different diamond varieties found here were formed by different processes. The structural features of the diamond single crystals (twinning, growth patterns, structure defects) and the composition of mineral I in diamond (chromium-free omphacite, Mn-bearing ilmenite) indicate that the diamonds formed at T and P of eclogite facies of metamorphism rather than at the parameters of their thermodynamic stability. The carbonado composition is dominated by native element minerals (diamond, aluminum), oxides (rutile, anatase), silicates (zircon), phosphates (xenotime and monazite), and hydroxyl-aluminophosphates (gorceixite, florencite). The structural relations point to the succession of mineral formation from diamond and rutile to hydroxyl-aluminophosphates. From their porous texture, grain and pore size, and the defects of the cubic structure of the diamond microcrystals, the carbonado polymineral aggregates were assumed to form in the pneumatolytic process at low P, high T gradients, and variable gaseous phase composition. Such conditions are typical of the open magmatic systems of subvolcanic and volcanic environments. The occurrence of the regularly oriented hexagonal lonsdaleite layers in the diamond structure is attributed to the dislocations in the cubic lattice of carbon atoms. These anomalies are probably syngenetic and due to the kinetics of crystalline carbon synthesis. The Late Jurassic ultrabasic volcanic rocks are suggested as the source for a diamond placer that contains diamond single crystals and polycrystalline aggregates. (Authors' abstract)

SERAFIMOVSKI, T., CIFLIGANEC, V., JANKOVIC, S. and **BOEV, B.**, 1996, Genetic model of the Buchim porphyry copper deposit, Republic of Macedonia: Plate tectonic aspects of the Alpine Metallogeny in the Carpatho-Balkan Region, Proceedings of the Annual Meeting, Sofia, UNESCO-IGCP Project No. 356, v. 1, p. 63-74.

Includes description of I and list of Th data. (F. Molnar)

SERRANO, L., VARGAS, R., STAMBUK, V., AGUILAR, C., GALEB, M., HOLMGREN, C., CONTRERAS, A., GODOY, S., VELA, I., SKEWES, M.A. and **STERN, C.R.**, 1996, The late Miocene to early Pliocene Río Blanco-Los Bronces copper deposit, central Chilean Andes: *in* "Andean copper deposits: new discoveries, mineralization, styles and metallogeny," Soc. Econ. Geologists Special Publication No. 5, Camus, F., Sillitoe, R.H. and Petersen, R., eds, 1996, p. 119-130. First author at División Andina, CODELCO, Casilla 6A, Los Andes, Chile.

Río Blanco-Los Bronces, one of three giant late Miocene to early Pliocene copper deposits in the Andes of central Chile, formed as a result of emplacement of both multiple mineralized breccias and porphyry intrusions into early and middle Miocene plutonic rocks and Cenozoic lavas. The deposit is distinctive in that a significant proportion of the >50x10^6 Mt of Cu it contains occurs within the matrix of mineralized breccia pipes or disseminated in the host rocks around the breccias.

FI and O-, S-, and H-isotopic data indicate that the metal-rich F that generated both the older biotite-rich and younger tourmaline-rich breccias, and caused the potassic and sericitic alteration associated with these two breccia generations, were magmatic in origin. Sr- and Nd-isotopic data imply that the magmas that exsolved the breccia-forming F, as well as those that formed the late porphyries, were distinct isotopically from the older host rocks of the deposit. The breccia-forming F are believed to have exsolved from magmas that crystallized to form plutons that are still not exposed at the surface, consistent with the deep, as yet unknown roots of these breccias. (From authors' abstract by E.R.)

SETTERFIELD, T.N., 1996, Geochemical and mineralogical alteration in porphyry style to epithermal hydrothermal systems, Tavua Caldera, Fiji (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A19–A20. Author at WMC Internat'l. Ltd., 22 Gurdwara Rd., Nepean, Ontario, Canada, K2E 8A2; e-mail (76002.1356@compuserve.com)

Porphyry-style, subeconomic Cu-Au mineralization, with associated albitic, phyllic and propylitic mineral assemblages, occurs at depth in the center of the shoshonitic Tavua Caldera, Viti Levu, Fiji. High sulphur-style epithermal alteration and minor Au mineralization occur above and are superimposed on the upper parts of the porphyry system. Low sulphur epithermal mineral assemblages and associated Au concentrations, including the ≥ 8.5 M oz. Emperor Au deposit, occur on the caldera margins. The caldera thus contains a continuum of mineralization and alteration styles, which are interpreted to have been localized by migration of intrusive activity and related hydrothermal circulation systems.

Porphyry-style alteration mineral assemblages contain variable amounts of illite, albite, quartz, anhydrite, chlorite, actinolite, carbonate, biotite, magnetite and copper sulphide minerals. These minerals, plus calculated formation T of chlorite from these assemblages, indicate F T in the 270 to 340°C range. Chemical ranges during alteration include addition of S, As and Cu, and loss of Ca, Mg, K and locally Fe. High sulphur epithermal alteration produces an advanced argillic assemblage, including alunite, pyrophyllite and diaspore. S and As are added; Fe, Mg, Ca, Na, K and Cu are all greatly depleted. The low sulphur epithermal mineral assemblage consists of early chlorite, carbonate and quartz, which occur throughout the deposit, and a late assemblage of quartz-adularia-illite-carbonate-ore minerals, which are proximal to the lodes. FI data and calculated T of formation of chlorite from the low sulphur epithermal assemblage indicate F T in the neighbourhood of 200°C. In mine-scale alteration, K and CO_2 are added whereas Mg, Ca, Na, Fe and SiO_2 are lost. In lode-related alteration, K, SiO_2, S, As and Au are added, and the rock is depleted in Mg, Ca, Na and Fe. TiO_2, Al_2O_3 and Zr are calculated to have been virtually immobile in all alteration processes. (Author's abstract)

SEWARD, T.M., HENDERSON, C.M.B., CHARNOCK, J.M. and DOBSON, B.R., 1996, An X-ray absorption (EXAFS) spectroscopic study of aquated Ag^+ in hydrothermal solutions to 350°C: Geoch. Cosmo. Acta, v. 60, no. 13, p. 2273-2282. First author at Inst. für Mineralogie und Petrographie, ETH-Zentrum, CH-8092 Zürich, Switzerland.

SHA, Deming, 1996, Gold deposits in west Tianshan Mountains: the late Paleozoic epithermal ones (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 652. Author at Shengyang Inst. of Geol. and Mineral Resources, China.

The gold deposits related with volcanism are epithermal ones and were divided into two types by the author: the adularia-sericite type silicified rock type. The adularia-sericite gold deposits (for example Axi gold deposit) have typical mineral assemblage of adular+sericite+quartz and low-T element assemblage of Au, Ag, As, Sb, Te, Se, etc. The gold mineralization were formed at 324.4-338.2 Ma in low-T (87-260°C), low-pressure (72-218x10^5 Pa) and enclosed reduction environment. The silicified rock type gold deposits (for example Yiermande gold eposit) is charac-terized by intense silicification and has low-T element assemblage of Au, As, Sb, Bi, Hg, Se etc. and has many similar features comparing with the Nansatus type gold deposit in Japan. (From author's abstract by E.R.)

SHANGGUAN, Zhiguan, KONG, Lingchang, SUN, Fengmin, GAO, Songsheng and XU, Xiangxi, 1996, Deep-seated fluid components and stable isotopic compositions in Tianchi Volcanic area, Changbaishan Mountains: Scientia Geologica Sinica, v. 31, no. 1, p. 54-64 (in Chinese, Engl. abst.)

The features of deep-seated F component and stable isotopic compositions in Tianchi volcanic area indicate that there are four water-bearing formations of every description. They are respectively the cold water aquifer (depth <2.2 km), upper, middle and deep-seated geothermal water (depths are separately 2.2-3.4 km, 3.5-3.9, >4.0 km). The modern geothermal water activity [are] all associated with strong deep-seated G discharges. The ratios of the carbon and helium stable isotopes suggest these deep-seated G came mostly from the mantle-derived magma. Among them there was a little air, and the contamination of the crust source G was not important. And now the mass mantle-derived G discharges concentrate mainly around the Tianchi caldera lake. It is entirely possible to exist fixed [place] hot mantle-derived magmatic reservoir in shallow crust there. Based on the carbon isotope geothermometer, the top of magmatic reservoir is 5 km from the land surface in crust. The G dynamic change monitoring suggests this hot magmatic reservoir is instable now, and must take the matter seriously. (Authors' abstract)

SHARPE, Robina, 1991, The distribution, mineralogy and paragenesis of the Hellyer baritic and siliceous caps: Bachelor of Science thesis, Univ. of Tasmania, 114 pp and appendices.

Baritic and siliceous caps are a feature of many volcanic-hosted massive sulphide deposits. Their distribution, mineralogy and geochemistry are important to the understanding of the genesis of these deposits.

Sulphur isotope studies of barite (with $\delta^{34}S$ values between +38 and +50 per mil) and pyrite (with $\delta^{34}S$ values between +6 and +18 per mil) revealed a duality in the source of sulphur during formation of the caps; incompletely reduced seawater sulphur, and magmatic sulphur. The wide range of $\delta^{34}S$ values are thought to be the result of fluctuating contributions from these two sulphur sources.

Formation of the barite cap at or above the seawater interface is interpreted to be the result of oxygenated seawater mixing with spent hydrothermal F enriched in barium, during periods of low hydrothermal flux, at T between 230 and 250°C. By contrast, silica cap precipitation requires the local dominance of H_2S and a combination of conductive cooling and mixing. This is evidenced by the presence of arsenopyrite, and the absence of hematite. (From author's abstract by E.R.)

SHARYGIN, V.V., STOPPA, F. and KOLESOV, B.A., 1996a, Zr-Ti disilicates from the

Pian di Celle Volcano, Umbria, Italy: European J. of Mineral., v. 8, no. 5, p. 1199-1212.

SHARYGIN, V.V., STOPPA, F. and **KOLESOV, B.A.**, 1996b, Cuspidine in melilitolites of San Venanzo, Italy: Dokl. Akad. Nauk, v. 348, no. 6, p. 800-804 (in Russian).

Rare diorthosilicate, cuspidine $Ca_4[Si_2O_7]F_2$, has been identified in polycrystal, M and combined (polycrystal + melt) I hosted by melilite from melilitolite of the Pian di Celle volcano. It is first finding of this mineral in magmatic silicate rocks *in situ*. Phase relationships inside I suggest the following sequence of their formation: Ti-magnetite ->phlogopite ->apatite ->kalsilite, clinopyroxene, götzenite ->Fe-sulphide ->glass. The glass of melilite-trapped I began to melt at 680-720°C. Colorless dp (kalsilite, cuspidine, göttzenite) fused at 770-860°C Unfortunately, complete homogenization of MI did not reach due to possible leakage. The decreasing of G bubble was fixed up to 850-900°C.

In contrast of cuspidine from skarns, the broad variations in the contents of CaO (58-44), ZrO_2 (0.2-10.6), Na_2O (0.5-3.6) and F (10.1-8.5 wt.%) are characteristic of the Pian di Celle mineral from core to rim. These variations assume possible existence of a limited solid solution between monoclinic cuspidine $Ca_4[Si_2O_7]F_2$ and triclinic hiortdahlite $NaCa_2Zr[Si_2O_7]OF$ (preferably, pseudomonoclinic hiortdahlite-2) owing to complex substitution $2Ca^{2+} + F^- <=> Na^+ + Zr^{4+} + O^{2-}$. Maximum contents of ideal hiortdahlite end-member in studied cuspidines is up to 39 mole% with 15% substitution of Ti for Zr.

Raman spectroscopy of cuspidines from San Venanzo together with cuspidine from the Anakit massif (Siberia) and hiortdahlite-1 from Langesundfjord (Norway) supports a possibility of solid solution and show that cuspidine with 10.5 wt.% ZrO_2 preserved monoclinic symmetry.

Peralkaline evolutionary character of initial melilitolite M rich in Ca, Zr, F and undersaturated in Si was favorable to form cuspidine at T>770-860°C and P<1 kb. (Abstract courtesy of Dr. V. V. Sharygin)

SHCHERBAN, D., 1996, Geology and physicochemical conditions of formation of epithermal fluorite deposits (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 675. Author at Colorado School of Mines, Golden, CO, U.S.A.

SHEARER, C.K., WIEDENBECK, M., SPILDE, M.N. and **PAPIKE, J.J.**, 1996, Element partitioning between immiscible high-Fe basaltic melt and high-Si rhyolitic t (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A288. First author at Inst. of Meteoritics, Dept. of Earth and Planetary Sci., Univ. of New Mexico, Albuquerque, NM.

We report the element partitioning between high-Fe basaltic M and high-Si, "rhyolitic" M coexisting within I in plagioclase crystals from Apollo 12 olivine basalts. These immiscible MI are typically rectangular in shape with orbicular rhyolite immersed in a basaltic matrix. Individual I are up to 120 µm in length with the immiscible "rhyolitic" spherules reaching 40 µm in diameter. The basalt component of the I is quartz-hypersthene normative with low Mg# (0.38 to 0.04). The "rhyolitic" component is corundum normative with a range of compositions from a high-Si, -K rhyolite to anomalously high-Si "rhyolite". The anomalous "rhyolites" are associated with basaltic I with lower Al_2O_3, alkali element abundance and higher Mg#. This range of compositions may reflect changes in the immiscibility field. Prior to ilmenite becoming a liquidus phase, the ratios between large-cation, low-valence lithophile elements and high field strength elements would not have changed appreciably during the fractional crystallization of the A12 olivine basalt. These crystallization characteristics will be compared to the trace element characteristics of the different immiscible M components determined by ion microprobe. (From authors' abstract by E.R.)

SHEETS, R.W., NESBITT, B.E. and **MUEHLENBACHS, Karlis**, 1996a, Meteoric water component in magmatic fluids from porphyry copper mineralization, Babine Lake area, British Columbia: Geology, v. 24, no. 12, p. 1091-1094. Authors at Dept. of Earth and Atmos. Sci., Univ. of Alberta, Alberta T6G 2E3, Canada.

Coexisting V-rich and high-sal "magmatic" FI from mineralized quartz±carbonate veins in porphyry Cu systems of the Babine Lake area are depleted in deuterium (D) relative to accepted magmatic isotopic values. The δD compositions of high-sal F from early mineralized veins range from -100‰ to -135‰ (standard mean ocean water), whereas FI in late veins and breccias have δD values between -138‰ to -153‰, and unmineralized, regional veins have δD values from -94‰ to -150‰. Multiple δD analyses of F from I are within ±5‰ for 14 of 17 duplicate analyses, which suggests that mixing of FI populations did not contribute significantly to the D-depleted values. A correlation between $\delta^{13}C$ values of vein carbonate and δD values of IF indicates that postentrapment reequilibration did not significantly alter isotopic compositions of FI. Incorporation of externally derived low-D material into the mineralizing intrusions, either from the influx into the M of deeply convected, evolved meteoric F or by crustal assimilation of D-depleted country rock, is required to explain the observed D-depleted values of the magmatic F. (Authors' abstract)

SHEETS, R.W., NESBITT, B. and **MUEHLENBACHS, K.**, 1996b, Comparative geochemistry of porphyritic intrusions of the Babine lake Area, west-central B.C.: Implications for porphyry Cu exploration (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A93. First author at Dept. of Earth and Atmospheric Sci., Univ. of Alberta, Edmonton, Alberta T6G 2E3.

An investigation of the Babine Lake porphyry Cu systems was conducted to determine if geochemical differences exist between mineralized and barren systems. Biotites from economic deposits exhibit more depletion in TiO_2 and Al_2O_3 and enrichment in F than sub-economic deposits. The Cl content of biotite decreases away from the ore zone in all Cu occurrences, but shows little variation between deposits. The halogen content of apatite is bimodal in the economic deposits with one group being enriched in Cl relative sub-economic deposits and unmineralized intrusions. Apatite from the lowest grade prospects are depleted in total F + Cl relative to apatite from economic and unmineralized systems. Changes in halogen chemistry of apatite occur irrespective of the sal of FI, which are similar for all deposits studied. All potassic alteration assemblages have Th greater than 450°C. Whole rock delta) ^{18}O values vary; higher grade deposits are depleted (3.5-8.0 ppt) relative to lower grade deposits and unmineralized granodiorites (both 6.5-10.0). The O-18 depletion is also observed in biotite: unmineralized and sub-economic systems systems have biotite values (5.3 to 6.6) higher than economic deposits (3.7 to 5.4). (From authors' abstract by H.E.B.)

SHEKHAWAT, M.S., 1996, Steatitization of ultramafic rocks of Dungarpur-Kherwara-Rikhabdev area, Rajasthan, India (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 670. Author at Dept. of Geol., M.L.S. Univ., Udaipur, India.

In Rahjasthan, ultramafic rocks host rich deposits of talc. The formation of talc deposits are the result of metamorphism of serpentinite bodies in upper green schist to lower amphibolite facies. The FI study and mineral assemblages suggest that the talc bearing rocks were subjected to a P of nearly 2.5 kb and T of about 400°C. (From author's abstract by E.R.)

SHELTON, K.L., UNDERWOOD, M.B., BURSTEIN, I.B., HAEUSSLER, G.T. and **HOWELL, D.G.**, 1996, Stable-isotope and FI studies of hydrothermal quartz and calcite veins from the Kandik thrust belt of East-Central Alaska; implications for thermotectonic history and terrane analysis: U.S. Geol. Surv. Bull B-2142, p. 111-131. Authors at Univ. of Missouri, Dept. of Geol. Sci., Columbia, MO, US.

SHEN, A.H., 1996, New technologies for hydrothermal experiments using resistance-heated diamond-anvil cells (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 555. Author at Bayerisches Geoinstitut, Universität Bayreuth, D-95440 Bayreuth, Germany.

After the introduction of the hydrothermal diamond-anvil cells for the studies of F PVTX properties, much progress has been made. This progress consists of the success of combining modern spectroscopic and GHz ultrasonic technologies with the hydrothermal diamond-anvil cells. This contribution describes experiments conducted in the author's institution and extends the techniques to possible applications in the future high P-T experimental studies of F.

Fourier transform infrared spectrometry was used to determine the water speciation in peraluminous silicate M up to 10 kbar and 1000°C. GHz ultrasonic interferometry was successfully combined with the hydrothermal diamond cells. This technique can be used to determine the elastic properties of F and to derive very precise PVTX properties of F. (From author's abstract by E.R.)

SHEN, Kun, XU, Huifen, YANG, Tiannan, and **XU, Zhiqing,** and 1996, Characteristics of metamorphic fluids in the eclogites and its countryrocks from the ultra-high-pressure metamorphic belt in the Jiaonan terrain, China (abst.): 30th Int'l Geol. Cong., Abstracts, v, 2, p. 480. First author at Shandong Inst. of Geological Sci., China.

The Jiaonan terrain is a part of the Dabie-northern Jiangsu-eastern Shandong ultrahigh-pressure metamorphic belt. Here eclogites occur as lenses, layers and irregular bodies in felsic gneisses, metasediments and ultramafics. The massive eclogites in gneisses contain only aq I of low-medium sal (type I) while those in ultramafics may contain $N_2 \pm CO_2$ I (type II). Phengite-quartz vein in the eclogites and retrograde eclogites with hornblende+plagioclase+quartz symplectite contain abundant CO_2-H_2O I and salt-saturated aq I with one (or more) solid(s) in addition to type I and II inclusions. The mylonitic gneisses and quartz veins which have undergone ductile deformation contain aq I with very low sal as well as some CO_2-H_2O I.

Most I are fracture-bound; however, some I in pyroxene in the eclogites and in garnet and quartz protected by garnet in the surrounding garnet-magnetite quartzite contain isolated (primary?) I. Microthermometric and mineral equilibrium data indicate that the P-T conditions for the entrapment of the earliest I are only compatible with those for the amphibolites after retrogression from the eclogites but much lower than the conditions at which the coesite-bearing eclogite formed.

A high water activity of the metamorphic F during eclogitization. The ultra high-P belt in the Jianonan terrain has experienced a clockwise P-T evolution of isothermal decompression (quick uplift). (Authors' abstract.)

SHEN, Weizhou, WANG, Dezi, LIU, Changshi, XIONG, Xiaolin and **LAI, Mingyuan,** 1996, Characteristics and origin of the Yanbei Porphyry tin deposit: Geol. J. of Universities, v. 2, no. 1, p. 85-91. Authors at Dept. of Earth Sci., Nanjing Univ.

The Yanbei porphyry tin deposit (Sn-F type) is characterized by enrichment of topaz of magmatic origin and thus differs from the world-famous Bolivian porphyry tin deposits (Sn-B type) which were rich in tourmaline. The ore-bearing parent rocks are Mesozoic volcanic-intrusive complex. They have high silica, peralumina, enriched incompatible elements, weak Ce and intensive Eu negative anomalies and lower ε_{Nd} values, high $^{207}Pb/^{204}Pb$ and higher $(^{87}Sr/^{86}Sr)$, and $\delta^{18}O$ values. These features indicate that the ore-bearing parent rocks were derived from the crustal materials and belong to the continental crust remelting type.

The ore bodies were located at the contact zone of granite porphyry with rhyolite porphyry in great thickness and homogeneous mineralization. Mineralogical composition of the deposit is relatively complex, of which cassiterite, pyrite and chalcopyrite are dominant, sphalerite and galena are less important. The wall-rock alterations are intense in mining district and are roughly grouped into three zones in space: topazitization, chloritization and sericitization from granite porphyry to fresh country rocks. The potassic zone which is typical for other porphyry type deposits is very weak in this ore district. The ore-forming T are mainly in the ranges of 339-324°C, 280-228°C and 180-129°C, displaying polymodal distribution feature. The ore-forming solution has $\delta^{18}O$ value of 7.8-4.2‰ and δD value of -49‰ to -61‰, indicating that it consisted dominantly of magmatic water. Lead isotopic compositions of pyrite are similar to those of feldspar in volcanic-intrusive complex and $\delta^{34}S$ values (-0.3‰-1.5‰) of pyrite close to zero. These characteristics suggest that the ore-forming materials were mainly derived from the magma. Therefore, the mineralization of Yanbei porphyry tin deposit is closely related to Mesozoic volcanic-intrusive complex in time, space and material source. (Authors' abstract)

SHENTU, Baoyong, WANG, Zeng, and **YAO, Peng,** 1996, The origin and evolution augen-gnessic granitiod in Zayü of Tibet, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 606. Authors at Chengdu Inst. of Geol. and Mineral Resources, CAGS, Chengdu 610082, Sichuan, China.

There are many very small [sized?] L and G-L I in feldspar or quartz augen their Th is 310°-315°C. The distribution types of the I are usually band plumose, and echelon in shope. The depth of the deformation is regarded as 10 km underground. (From authors' abstract by E.R.)

SHEPHERD, A.D., FENSTER, S. and **HUFF, W.D.,** 1996, Mineralogical and chemical characteristics of the Deicke, Millbrig and other Middle Ordovician K-bentonites from Big Ridge, Etowah Co., Alabama: Geological Soc. of America abstracts with programs, v. 28, no. 3, p. 98-99.

Indexed under FI (E.R.)

SHEPHERD, T.J. and **CHENERY, S.R.,** 1996, Chemical characterisation of hydrothermal fluid inclusions by laser ablation-ICP-mass spectrometry (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 118. First author at British Geol. Survey, Nicker Hill, Keyworth, Nottingham NG12 5GG, U.K.; e-mail (t.shepherd@bgs.ac.uk)

Using a new and simple aq solution method for the calibration of laser ablation ICP-MS analysis of single I, a wide range of elements can now be quantitatively determined. The standards are easy to prepare and offer an almost unlimited range of F compositions. They are also applicable to other laser ablation techniques (e.g. ICP-AES) and are largely independent of the laser wavelength. Extensive evaluation tests have been carried out on synthetic FI in halite to determine working detection limits, precision and accuracy as a function of I volume. Data will be presented for Li, Mg, K, Ca, Rb, Sr, Cs, Ba, Mn, Cu, Zn, Pb, B, including results for the direct measurement of Cl/Br ratios. Halogen measurement permits potential sourcing of hydrothermal F and allows normalization of analyses to the major chloride anion component. Examples will be given illustrating the use and limitations of laser ICP-MS for the determination of the metal content of hydrothermal FI associated with various types of ore deposit (MVT, porphyry Cu-Mo, U-Th-REE). Polyatomic interferences restrict the measurement of certain elements (As, P, S,V) whilst others (Au) appear to be below the detection threshold of the current instrument. Reference will be made to the use a high T ablation cell for the analysis of multi-solid, high T I. (Authors' abstract)

SHI, Jixi and **YU, Xiaoyin,** 1996, Characteristics of organic matter in carbonate rocks and unconventional evaluation of oil and gas: Acta Mineralogica Sinica, v. 16, no. 2, p. 103-108. Authors at Inst. of Geoch., Chinese Acad. of Sci., Guiyang, 550002.

Over years of research and practice make it possible to distinguish oil-generating from non-generating carbonate rocks, oil/gas-generating strata of commercial importance from non-generating strata, and hydrocarbon-source rocks from reservoir rocks in terms of the data on organic matter in FI. This approach is different from the conventional method and is especially applicable to the carbonate rocks on which only a small amount of residual organic matter is adsorbed and of which the extent of thermal alteration is high. This method has the advantages of simplicity, economy and easy popularization. (Authors' abstract)

SHI, Lida and **LI, Cunyou**, 1996a, A research on the main minerogenetic physical-chemical condition of some large gold deposits in the north of China (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 5. Authors at Shenyang Inst. of Geol. and Mineral Resources, CAGS, P.R. China.

The FI from some main large gold deposits in the ZhaoYe gold minerogenetic belt of Shandong Province, the XiaoQinLing gold minerogenetic belt of Henan Province and the JinChangYu gold minerogenetic belt of Hebei Province were studied from 1980 to 1995. These studies indicate that there are many common characters among these gold deposits and special features in comparison with the similar type gold deposits in other countries.

1. The gold ore bodies generally contain CO_2 I. The higher the gold content is, the more the CO_2 I and the CO_2 content is in the I.

2. All the gold ore bodies contain critical I, and most of the critical T of these I are lower than that of water's (374.2°C). This indicates that minerogenetic F were in critical or supercritical state, had lower sal and were mixed with an amount of CO_2 [sic]. This is different from the character of the same type of gold deposits in other countries.

3. The precipitation of gold in the minerogenetic F happened in a broad middle-high T area and the main minerogenetic T which have been rectified by the P were 245-400°C. The minerogenetic F were boiled for several times.

4. The minerogenetic P changed from the steam P (57 x 15^5Pa), produced by the boil of the minerogenetic F, to the critical P (500-1050 x 10^5Pa), mostly between 250-600 x 10^5Pa.

5. There are two kinds of immiscible minerogenetic F with different sal. One is lower in sal (5.1-8.8 wt% NaCl) which might be from relict metamorphic water, and the other kind is higher in sal (12.0-17.0 wt% NaCl) and might be from magmatic water. Both kinds of F were involved in ore-generating process.

6. During the later mineralization period, the T, P, and sal of the minerogenetic F dropped, the organic mass increased, and the reducibility strengthened.

7. The main gold mineralization took place after the major regional metamorphism of the host rocks. [sic] (Authors' abstract.)

SHI, Lida and **LI, Cunyou**, 1996b, A research on the main minerogenetic physical-chemical condition of some large gold deposits in the north of China (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special isue from Workshop at 30th I.G.C., p. 29-30. Authors at Shenyang Inst. of Geol. and Mineral Resources, CAGS, China.

Same as previous abstract (E.R.)

SHI, Rendent and **WANG, Bixiang,** 1996, The mineralization characteristics of gold deposits in volcanic areas of China (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 650. Authors at Inst. of Geol., Beijing, China.

In the Babaoshan epithermal gold deposit in Zhejiang, the mechanism of gold deposit formation is as follows: the formation T are mainly 140-330°C, belonging to the intermediate to low range; the oxygen fugacity fO_2 is low, about 10^{-38} to 10^{-41}; the ore forming solutions is of the KCl - $NaCl$ - $CaSO_4$ - H_2O system; the sal is low, being 0.7 to 2.5 wt.% eq. NaCl; the δD (‰) and $\delta^{18}O_{H_2O}$ (‰) of the FI are -58.5 to -91.1 and +3 to -9, respectively, indicating that the ore-forming solutions are composed of a mixture of meteoric water and magmatic hydrothermal F. To sum up, gold mineralization should be concentrated in areas where the stress field, energy field, thermal flow field, geochemical field and geophysical field coincide. (From authors' abstract by E.R.)

SHIBUE, Yasuhiro, 1993, Fluid inclusion study on some tungsten deposits in Japan: Hyogo Univ. of Teacher Education J., v. 13, Ser. 3-1 (Natural Sci.) p. 43-55 (in Japanese; Engl. abst.).

Th and sal data are given on the Kagata (Ibaragi), Kaneuchi (Kyoto), Fujigatani (Yamaguchi), Kiwada (Yamaguchi), and Kuga (Yamaguchi) tungsten deposits in Japan. The data are as follows: Kagata, 232 to 336°C (average = 289°C) for scheelite and 279 to 301°C (average = 290°C) for clinopyroxene; Kaneuchi, 278 to 290°C (average = 284°C) for cassiterite and 207 to 284°C (average = 230°C) for calcite; Fujigatani, 218 to 229°C (average = 222°C) for vein calcite; Kiwada, 238 to 378°C (average = 292°C) for garnet, 229 to 364°C (average = 289°C) for clinopyroxene, 224 to 355°C for scheelite (average = 266°C), 229 to 264°C (average = 244°C) for skarn calcite; Kuga, 242 to 366°C (average = 280°C) for garnet, 271 to 318°C (average = 299°C) for clinopyroxene, 208 to 278°C (average = 220°C) for skarn calcite.

Sal of FI in scheelite and clinopyroxene from the Kagata deposit range from 5 to 11 NaCl eq. wt.% (average = 8) and from 3 to 9 NaCl eq. wt.% (average = 7), respectively. Scheelites from garnet-clinopyroxene skarn and quartz veins of the Kiwada No. 11 ore body show the ranges from 3 to 7 NaCl eq. wt.% (average = 5) and 1 to 9 NaCl eq. wt.% (average = 4), respectively.

Corrections of these Th by present sal values show that the T of the studied deposits were higher than 350°C. FI in calcites from the Kaneuchi, Fujigatani, Kiwada, and Kuga deposits show that the T at the late stage of the mineralization were still higher than 200°C. (From author's abstract by E.R.)

SHIBUE, Yasuhiro, 1996a, Calculation of quartz precipitation from hydrothermal solution by mixing: Resource Geology, v. 46, no. 3, p. 117-124. Author at Geoscience Inst., Hyogo Univ. of Teacher Education, Yashiro-cho, Kato-gun, Hyogo 673-14, Japan.

A model calculation of quartz precipitation from hydrothermal solution by mixing is performed. This model considers that a high-sal and high-T solution mixes with a low-sal and low-T solution at the constant pressure (1000 bars or 500 bars) or V-L equilibrium pressures. The T of the high-sal solution is assigned to be 600°C (at 1000 bars), 450°C (at 500 bars) or 300°C (at V-saturation). The low-sal solution is 200°C at the three P conditions. The sal of the high-T solutions is 20 or 10 NaCl wt.%, and that of the low-T solution is 1 NaCl wt.%. Both T and NaCl concentration of the mixed solution are lowered by stepwise increase in the weight fraction of the low-sal and low-T solution.

Calculations indicate that the amounts of precipitated quartz show the bell-shaped patterns against the T of the mixed solution. The model calculation is then applied to the cooling- and dilution-path of the hydrothermal solution for the Fujigatani-Kiwada deposits. By converting the solution T into the Th, the quartz precipitation curve is recast onto the relation between Th (and sal) and the precipitated amount. The calculated results show the bell-shaped patterns observed for the frequency diagrams of Th and sal of FI. (Author's abstract)

SHIBUE, Yasuhiro, 1996b, Empirical expressions of quartz solubility in H_2O, $H_2O + CO_2$, and H_2O + NaCl fluids: Geochemical J., v. 30, p. 339-354. Author at Geoscience Inst., Hyogo Univ. of Teacher Education, Yashiro-cho, Kato-gun, Hyogo 673-14, Japan.

An empirical equation of quartz solubility in H_2O at elevated P and T (up to 10 kb and 900°C is obtained based on the published experimental results. The empirical constant value for quartz solubility in H_2O + NaCl F is 3.24740, which gives the calculated solubilities consistent with the experimental results done at 0.2 kb to 2 kb, 200°C to 700°C, and up to 33.6 wt.% NaCl concentration. (From author's abstract by E.R.)

SHIBUE, Yasuhiro and **KUSAKABE, Minoru,** 1996, Hydrogen isotopic ratios of the ore-forming fluids responsible for the Kaneuchi and Ohtani tungsten deposits, Kyoto Prefecture: Involvement of magmatic fluid and organic water in the ore-forming fluids: Resource Geol., v. 46, no. 5, p. 255-266 (In Japanese, Engl. abst.). First author at Geoscience Inst., Hyogo Univ. of Teacher Education, Yashiro-cho, Kato-gun, Hyogo 673-14, Japan.

The possible roles of hydrothermal solutions of magmatic and sedimentary-rock origins in the mineralization of the Kaneuchi and Ohtani tungsten deposits, Hyoto Prefecture, are evaluated on the basis of hydrogen isotope geochemistry of the host rocks and hydrothermal muscovite. The hydrogen isotopic ratios of the Ohtani granitic rocks range from -53 to -87‰. Based on the isotopic ratios of the granitic rocks, the δD values of the magmatic F related to the Ohtani and Kaneuchi deposits are estimated to be from -42 to -76‰. 'The δD values of hydrothermal muscovite from the Ohtani deposit range from -90 to -94‰. The δD values of the hydrothermal solution in equilibrium with muscovite are calculated to be from -62 to -80‰ at precipitation T of 368° to 488°C. Therefore, the δD values of the hydrothermal solution for the muscovite mineralization agree with the range of the magmatic F.

On the other hand, the δD values of the hydrothermal solution in equilibrium with the Kaneuchi muscovite agree with the δD range of the magmatic F at 530°C or below. However, the δD values are lower than the magmatic value when calculated above 550°C. The magmatic F probably mixed with a deuterium-depleted hydrothermal solution at the early stage of the mineralization. It is suggested that the deuterium-depleted hydrothermal solution is originated from organic materials in the host rocks.

Previous results on G compositions of FI from both deposits are interpreted as the mixing of a magmatic F with a relatively carbon-enriched hydrothermal solution. Carbon in the hydrothermal solution responsible for the Kaneuchi deposit partly originated from organic materials in the host sedimentary rocks. (Authors' abstract)

SHIGA, T., HYODO, M., SASADA, M., SAWAKI, T., YAGI, M. and **TAKAGI, H.,** 1996, Measurement and study of homogenization temperatures of synthetic fluid inclusions in the WD-1 well (abstr.): Newsletter of the Japanese Assoc. of Geothermal Fluid Inclusionists, 1996, no. 7, p. 29 (in Japanese).

See FIR v. 28, p. 156 (E.R.)

SHIMIZU, Toru, MATSUEDA, Hiroharu, ISHIYAMA, Daizo and **MATSUBAYA, Osamu,** 1996a, Genesis of gold and silver ore deposits at the Koryu mine, southwestern Hokkaido, Japan (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 736. First author at Dept. of Earth and Planet. Sci., Hokkaido Univ., Japan.

See next item (E.R.)

SHIMIZU, Toru, MATSUEDA, Hiroharu, ISHIYAMA, Daizo and **MATSUBAYA, Osamu,** 1996b, Genesis of epithermal gold and silver ore deposits of the Koryu Mine, southwestern Hokkaido, Japan, Part I. Morphology of quartz and fluid inclusions (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 27-28. First author at Dept. of Earth and Planetary Sci., Grad. School of Sci., Hokkaido Univ., Sapporo 060, Japan.

The Koryu mine is an epithermal gold-silver-quartz vein deposit in southwestern Hokkaido, Japan. It occurs in E-W shear zone of black mudstone in Niocene. The deposit consists of eight major veins with general structure and texture, both in vertical and horizontal directions. K-Ar ages for adularia from Nos. 1 and 3 vein are 0.8-1.2 Ma, indicating a Pleistocene age of mineralization. The veins have been divided into two mineralization epochs, the Earlier and the Later, on the basis of cross-cut 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). Stage L-III is the dominant gold-silver mineralization stage.

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 Mg-rich interstratified chlorite/smectite. They are intimately associated with microcrystalline quartz precipitating alternatively with adularia and comb texture quartz.

The representative gold-silver bearing minerals are electrum, acanthite-aguilarite, polybasite-pearceite, pyrargyrite-proustite, jalpaite, mckinstryite, hessite, Ag-Te-Se-S mineral, and tetrahedrite. Positive correlation is observed between gold-silver mineralization and large number of stages showing various quartz structures and textures. In Bonanzas, the quartz-adularia associations tend to occur intermittently with those of gold-silver minerals, microcrystalline quartz and interstratified clay minerals.

Based on the interpretation of FI data, the formation T (in each mineralization stage) are around 250°C throughout stages except for stages E-III-b, L-II and L-VII (196-230°C). The sal show low values ranging from 0.5 to 3.3 NaCl eq. wt%. Freezing point depression by CO_2 in FI is about 0.5°C (stage L-I-a) and 0.6°C (stage L-VI-c), reducing 0.8 and 1.0 wt% NaCl eq., respectively. It is assumed that gold-silver minerals precipitated from low-saline F of about 250°C.

"Pseudodendritic texture" in quartz must be an indicator of boiling phenomena of hydrothermal F. The texture is observed in comb texture quartz temporary and spatially except for the comb texture quartz in stage L-VI-c. Comb texture quartz showing the texture tend to occur alternatively with gold-silver minerals and microcrystalline quartz. These temporal and spatial observations indicate that boiling occurred intermittently and boiling zone fluctuated throughout mineralization. Combined with the P-V-T data of dilute saline solutions, the FI data indicate that maximum P total of ore F were about 68 bars, indicating 850 m as the maximum depth of mineralization. This value is consistent with an estimated value of 670-870 m based on geological studies. (Authors' abstract)

See also Shimizu, 1995, FIR 28, p. 157 (E.R.)

SHIMIZU, Toru, MATSUEDA, Hiroharu, ISHIYAMA, Daizo and **MATSUBAYA, Osamu,** 1996c, Genesis of epithermal gold and silver ore deposits of the Koryu mine, southwestern Hokkaido, Japan, Part II. Formation environments and stable isotopes (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 28-29. First author at Dept. of Earth and Planetary Sci., Grad. School of Sci., Hokkaido Univ., Sapporo 060, Japan.

Physicochemical studies suggest that epithermal gold and silver mineralization of the Koryu mine occurred under the following approximate condition of the F: T = 250°C, pH - 5.8, log fO_2 = -36.5 atm., logfCO_2 = 1.5 atm., log f S_2 = -10.8 atm. and log Total S = -2.5 mol/kg.

The stable isotope data combined with previous paragenetic, quartz morphologic and FI studies suggest the following genetical model of the Koryu gold-silver deposits. The veins consist of two distinct mineralization epochs, the Earlier and the Later, which activated Types (1) and (2) hydrothermal F, respectively. Both types could be meteoric water in origin, interacted with surrounding rocks under the high water/rock ratio. Type (1) was characterized by high $\delta^{18}O$ F (-5.8 ~ -5.2 per mil, while Type (2) by low $\delta^{18}O$ F (-9.9 ~ -6.5 per mil. Type (1) F might pass through underlying basement rocks and leached Ca and Mn which are precipitated as manganocalcite and johannsenite in the Earlier mineralization epoch. Type (2) F ascended through new conduits and might carry large amounts of gold and silver, although the origin of the metals are not clarified yet.

Periodical P release by intermittent boiling must be the most significant mechanism for producing complicated crustiform bands with numerous changes in mineral composition, quartz structures and textures. `When the hydrothermal F ascended discretely to the boiling zone in the shallow level (<850 m) during the Later epoch, gold and silver are precipitated as a result of destabilization of Au(HS) 2- and Ag(HS) 2-from a neutral pH and 250°C F. The destabilization of the thio-complexes could occur due to physicochemical changes of the F by intermittent boiling, such as discontinuous removal of G and pH changes. (Authors' abstract)

See previous item (E.R.)

SHMULOVICH, K.I. and **GRAHAM, C.M.,** 1996, Melting of albite and dehydration of brucite in H_2O-NaCl fluids to 9 kbars and 700-900°C: implications for partial melting and water activities during high pressure metamorphism: Contrib Mineral Petrol, v. 124, p. 370-382. First author at Inst. of Experimental Mineral., Russian Acad. of Sci., 142432 Chernogolovka, Moscow District, Russia.

SHOBHITA, K., RAMANAMURTHY, K.V. and **YADAV, O.P.,** 1996, Fluid inclusion study on vein quartz in uranium mineralised Middle Proterozoic quartz biotite schists in Ladikabas area, Sikar district, Rajasthan, India: J. of Atomic Mineral Sci., v. 4, 1996, p. 49-53. First author at Atomic Minerals Div., Dept. of Atomic Energy, Hyderabad 500 016.

FI in vein quartz associated with uraninite bearing Middle Proterozoic quartz - biotite schists (Ajabgarh Group, Delhi Supergroup) are primarily liquid (L) + vapour (V) + solid (S) type, with halite as the solid phase. The overall density of the I vary from 1.032 to 1.248 g/cc. The P FI homogenise by disappearance of halite in the T range of 250 to 350°C. The halite dissolution T indicated a sal of 34 to 40 wt.% eNaCl. First Tm ice fall in the range of -23 to -24°C and correspond to the Te of NaCl - KCl - H_2O system. Highly saline solutions, enriched in soda and potash, in the T range of 250 to 350°C, could be responsible for the mineralisation of uraninite in this area. These F and uranium mineralisation may be genetically related to the albitites of the region. (Authors' abstract)

SHOJI, T. and **ZAW, T.,** 1990, Fluid inclusions of granitoids and their bearing on mineralization in South Korea: J. Korean Inst. Mining Geol., v. 23, p. 127-133.

SHUGUROVA, N.A. and **KAZANSKY, Y.P.,** 1996, Gas composition of inclusions in Proterozoic siliceous rocks as relict of ancient atmosphere (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 148. Authors at Unit. Inst. Geol., Geophys. Mineral., Siberian Branch of Russian Acad. Sci., Novosibirsk, Russia.

Different points of view were stated on the composition of Proterozoic atmosphere. Authors have proposed the adsorbsional-volumetrical method of G composition diagnosis based on experimental comparative investigations of the composition of I in newly-formed authigenic minerals and solutions from which these minerals are formed. Such analysis has shown the identity of G composition from solutions and minerals. Analysis of G I from Proterozoic siliceous rocks has revealed a predominance of N_2, CO_2 and O_2. Quantity of O_2 was found about 1.5 times smaller than in D-K rocks. However, Proterozoic association differs from G composition of Archean-Lower Proterozoic siliceous rocks. Consequently, the obtained data are characteristic of transitional type of atmosphere: between anoxic (Archean-Early Proterozoic) and modern (Devonian-Holocene). These results are confirmed by isotopic carbon data CO_2 (Karhu) and thermodynamic calculations. (From authors' abstract by E.R.)

SIANISYAN, E.S., 1994, Groundwater chemical evolution in sedimentary basins based on fluid inclusion data: Dok. Ross. Akad. Nauk, 1994, v. 335, no. 2, p. 210-213 (in Russian, translated in Transactions Doklady-Russian Acad. of Sci.: Earth Sci. Sections, 1996, v. 337, no. A/6, p. 133-137).

SIANISYAN, E.S. and **VOLKOV, V.N.,** 1996, The catagenesis of deep-seated ground water: Evidence from fluid inclusion studies: Lithology and Mineral Resources, 1996, no. 3, p. 235-240 (In Russian, translated in Lithology and Mineral Resources, v. 31, no. 3, p. 209-313, 1996). Authors at Rostov State Univ., ul. Zorge 40, Rostov-on-Don, 344090 Russia.

Catagenesis of the ground water of sedimentary basins have been studied on the basis of FI investigation in the minerals from rocks and veins. FI have been considered as relics of ground water. The comparison of chemical composition of paleoseas, vacuole water, and modern stratal water from Cretaceous carbonate sequences allows for the evolution of natural solutions of distinctive tectonic settings of Ciscaucasian region. Based on our studies, main sources and catagenetic alteration of the ground water composition have been revealed. (Authors' abstract)

SICREE, A.A. and **BARNES, H.L.,** 1996, Upper Mississippi Valley district ore fluid model: the role of organic complexes: Ore Geology Reviews, v. 11, p. 105-131. Authors at Ore Deposits Research Sect., Pennsylvania State Univ., University Park, PA 16802, USA.

Ligands responsible for zinc and lead mobility in solutions forming Mississippi Valley-type (MVT) deposits have not yet been identified and this deficiency precludes formulation of detailed geochemical models of the genesis of MVT deposits. A suitable ligand must be identified that is capable of complexing a minimum of 10 ppm of zinc and of lead. Comparison of three models for MVT ore formation with geochemical constraints on the ore-forming F of the Upper Mississippi Valley district leads to the conclusion that the reduced sulfur model applies best to this district.

Experiments were carried out to test the chemical compatibility of a variety of organic ligands with the geochemical constraints of the reduced sulfur model. Results show that the monocarboxylic acids and the thiocarboxylic acids are weak ligands for zinc and cannot play a role in MVT deposit genesis. Oxalate, although a strong ligand for Zn(II), is precluded from contributing to MVT formation because it readily precipitates as calcium oxalate in the presence of calcium ion. In general, none of the short-chain mono- or dicarboxylic acids nor the thiols tested form zinc complexes strong enough to contribute to MVT deposit genesis. Other longer-chain and thiocarboxylic acids as well as humic and fulvic acids remain to be investigated as transporting agents informing these deposits. (From authors' abstract by E.R.)

SIDDAIAH, N.S., 1996, Metamorphic fluids and multiple lithologies as sources for the Kolar gold-quartz vein deposits: Evidence from REE and isotope studies: Newsletter of Int'l. Liason Group on Gold Mineralization, no. 23, p. 47-48. Author at Wadia Inst. of Himalayan Geol., Ehra Dun - 248 001, India.

The famous Kolar gold deposits offer an excellent opportunity to understand the relation between tectonic processes, F evolution and gold metallogeny. Discussed here are the nature of the F, F path, and the processes involved in the formation of gold quartz vein deposits using lanthanide geochemistry, radiogenic and stable isotope data on various representative samples including gold-quartz veins, altered and unaltered wallrock, mineral separates (quartz, pyrite & calcite) and mafic I from the gold-quartz veins, and the intrusive pegmatites.

The gold-quartz vein samples have LREE-enriched HREE-depleted chrondrite-normalised patterns without any Eu anomaly. The monomineralic quartz from the gold-quartz veins has very low concentrations of total REE (0.15 ppm) and has LREE-enriched and HREE-depleted chrondrite-normalised abundances with positive Eu anomaly, indicating the REE pattern of the F that precipitated the gold-bearing quartz veins. These REE patterns are similar to the REE patterns of metamorphic F. The $\delta^{18}O$ data for the quartz vein (11.6‰) and the calculated $\delta^{18}O$ for the F (8.2‰) that precipitated the gold quartz-vein deposits also suggest a metamorphic source for the F. The REE geochemistry of the gold-quartz veins, the immediate alteration zone, and the host amphibolites indi-cate that the REE chemistry of the immediate amphibolite has been modified by the F during the carbonate alteration. The increase in REE abundances and the change in the REE patterns of the host rocks are likely to have resulted from high F/rock ratios.

Based on Nd isotopic data on the gold-quartz veins, altered zone, and the mafic I, an amphibolitic source for the REE in the F has been proposed. The Pb isotope data for the vein quartz and for the galena from the gold-quartz vein deposits suggest a mixed source (older gneiss and amphibolite) for the Pb. Osmium isotope data on the amphibolites and on the gold-quartz vein deposits indicate a magmatic source for the noble metals. However, the REE and Nd isotopic data on the pegmatites associated with the gold-quartz vein deposits indicate a gneissic source for the REE in the pegmatites. Thus the F responsible for the gold-quartz vein mineralization in the Kolar belt appear to have interacted with multiple lithologies of diverse composition and probably diverse ages during the protracted period of deformation associated with the accretionary tectonics which juxtaposed the late Archaean terranes in the Kolar area. (From author's abstract by E.R.)

SILBERMAN, M.L. and **HOLLISTER, V.F.,** 1995, Silver-gold and polymetallic quartz veins in the Bodie mining district, Mono County, California–an indication of a porphyry copper-molybdenum deposit at Depth? (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A72-A73. First author at U.S. Geol. Survey, Denver Federal Center, Denver, CO 80225, USA.

FI and isotopic data from the low-sulfide, Ag-Au veins suggest that the veins formed from an ore F of low sal, ≈240°C, 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 up to four dm. The oxygen isotopic signature of the quartz is more enriched in the heavy isotope (18°) [sic] than that of the Ag-Au veins.

Taken together, the geochemical, geophysical, alteration pattern distribution, and FI data suggest that Bodie is underlain by an intrusive mass, probably of felsic composition (due to the Mo, Sn, and W anomalies), and that at least a deep stage of polymetallic Ag-rich veins formed from a F of high sal, with characteristics similar to those found within and peripheral to porphyry Cu-Mo systems. (From authors' abstract by H.E.B.)

SIMMONS, S.F., RAHMAN, M.M. and **WATSON, A.**, (eds.), 1996, Proceedings of The 18th New Zealand Geothermal Workshop 1996: Geothermal Inst. and The Univ. of Auckland, 351 pp. ISBN 0-86869-074-0.

SIMON, S.B., DAVIS, A.M., RICHTER, F.M. and **GROSSMAN, L.**, 1996, Experimental investigation of the effect of cooling rate on melilite/liquid distribution coefficients for Sr, Ba, and Ti in Type B refractory inclusion melts (abst.): Lunar and Planetary Sci. Conf. Abstracts, v. 27, part 3, p. 1201-1202.

SIMONOV, V.A., SILANT'YEV, S.A., MILOSNOV, A.A. and **KOLOBOV, V.Yu**, 1995, Fluid inclusions in metagabbroid amphiboles and plagioclases from the 115° 20' Cape Verde fracture zone, Central Atlantic: Dokl. Ross. Akad. Nauk, v. 341, no. 5, p. 676-681 (in Russian, translated in Trans. (Doklady) Russian Acad. Sci., Earth Sci. Sect., v. 344, p. 257-263, 1996). Authors at Joint Inst. for Geol., Geophys., and Mineral., Siberian Div., Russian Acad. of Sci., Novosibirsk, and Vernadskiy Inst. for Geoch. and Analytical Chem., Russian Acad. of Sci., Moscow.

Abstract in FIR v. 28, p. 159 (E.R.)

SINGOYI, Blackwell, 1995, Mineral paragenesis, geochemistry and fluid characteristics of the Kara scheelite-magnetite skarn deposit, northwestern Tasmania: Master of Economic Geology thesis, Univ. of Tasmania, 161 pp.

The Kara scheelite-magnetite deposit in northwestern Tasmania consists of several skarn bodies with total remaining mineable ore reserves estimated at 1.7 Mt magnetite @ > 30% Fe, and 0.3 Mt scheelite @ 0.52% WO_3 by 1992. The major orebodies are hosted by Paleozoic limestone or calcareous sandstones in contact with the Devonian Housetop Granite. The predominant skarn minerals display a [spatial] zonation that ranges from epidote-quartz to garnet, magnetite-amphibole, vesuvianite and clinopyroxene zones away from the granite contact and reveal at least four stages of skarn formation and ore deposition.

Stages I and II mineral assemblages represent early skarn formation and are dominated by anhydrous minerals of clinopyroxene and garnet. Stages III and IV minerals represent late skarn-forming phases and pervasively replace early mineral assemblages. Scheelite occurs in stages I-III and generally shows a close spatial association with hydrous minerals (vesuvianite in stage I/II and amphibole in stage III). Abundant scheelite is found in stage III where it forms very coarse grains up to > 5 cm. Magnetite occurs in stages II and III but is also more abundant in stage III. Garnet appears to have the highest levels of tin (up to 0.37 wt.% SnO_2) and may be the major carrier of tin in the skarn. Scheelite contains moderate amounts of molybdenum (< 3 wt.% MoO_3) which give powellite mole proportions of up to 6% and is unaccompanied by molybdenite.

FI microthermometric measurements of P FI for skarn minerals reveal systematic declining T from early mineral assemblages to later stages, but sal values are variable. Stage I clinopyroxene yielded a Th range of 460 to 620°C (modes at 520°C and 600°C). The stage II minerals gave a Th range of 350 to 570°C (mode at 500°C). The stage III mineral assemblage yielded Th ranging from 240 to 360°C (mode at 300°C). Stage I clinopyroxene gave sal values from 2.0 to 10.0 eq. wt.% NaCl. The stage II mineral assemblages showed sal of 12.0 to 16.0 eq. wt.% NaCl. The stage III mineral assemblage yielded sal values of 0.2 to 19.8 eq. wt.% NaCl (modes at 5 and 15 eq. wt.% NaCl).

Isotopic measurements of the protolith Gordon Limestone reveal $\delta^{13}C$ composition from -1.6 to -4.4‰ (PDB) and $\delta^{18}O$ composition of 10 to 23‰ (SMOW) which are both depleted with respect to the unmetamorphosed Gordon Limestone values. The isotope compositions of the stages III and IV skarn calcite range from -1.7 to -7.3‰ (PDB) (mean -4.5‰) for carbon and 3.4 to 14.0‰ (SMOW) (mean 11‰) for oxygen. Calculated isotopic compositions yield $\delta^{13}C_{CO_2}$ values of 0.0 to -5.0‰ (PDB))mean -3‰) and $\delta^{18}O_{H_2O}$ values of 0.0 to 10.0‰ (SMOW) (mean 7‰). Depletion in isotopic values for the protolith marble are interpreted to be dominantly due to interaction with magmatic F from the nearby granite which are also responsible for the formation of skarn calcite. The values below the magmatic range in the skarn calcite are interpreted to be due to minor contribution from meteoric F. Oxygen isotope values of stages II to III magnetite vary from 2.7 to 4.7‰ (SMOW) and yield $\delta^{18}O_{H_2O}$ values of 12.3 to 13.9‰, whereas oxygen isotopic compositions of stages II to III scheelite vary from 5.2 to 6.4‰ (SMOW) and yield $\delta^{18}O_{H_2O}$ values of 6.0 to 9.0‰. These $\delta^{18}O_{H_2O}$ values are generally in agreement with the isotope values from skarn calcite and confirm a magmatic source for the F.

FI and stable isotope data indicate that early skarn formation was probably solely due to magmatic F, while later skarn formation and ore deposition was developed from magmatic F mixed with minor meteoric F. Chemistries of clinopyroxene, garnet and scheelite (unaccompanied by molybdenite) suggest that the Kara skarn deposit was formed under highly oxidised conditions. The deposit differs significantly from other scheelite deposits such as CanTung in the abundance of magnetite (up to > 90 vol%) and lack of sulphides (e.g. pyrrhotite). (From author's abstract by E.R.)

SIVORONOV, A.A., BOBROV, A.B., MALYUK, B.I. and **PAVLUN, M.M.**, and 1996, Economic gold mineralization in the Ukrainian Shield (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 531. First author at Dept. of Geol., L'viv State Univ., Ukraine.

Charnockite-granulite structure-formational complex (SFC). Gold deposits of Maisk type. Hosted by diaphthored granulite units of lower contrasted mafic-ultramafic part of leukogranulite formation. Ore-forming conditions based on FI studies is interpreted as dominated hydrocarbon-CO_2 F system that were thermostated and released in wide depth range of mineralization and lack of gold concentration in physico-chemically gradiented zones.

Tonalite-greenstone SFC. Lode gold deposits include quartz-veins and mineralized zones. (Balka Zolotaya and Sergeevskoye deposits respectively). FI studies suggest for metamorphic-hydrothermal nature of mineralization related to latest events of the above association development and their postmagamatic F systems. Ore zonation for reconstructed paleovolcanic systems from the proximal, volcanic-center, sites to distal, volcanic-pyroclastic ones can be expressed as follows: molybdenite-pyrite-quartz and epidote-carbonate through epidote-quartz, pyrite-quartz, pyrite-chalcopyrite-quartz, sphalerite-quartz, pyrite-carbonate to pyrite-pyrrotite-chalcopyrite-sphalerite-quartz with gold. (From authors' abstract by E.R.)

SKEWES, M.A. and **STERN, C.R.,** 1996, The magmatic-hydrothermal-epithermal transition in large mineralized Miocene breccia pipes, central Chilean Andes (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A333. First author at Dept. of Geological Sci., Univ. of Colorado, Boulder, CO 80309-0250; e-mail (skewes@stripe.colorado.edu)

Large mineralized breccia pipes, some with > 10 × 10^6 Mt Cu, are prominent features in the Miocene deposits Los Pelambres, Los Bronces-Rio Blanco and El Teniente of central Chile. Vertical extension of >1,800 m has been documented for one pipe, and erosion has exposed older pipes to levels originally >3,000 m below the surface. Deeper levels of the pipes have mafic, biotite-rich igneous and/or hydrothermal biotite ± quartz ± K-spar ± magnetite ± sulfides (bornite, chalcopyrite, minor pyrite) matrices. Clasts have S biotite and K-spar. High T, saline FI, which homogenize by halite disappearance, are common, and O-isotopes confirm magmatic affinities for the breccia-forming F. Intermediate levels have matrix dominated by tourmaline ± biotite ± quartz ± sulfides (chalcopyrite, pyrite, minor bornite), and clasts with sericitic alteration. Halite-bearing FI, which homogenize by bubble disappearance, co-exist with V-rich I suggesting boiling. Upper levels are dominated by rock-flour cemented by quartz ± sericite ± tourmaline ± barite ± gypsum ± sulfides (pyrite, chalcopyrite, sphalerite, tetrahedrite-tennantite, galena) ± carbonates. Both V- and L-rich two-phase FI, without halite crystals, prevail. V produced by boiling of magmatic F at intermediate levels, and/or meteoric water, may have played a role in the formation of the upper epithermal levels of these pipes, some of which have Ag, but not Au. (Authors' abstract)

SLIM-SHIMI, N., MOELO, Y., TLIG, S. and **LEVY, C.,** 1996, Sulfide geochemistry and genesis of Chouichia and Ain el Bey copper deposits in northwestern Tunisia: Mineral. Deposita, v. 31, p. 188-200. First author at Laboratory of Geoch. and Mineral., Dept. of Geol., Faculty of Sci., Campus Univ., 1060 Tunis, Tunisia.

The Chouichia and Ain el Bey copper veins are hosted in sedimentary sequences in a regional shear zone. Paragenetic assemblages were formed during four distinct stages all of which are separated by fracturing and brecciation: Stage 1 consists of low T siderite (160-180°C). Stage 2 includes pseudomorphing of marcasite by As-rich pyrite and arsenopyrite, and formation of chalcopyrite at higher T (200-300°C) from S-rich, Fe-Cu-bearing F. Stage 3 involves fracturing and brecciation predating deposition of enargite, luzonite and tennantite at Ain el Bey, and famatinite and tetrahedrite at Chouichia, from As-Sb-Bi-bearing ore-forming F. In stage 4 fracturing was followed by calcite formation in voids. Comprehensive data including FI in siderite and calcite, support an input of magmatic hydrothermal ore-forming F, although contamination by sedimentary sulfur were also identified. (From authors' abstract by E.R.)

Some rare I found in ten samples, in siderite II at Ain el Bey and in calcite II at Chouichia, were measured. Continuous heating permitted homogenization of P I in the range 163.7-182.7°C; freezing gave a mean T of -21°C thus indicating a sal of 23.2% eq. NaCl. FI of calcite II of Chouichia show from 121 to 185°C. (From authors' text by E.R.)

SMIRNOV, S.Z., BAKUMENKO, I.T. and **TOMILENKO, A.A.,** 1996, Formation features of fluid and melt inclusions in synthetic gemstones manufactured by flux and hydrothermal processes (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 504. Authors at UIGGM SB RAS, Novosibirsk, Russia.

Flux grown ruby, spinel and emerald crystals and also hydrothermally grown crystals of beryl and emerald from different manufacturers were used to establish peculiarities of inclusion origin in synthetic crystals.

I in the flux synthetics have same features as I in magmatic minerals. I in hydrothermal synthetic crystals are similar to the natural ones in the phase composition but strongly differ in shape. This study displayed that entrapment of I [in] flux and hydrothermal processes are similar to I formation in natural minerals of magmatic and hydrothermal origin respectively. Flux I perform a good distinctive feature of synthetic gemstones because they have no, as a rule, magmatic natural counterparts. I in the hydrothermally grown crystals are similar to the I in natural ones much more. However they have very distinct shape, which is determined by the regeneration features of the industrial growth process. (From authors' abstract by E.R.)

SMITH, D.W., CRAW, D. and **KOONS, P.O.,** 1996, Tectonic hydrothermal gold mineralisation in the outboard zone of the Southern Alps, New Zealand: New Zealand J. of Geol. and Geophys., v. 39, p. 201-209. Authors at Geology Dept., Univ. of Otago, P.O. Box 56, Dunedin, NZ.

Gold-bearing veins cut a belt of low-grade (pumpellyite-actinolite/greenschist facies) schist in the Ben Ohau Range. The veins consist of quartz, ankerite, calcite, chlorite, and pyrite, with minor chalcopyrite and galena. Hydrothermal alteration of host rock is minor apart from Sr enrichment (up to four times background). FI in quartz are aq with minor dissolved CO_2 and salts (<4 wt% NaCl equivalent), and homogenise at 236-270°C. The veins formed at 300±20°C and 1000±800 bars F P, probably under a hydrostatic F P regime. Oxygen and carbon isotopic data ($\delta^{18}O = +10$ to $+14$; $\delta^{13}C = -6$ to $-10‰$) are similar to data from economic metamorphogenic Au deposits of the nearby Otago Schist, but minor meteoric incursion may have occurred. Isotopic data are also similar to veins formed in the inboard zone of the Southern Alps orogen. The Ben Ohau veins demonstrate that gold can be concentrated in low-grade schists distant from the most active part of the hydrothermal system driven by continental collision. (From authors' abstract by E.R.)

SMITH, M.P., 1996, Fluid inclusion volatile well logs of the Gravberg #1 well, Siljan Ring, Sweden (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 122. Author at Advanced Hydrocarbon Stratigraphy, Inc., 3520 South Rolling Oaks Drive, Tulsa, OK 74107-4515 USA; e-mail (AHStrat@AOL.COM)

The Gravberg#1 Well was drilled in the Siljan Ring meteorite impact crater, Sweden, to test Tommy Gold's abiogenic petroleum hypothesis. 425 cuttings samples from this well from 720 feet to 18,440 feet were analyzed for FI volatiles using Advanced Hydrocarbon Stratigraphy's proprietary automated mass spectrometer system.

For each sample, FI volatiles are released into the mass spectrometer as several bursts of G. Each burst results from squeezing each sample in a series of P steps. Only one sample is in the analytical chamber at a time. The samples were subjected to no heat prior to, or during analyses. Following I volatiles analyses, the sample is transferred to another chamber and pyrolyzed. The G evolved by pyrolysis is analyzed by another mass spectrometer. Several hundred samples can be analyzed in one day. This high analytical throughput allows FI maps and well logs to be constructed.

The resulting Fluid Inclusion Volatile maps and well logs can be used in petroleum, minerals, and geothermal exploration, and to address some environmental issues.

The Gravberg #1 Well shows these features:

1) Air I are ubiquitous shallow in the well, especially in the upper 4,000 feet. This air may have been trapped as a result of the meteorite impact, and samples from Meteorite Crater, Arizona are being collected to begin testing this idea. If this is correct, than this would be a unique method of sampling ancient atmosphere.

2) Helium-bearing I are ubiquitous deep in the well, especially below 13,750 feet to TD (18,440). It is possible that He-bearing I were ubiquitous throughout the granite before meteorite impact, and that the impact destroyed these I down to this level.

3) Methane-bearing I are ubiquitous below 5,000 feet to TD, i.e. this well sampled over 13,000 feet of methane-bearing I. The top of the methane-bearing I is a sill, which may be acting as a seal to migration. Although the methane-bearing I are particularly intense in the mafic sills, they are present in almost all granite samples below 5,000 feet. Samples below 13,750 feet are particularly methane-rich. From a petroleum exploration point of view, these data are encouraging.

Very preliminary interpretation of this ongoing work suggests that FI volatile mapping may offer a unique method of mapping paleo-meteorite-impact shock waves (ambient F trapped near maximum shock, and ancient I destroyed).

Although this author does not at this point endorse them, it may be necessary to reconsider some of Tommy Gold's ideas. (From author's abstract by E.R.)

SMITH, Martin, BANKS, D.A., YARDLEY, B.W.D. and **BOYCE, Adrian,** 1996, Fluid inclusion and stable isotope constraints on the genesis of the Cligga Head Sn-W deposit, S.W. England: Eur. J. Mineral., v. 8, p. 961-974. First author at Dept. of Earth Sci., Univ. of Leeds, Leeds, U.K.

Samples of veins from the Cligga Head granite-hosted Sn-W deposit, S.W. England, have been studied by microthermometry, and analysed for the oxygen-isotope composition of quartz, cassiterite and wolframite and the hydrogen-isotope composition of FI. Samples of vein quartz were also analysed for F-I chemistry using a crush-leach technique. Oxyten-isotope geothermometry using quartz-cassiterite and quartz-wolframite pairs indicates T of 350 to 400°C, although disequilibrium may be common. Coupled with F-I Th of between 300-350°C the data suggests hydrothermal activity at 350 to 400°C, and 0.7 to 1.7 kbar F P. High Th in some FI suggests that P may have dropped below 0.7 kbar during periods of vein dilation. The calculated oxygen- and measured hydrogen-isotopic composition of vein F ($\delta^{18}O$ from 6.0 to 10.8‰; δD from –52 to –22‰) is consistent with an origin as F that had equilibrated with granite at T from approximately 500 to 300°C.

Crush-leach analyses show the IF to be Na-K-Fe-Ca chloride brines with significant levels of B, F and SO_4. The K/Na ratios are consistent with equilibration with granite at progressively lower T. Log Br/Cl in the IF ranges from –3.40 to –2.90, comparable to the ratios of modern fumarole G, and consistent with the degassing of magmatic volatiles as the source of sal. (Authors' abstract)

SMITH, M.P., POTTORF, R.J. and **SYKES, M.A.,** Stratigraphic evaluation of petroleum migration and seals using fluid inclusion and rock pyrolysis volatiles; application to three deep wells, onshore Trinidad (abst.): American Assoc. of Petrol. Geologists Bulletin, v. 80, no. 8, p. 1337. First author at Advanced Hydrocarbon Stratigraphy, Tulsa, OK, US

Advanced Hydrocarbon Stratigraphy Inc's FI and rock pyrolysis well profiles evaluate petroleum migration and seals. Up to five hundred cuttings samples are typically analyzed for a 15,000 foot well. Compounds analyzed include methane and other paraffins, naphthenes, benzene, toluene, carbon dioxide and a range of other minor compounds. The utility of this new technology is demonstrated using three deep exploration wells drilled onshore Trinidad, one of which was analyzed while drilling. Exploration utility of this new technology includes detecting oil or G migration through a dry hole without shows, whether oil has migrated through a G-charged reservoir and seal location. Non-collective FI volatile stratigraphy evaluates petroleum migration, product types and seals. Petroleum migration is manifested as large compartments of petroleum I-bearing strata. I volatiles can be characterized as oil, wet G, dry G, biodegraded oil, or as exhibiting no evidence of migration. Seals occur between petroleum I-rich compartments and strata having no evidence of migration, or between compartments containing distinctly different petroleum I types. Rock pyrolysis volatile stratigraphy evaluates source rock and sequence stratigraphy and the distribution of carbonates, sulfates and clays. (Authors' abstract)

SMITH, M.P. and **YARDLEY, B.W.D.,** 1996, The boron isotopic composition of tourmaline as a guide to fluid processes in the southwestern England orefield: an ion microprobe study: Geoch. Cosm. Acta, v. 60, no. 8, p. 1415-1427. Authors at Dept. of Earth Sci., Univ. of Leeds, Leeds LS2 9JT, UK.

The boron isotopic composition ($\delta^{11}B$) shows a relatively wide range (+0.6 to -12.7‰) and falls at the lighter end of the range for typical continental crust. We attribute this to fractionation of boron isotopes between aq and M species during the exsolutioin of an aq F phase from the magma. The aq phase formed by degassing of the magma is considered to have crystallised to form the tourmalinites and quartz-topaz-tourmaline rocks common throughout the area. Decreases in the $\delta^{11}B$ values occur within certain zones of individual tourmaline crystals from these rocks. This is ascribed to loss of ^{11}B in the V phase during boiling caused by decompression of the aq F on fracturing. The calculated boron isotope composition of F in equilibrium with tourmalines from the Cligga Head greisen bordered vein system agrees closely with that calculated for the tourmalinite F and suggests a constant, granite-derived source of boron during the early hydrothermal evolution of the stock. The lack of isotopic zoning within the tourmalines from the Cligga Head hydrothermal veins suggests that phase separation did not occur or was very limited during hydrothermal circulation in the vein system. (From authors' abstract by E.R.)

SMITH, M.P., YARDLEY, B.W.D. and **VALLEY, J.W.,** 1996, The record of multistage fluid flow in recent geothermal quartz from Soultz-Sous-Forêts, France (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 119-121. First author at Dept. of Earth Sci., Univ. of Leeds, Leeds, LS2 9JT, U.K.

Soultz-sous-Forêts is the site of the European Hot Dry Rock geothermal energy project. In hole EPS1, fluid at 150°C and with a sal of ≈10 wt.% NaCl eq. was produced from a large (≈35 cm thick) quartz vein, in granite (Pauwels et al., 1993). Previous studies of quartz from this vein have shown it to contain 2 phase aq FI with a range of sal extending both above and below the modern F sal but Th values that indicate F T similar to the modern F (Dubois et al., 1996). The aim of the present study is to refine the quartz paragenesis within the vein and to attempt to correlate it with different F types in order to establish the chronology of F and to determine whether the vein is actively forming today. The sample used was a 100 μm thick quartz wafer from the vuggy central portion of the vein.

After imaging using the cathodoluminescence (CL) mode of a Camscan series 4 SEM, the sample fragments were soaked for 48 hours in fluorosilicic acid in order to remove mica and carbonates. This also etched the surface of the sample so that the textural zones identified using CL could easily be distinguished using optical microscopy. The sample was broken into 61 distinct quartz domains, which were analysed for their oxygen isotope composition using laser fluorination.

Two main groupings of FI sal have been recognised in the vein. These are a population with 11 to 15 wt.% NaCl eq. (principally P) and a mixed P and S population with 4 to 8 wt.% NaCl eq., with a range of intermediate compositions. A series of texturally-distinct quartz types were observed and placed in chronological order using the SEM-CL images.

The $\delta^{18}O$ values of the earliest generation of quartz are closest to previous analyses of P granitic quartz (8.7-9.8‰; Yardley et al, 1995), suggesting that these fragments may result from brecciation and recementation of the vein wall rocks. The FI population within this quartz thus represents the trapping of S I as the quartz was repeatedly fractured throughout the formation of the vein.

Overall no correlation is seen between P FI sal and quartz $\delta^{18}O$ suggesting that the isotopic composition of the F is controlled by equilibration with the host rock independent of original F source. The uniformity of Th suggests a relatively constant T hence thermal variations are unlikely to account for the wide range of $\delta^{18}O$. The variation in F sal has been interpreted as the result of mixing between low sal surface F and brines derived from an evaporated seawater, probably formed by interaction of F with evaporite layers in the sedimentary cover (Pauwels et al., 1993; Dubois et al, 1995). The sal data from this study supports such a hypothesis, and further suggests that the low sal end member may have become more dominant with time.

Conclusions

Vein quartz from Soultz-sous-Forêt, France records a protracted history of F flow in its texture, its trapped FI, and in its oxygen isotope composition. The sal of FI indicates that the F was sometimes more concentrated than at present, with the input of lower sal, probably surface F probably increasing with time. The oxygen isotope composition of quartz indicates the F $\delta^{18}O$ was often controlled by equilibrium with feldspar in the host granite, although periodically heavier F, possibly derived from the overlying sediments, have entered the fracture system and precipitated quartz. (From authors' abstract by E.R.)

SO, Chil-Sup and **YUN, Seong-Taek,** 1996, Geochemical evidence of progressive meteoric water interaction in epithermal Au-Ag mineralization, Jeongju-Buan District, Republic of Korea: Economic Geol., v. 91, p. 636-646. Authors at Dept. of Earth and Environmental Sci., Korea Univ., Seoul 136-701, Republic of Korea.

Studies of FI on more than 80 samples (quartz, sphalerite, barite and calcite) from the Daedu and Pungweol epithermal polymetallic Au-Ag mines show two types of FI: aq L-rich (type I) and aq V-rich (type II). Th (in L and V, respectively) range 100-300°C, with different modes for different mineralization stages. Sal ranged from 0 to 6 wt% NaCl eq., decreasing with time.

The relationship between Th and sal indicates a complex history of boiling, cooling, and dilution.

The observed evidence of F boiling during early stage I was used to estimate F P as ~ 600 m from surface. (E.R.)

SOBACHENKO, V.N., 1996, Petrologo-geochemical peculiarities of near-fault metasomatism and rare-metal ore formation in the Precambrian rocks, south of Siberian platform (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 537. Author at Inst. of Geochem., Irkutsk, Russia.

The main types of near-fault metasomatites are formed under high activity of K or Na, and also F and CO_2 in F-solutions and under wide T range from 500 to 150-200°C.

The deep nature of F is revealed by using original petrologo-geochemical data obtained via G-chromatographic, isotopic and other analytical methods for rocks and minerals. (From author's abstract by E.R.)

SOBOLEV, A.V., Ed., 1996a, Editor's note: Melt inclusions and petrogenetic indicators in igneous environments: Petrol., v. 4, no. 3, Special Issue p. 208 (in Engl.) ISSN 0869-5911.

Abstracts of nine individual papers (109 pp) are in this volume of FIR (E.R.)

SOBOLEV, A.V., 1996b, Melt inclusions in minerals as a source of principle petrological information: Petrologiya, v. 4, no. 3, pp. 228-239, (in Russian, translated in Petrol., v. 4, no. 3, p. 209-220). Author at Vernadsky Inst. of Geochem. and Analytical Chem., Russian Acad. of Sci., ul. Kosygina 19, Moscow, 117975 Russia.

Secondary ion mass spectrometry and electron microprobe studies demonstrated that M I in magnesian olivine bear evidence of the composition and formation conditions of the primary melts and their mixing products, including the initial water contents of the mantle M. This information is partially or completely obliterated in the compositions of rocks and glasses by later processes of mixing, contamination, degassing, and crystal fractionation. The typical oceanic basalt of the Mid-Atlantic Ridge is shown to have formed through the mixing of P M that were derived by the critical melting of a mantle column, more than 50 km thick. The melting began in the presence of garnet and proceeded in an open system which could retain no more than 2-3 wt% M. The mixing of the P M took place both in magma chambers, simultaneously with crystallization and, probably, during M transport through the mantle. The initial concentrations of H_2O in the mantle magmas of suprasubduction zones were as high as 2-3 wt%, which is significantly higher than was estimated previously. No correlation was found between the concentrations of H_2O in the P MORB magmas and those of elements with a similar incompatibility degree (La, Ce, K). This fact may indicate the continuous interaction of the M with H_2O-bearing CO_2-rich F. (Authors' abstract.)

SOBOLEV, A.V. and **CHAUSSIDON, Marc,** 1996, H_2O concentrations in primary melts from suprasubduction zones and mid-ocean ridges: Implications for H_2O storage and recycling in the mantle: Earth and Planet. Sci. Lett., v. 137, no. 1-4, p. 45-55. First author at Vernadsky Inst. of Geoch., Russian Acad. of Sci., 19 Kosigin Street, Moscow, 117975, Russia.

A total of 145 I, trapped and isolated in Mg-rich olivine phenocrysts ($Fo_{0.87-0.94}$) from basalts and ultramafic lavas, and representing the most primitive mantle M known, have been analysed by ion microprobe for their H_2O contents. This approach allows us to conduct a general survey of the distribution of water in primary M derived from the mantle beneath mid-ocean ridges and above subduction zones. The primitive M included in MORB olivines have low H_2O contents (mean at 0.12 wt% for N-MORB (14 samples), 0.17 wt% for T-MORB (9 samples) and 0.51 wt% for E-MORB (14 samples)). A strong decoupling between H_2O and K_2O has been found in some MORB primary M which might well be explained by the presence of a H_2O-bearing CO_2-rich F. In contrast with mid-ocean ridges, primitive M of subduction zones basalts are very rich in H_2O (between 1.0 and 2.9 wt% (mean at 1.7 wt%, 84 samples) for boninites and between 1.2 and 2.5 wt% (mean at 1.6 wt%, 24 samples) for island arc tholeiites)). In addition, most of these M have high H_2O/K_2O ratios which are consistent with a transfer of H_2O as a F phase from the subducted slab to the mantle wedge. For boninites and island arc primary M, the present H_2O contents are ≈2.5× higher than commonly assumed, which suggests that the amount of H_2O released to the surface in arc magmatism has been previously underestimated. (Authors' abstract)

SOBOLEV, A.V., MIGDISOV, A.A., and PORTNYAGIN, M.V., 1996, Incompatible element partitioning between clinopyroxene and basalt liquid revealed by the study of melt inclusions in mineral from Troodos lavas, Cyprus: Petrologiya, v. 4, no. 3, p. 228-239, (in Russian, translated in Petrol., v. 4, no. 3, pp. 209-220). Authors at Vernadsky Inst. of Geochem. and Analytical Chem., Russian Acad. of Sci., ul. Kosygina 19, Moscow, 117975 Russia.

MI in clinopyroxene from Troodos lavas were studied by the methods of high-T optical thermometry, S ion mass spectrometry, and microprobe analysis to determine the partition coefficients of Ba, Sr, Y, Ti, La, Ce, Nd, Sm, Dy, Er, and Yb between low-Al, high-Mg clinopyroxene and boninite-like melt for Ts of 1100-1190°C and a hydrous F P of 1 kbar. Variations of the partition coefficients were found as a function of the T and the Al_2O_3 content in clinopyroxene. The results proved the study of M I in minerals to be an efficient tool for determining the coefficients of trace element distribution between the crystalline phase and the L. (Authors' abstract.)

SOKOLOV, S.V., 1996, Formation temperatures and temperature facies of carbonatites from the alkaline ultramafic complexes: Geokhimiya, 1996, no. 1, p. 15-21 (in Russian, Engl. abst.)

Several different methods were used to estimate the formation T of carbonatites that are associated with alkaline carbonatite platform complexes: (1) homogenization of I of the mineral-forming medium, and (2) thermometers based on the T dependence of chemical and isotope compositions of minerals (the methods of L.L.Perchuk, and the isotope, calcite-dolomite, and magnetite-ilmenite methods). In addition, experimental data were used that were obtained from carbonate and silicate-carbonate systems at pressures and X_{CO_2} concentrations encountered in the carbonatite process. The Th for the MI have been demonstrated to be consistent with the experimental data, whereas most mineralogical thermometers underrate postcrystallization equilibrium T. The formation T for the mineral assemblages that represent specific carbonatite stages are shown to partly overlap, because T maxima for the later stages are higher than T minima for the earlier stages. Hence, the currently accepted scheme of T facies for the carbonatite process should be corrected. (Author's abstract)

SOLER, A., CARDELLACH, E., ARCOS, D. and DELGADO, J., 1996, The gold-bearing mineralizations in the Pyrenees and their significance in the evolution of the Hercynian orogen: IV Spanish Geol. Cong., Universidad de Alcalá, 1-5 July, 1996, published by Geogaceta, , v. 20, no. 7, p. 1554-1557 (in Spanish; Engl. abst.). First author at Dpto. de Cristalografia, Mineralografia y Depósitos Minerales, Facultad de Geologia, Universidad de Barcelona, C/Marti I Franqués s/n. 08028 Barcelona.

Gold is found in the Hercynian terranes of Central and Eastern Pyrenees as disseminations in metasediments of lower Paleozoic age; in veins contemporaneous with the main Hercynian foliation; in veins related to the Hercynian shear zones, faults and thrusts that postdate the main foliation and in skarns related to late Hercynian granites. Gold is associated to arsenopyrite, a typical feature throughout the Pyrenees. Two types of mineralizing F have been recognized: a CO_2-rich low sal (6% wt. NaCl eq.) F, present in the synfoliation veins and a CO_2-free and high sal (up to 30% wt. NaCl eq.) F found in the post-foliation deposits. Ore deposition took place around 500°C and 5 kb in the synfoliation veins and around 350°C and 2 kb in the post-foliation veins and skarns. The late Hercynian uplift of the metamorphic terranes 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. In the case of the skarns, the F were mobilized because of the thermal gradient related to the contact metamorphism. (Authors' abstract)

SOLODOV, I.N. and KOCHKIN, B.T., 1996, Influence of geostructural and geochemical factors on the distribution of technogenous sulfite [sic] brines in the aquifer enclosing the Bukinai uranium ore body (Kizil Kum): Geologiia Rudnykh Mestorozhdenii, v. 38, no. 1, p. 87-xx (in Russian).

SOMANI, R.L., 1996, Fluid inclusion study in octahedral fluorite from Chowkri-Chapoli, India (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 705. Author at Dept. of Geol., Univ. of Rajasthan, India.

At Chowkri the fluorspar mineralisation occurs in tonalite, reef quartz and hornblendite. At Chhapoli mineralisation is hosted in feldspathic quartzite. At both the localities the fluorite occurs as large, varied-color zoned octahedral crystals and as coarse granular fluorite. Associated minerals are quartz, calcite, apatite, galena and pyrite. P negative faceted I of tetrahedron shape are more common than S and pseudosecondary I. In the green fluorite regular tetrahedron shape I are more common than in the purple fluorite or purple bands in the green fluorite. FI range in size from 5 to 70 micron (one axis of a tetrahedron). Degree of fill is in general high mostly more than 95%. Three types of FI have been observed in the zoned crystals, most I in core are Type-I (L+V+Halite), having the sal (in eq. wt. % NaCl) 27 to 31 (with an average of 29.8) and Th (Th) 170° to 195°C. Most I in the middle zone are type-II (L+V) having sal (critical sal also showing metastability) and Th 21.4 to 26.3 & 170° to 200°C respectively. I in the outer zone of the crystal formed during the closing stage of fluorite formation are Type-III (L+V) having the sal and Th in the range of 25.9 to 3.4 and 130° to 190°C respectively. Cryometric study suggest the first melting T in Type- I, II & III inclusion is between -45 to -52 indicating the presence of Ca and NaCl in the F. The FI measurement indicated that the F stayed at nearly the same T and sal for most of the mineralizing period. The drop in T and sal in the final stage of deposition strongly suggest an influx of cool, probably meteoric water. The fluorite mineralisation ceased with the decrease in sal. The mechanism of fluorite deposition is by cooling combined with chemical changes, pH variation and wall rock alteration. Fluorine bearing solution are genetically related to granitic activity. Fluorine and Ca were simultaneously transported in solutions as complexes NaF^0, CaF^+, Na_2F^+. Ca may have leached from granitic host rock as these rocks are depleted in Ca content. (From authors' abstract by E.R.)

SOMANI, R.L. and **SRIVASTAVA, P.K.,** 1996, CO_2 metamorphism in granulitic terrain at Bandanwara, Western Indian Shield, India (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 555. Authors at Dept. of Geol., Univ. of Rajasthan, Jaipur-302004 India.

Granulite facies rocks of Banded Gneissic Complex of Western Indian Shield are exposed around Bandanwara (26°8":74°42") 43 km south of Ajmer in Rajasthan, India.

FI studies in quartz and garnet grains in granulite from Bandanwara area indicates CO_2 densities 1.00 to 1.07 gm/cm^3 in the P and 0.87 to 0.90 gm/cm^3 in the S I. The CO_2 I are entrapped at the peak of metamorphism and suggest the P to be 7.2 to 9.2 kbar at an estimated T of 650-850°C. This is consistent with the P estimated from the mineral assemblages for the granulite facies rock in the area. S multiphase I containing 2-3 solid phases may be due to retrograde metamorphism.

Granulite facies terrain are generally regarded as exhumed section of the lower crust which have been subjected to the high P-T conditions. Out of the three models for the genesis of granulite like absorption of H_2O into anatectic M V deficient metamorphism and dilution of pore F with externally buffered CO_2 [sic]. The presence of biotite in a stable phase in granulite ruled out the formation of granulite by V deficit metamorphism in the present area. (Authors' abstract)

SONG, Cian, 1993, The minerogenetic mechanism and geochemical model of Shanhu W-Sn ore field, Buangxi: J. of Guilin College of Geol. (Guilin Yejin Dizhi Xueyuan Xuebao), v. 13, no. 4, p. 376-385 (in Chinese, Engl. abst.). Author at Dept. of Exploration Geol., Guilin College of Geol.

There are three types of ore deposits in Shanhu W-Sn ore field: wolframite-cassiterite-quartz vein, wolframite-stibnite- fluorite- quartz vein, and ferberite- quartz breccia vein types. Taking Changyingling hidden granite as a centre they form unilateral- horizontal zoning from the east to the west and vertical zoning from the depth to the upper part. They are considered as the same series. During early period, the ore-forming F is characterized by similar sulfate-type magmatic water which is rich in W, Sn, F, B, etc. and hypo- mesothermal, acid, higher f_{S_2} and lower f_{O_2}. By the later period, the ore- forming Fl gradually transforms into a similar chloride- type mixed- F which is contaminated with groundwater, rich in Cl and meso- epithermal, weak acid-neutral, higher f_{O_2} and lower f_{S_2}. Supply of the ore-forming materials is provided from magmatic to stratigraphic source. The formation of the mineralization series may be considered to be a result of evolution of the ore-forming F, and their ore-forming materials come from many sources. The three types of ore deposits in the series are regarded as polygenetic compound ore deposits. (Cation and anion chemistry and H & O isotopes of FI are given. (H.E.B.).)

SOTNIKOV, V.I. and **BEREZINA, A.N.,** 1996, Chlorine and fluorine in the Sorskii porphyry copper molybdenum ore deposit, Kuznetsk Ala Tau Range: Geochem. Int'l., v. 34, p. 280-xxx

SOURS-PAGE, R., JOHNSON, K.T.M. and **NIELSEN, R.L.,** 1996, The phenomenon of MORB over-enrichment: Evidence from melt inclusions from the Endeavour Segment, Juan de Fuca Ridge: 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F842, November 12, 1996. First author at COAS, Ocean. Admin. 104, Oregon State Univ., Corvallis, OR 97331.

Over-enrichment, a phenomenon common to many MORB suites, is defined as the enrichment of incompatible elements as a function of Mg# greater than that which can be attributed to fractional crystallization alone. Attempts to simulate the generation of over-enrichment have been made by modeling a variety of processes including boundary layer fractionation (BLF) and paired fractionation and recharge (PRF). These modeled processes have been unable to adequately reproduce such trends in detail. The Endeavour Segment of the Juan de Fuca Ridge is a region where an over-enriched depleted suite is present (Karsten et al., JGR, 1990). We have used re-homogenized MI from primitive plagioclase phenocrysts to investigate the petrogenesis of these magmas. If the evolved, enriched members of the depleted suite were produced by a fractionation dominated process from primitive, depleted parents, then the MI from primitive composition phenocrysts in the enriched lavas should be depleted.

Feldspar-hosted MI are generally more primitive (Mg# up to 75) than their host lavas. The trace elements K_2O, P_2O_5 and TiO_2, exhibit systematic variations in excess of analytical error, with P_2O_5 and TiO_2 correlated with HREE, and K_2O correlated with LREE. Most important, in spite of the observed compositional diversity, the average enrichment of MI of a specific lava is related to that of the host lava composition. In addition, the host lava can generally be produced by simple fractionation of the average MI composition. These observations imply that enriched, evolved lavas are derived from enriched parents, not from depleted parents by some set of fractionation dominated processes. Therefore, many MORB suites are not suites in the sense that we have assumed in our models, but are derived by mixing different proportions of an array of parent magmas. (Authors' abstract)

SOUZA NETO, J.A., LEGRAND, J.M., and **SONNET, Ph.,** 1996a, Characterization of metasomatism with geochemistry and fluid inclusions in gold-bearing calc-silicate rocks of Itajubatiba, NE Brazil (abst.): 16th Earth Sciences Meeting, [Abstracts], pub. by Soc. Géol. Fr., Paris, p. 102 (in French). First author at Lab. Géologie et Minéralogie, Université Catholique de Louvain, Place Pasteur 3, B-1348 Louvain-la-Neuve, Belgium.

The gold-bearing mineralization of Itajubatiba occurs in calc-silicate rocks, present as lenses in marbles. These geological terranes are on a dextral transgressive shear-zone. Between the last two tectonic episodes (transition from ductile to fragile) there was an important metasomatic event, which led to the [formation?] of three types of calc-silicate rocks (marbles, metasyenogranites and metatonalites), and probably also of the gold mineralization. FI in quartz from the calc-silicate rocks, from quartz veins and from quartz-calicite-sulfides veins are of two types: pure carbonic type and low-sal aq type. The latter Is contain Ca and Mg (as one could expect from the geochemical balances). They were formed between 220 and 478°C and between 0.2 and 4.3 kbar. (From authors' abstract, translated by E.A.J. Burke.)

See also adjacent item. (E.R.)

SOUZA NETO, J.A., LEGRAND, J.M. and **SONNET, Ph**, 1996b, Fluid inclusion evidence for chemical composition of metasomatic fluids in a gold deposit hosted in calc-silicate rocks, Itajubatiba, NE Brazil (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 123-125. First author at Lab. Geologie et Mineralogie, Universite Catholique de Louvain. 3, Place Louis Pasteur, 1348, Louvain-la-Neuve, Belgium.

A metasomatic event transformed the marble and alkaline rocks into calc-silicate rocks. Gold occurs as disseminated grains or in tension gash fractures where it associates with quartz, calcite, pyrrhotite, pyrite and chalcopyrite within the calc-silicate rocks (Souza Neto, 1995).

FI were investigated in quartz and calcite in three samples: a barren quartz vein, a gold-bearing quartz-sulphide-calcite vein and a calc-silicate rock. They consist of two types: carbonic I and aq-saline I, some with dm halites.

Tm_{CO_2} varies from –57.3 to –56.0°C ranges from –25.4 to 30.4°C, and a peak of distribution at 5.0° Te of aq-saline I range from –64.2 to –34.7° C and maximum frequency at –52.5° C and Tm ice ranges from –46.4 to 1.1°C, with a maximum frequency at –2.5°C. Th ranges from 84.8 to 529.1°C, with three peaks in the distribution at 140, 260 and 340°C.

This study suggests that there is a compositional similarity between the metasomatic F which caused the formation of the calc-silicate rocks and the F present during the formation of the veins. These F had a composition involving CO_2 and H_2O, with probably dissolved Ca, Mg, Fe and K. (From authors' abstract by E.R.)

See also adjacent item. (E.R.)

SPAN, R. and WAGNER, W., 1996, A new equation of state for carbon dioxide covering the fluid region from the triple-point temperature to 1100 K at pressures up to 800 MPa: J. Phys. Chem. Ref. Data, v. 25, no. 6, p. 1509-1596. Authors at Lehrstuhl für Thermodynamik, Ruhr-Univ. Bochum, D-44780 Bochum, Germany.

SPANGENBERG, J., FONTBOTÉ, L., SHARP, Z.D. and HUNZIKER, J., 1996, Carbon and oxygen isotope study of hydrothermal carbonates in the zinc-lead deposits of the San Vicente district, central Peru: a quantitative modeling on mixing processes and CO_2 degassing: Chemical Geol., v. 133, p. 289-315. First author at Département de Minéralogie, Univ. de Genève, 13, rue des Maraîchers, CH-1211 Genève 4, Switzerland.

Carbon and oxygn isotope studies of the host and gangue carbonates of Mississippi Valley-type zinc-lead deposits in the San Vicente District were used to constrain models of the ore formation.

A mixing model between an incoming hot saline slightly acidic radiogenic (Pb, Sr) F and the native formation water explains the overall isotopic variation. P variability plays a major role in the ore precipitation during the late hydrothermal events in San Vicente. (From authors' abstract by E.R.)

SPIRIDONOV, E.M., 1995, The inversional plutonogenic gold-quartz associationof the northern Kazakhstan Caledonides: Geol. Ore Deposits, v. 37, p. 149-175. Author at Moscow MV Lomonosov State Univ., Vorobevy Gory, Moscow 119899, Russia.

The main Au deposits of northern Kazakhstan are associated with the Stepnyak-type minor intrusives distinguished by Yu. A. Bilibin as the Stepnyak complex–a postbatholith association of Au-bearing minor diorite intrusives that are younger than the tonalite-granodiorite association (TGA). Now, it is evident that all the TGA intrusives are Au-bearing to various extents, and the Stepnyak-type intrusives, along with the main Au deposits, belong to the TGA derivatives. Minor Au-bearing plutons are composed of early (prebatholith intrusive phase) bodies consisting of quartz biotite-hornblende leucogabbro-norites (stepnyakites); these intrusive bodies mark deep-penetrating faults that subsequently serve as ore-conducting structures. The gold-quartz association (GQA) is due to beresitization and listvenitization processes that represent the youngest episodes of the postintrusive hydrothermal activity. The ores had deep-seated sources of Au, Hg, Sb, and Te; the Au concentration was promoted by hydrocarbons and bitumoids. The ores were generated in a brittle deformation zones above the 400°C isotherm at the depth interval of similar to 1-12 km. The ore deposition was characterized by the following maximum parameters: T 370°C, P 3.6 kbar, solution sal 17%, CO_2 7 mol/kg, CH_4 2.5 mol/kg, P-H_2S 2.5 kbar. The deposits formed in relatively ordered closed systems that stipulated a stable composition of ores and ore minerals along the vertical section of particular deposits and the differentiation of ore material at various levels with specific facies and corresponding mineral types of deposits: gold-Ag-sulfosalt-antimonite (with alpha-amalgam of Au) and gold-galena-sulfoantimonide types (P 0.3-1 kbar) in the hypabyssal zone; gold-galena-sulfoantimonide and gold-galena (with tellurides) types (P 1-1.8 kbar) in the mesoabyssal zone; and gold-galena-telluride and gold-telluride types (P 2-3.6 kbar) in the abyssal zone. The mineral facies of ores are strongly governed by the composition of host rock and the concentration of S. The TGA-GQA inversional series originated as a result of the strongest thermal influence upon the Earth's crust, and probably, they correspond to the maximum metamorphism and strong F H_2O-CO_2 flux (Author's abstract)

SPIRIDONOV, E.M., 1996, Inversion plutonogenic gold-quartz formation of Caledonides of the north-central Kazakhstan (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 743. Author at MSU, Russia.

The GQF deposits are composed of quartz and carbonate-quartz veins, stockworks of veinlets of the same composition, [and] mineralized altered wall-rocks. Typomorphic minerals are high-purity gold, arsenopyrite, scheelite, Te-, Bi-, Se-free fahlerz. The majority of ores are associated with small multiphase intrusions.

Hydrocarbon and bituminoids assisted in Au concentration in ores. The highest values of ore deposition-beginning are T=370°C, sal of Mg-K-Na-Cl fluids 17%, C_{CO_2} and C_{CH_4} 7 and 2.5 mole/kg of F, respectively, P_{H_2S}=2.5 kb [sic]. The productive mineral association (gold, Au tellurides) was formed at 200-180°. Mineral facies of ores are to a great extent function of host-rock compositions and sulphur contents. (From author's abstract by E.R.)

SPRY, P.G., PAREDES, M.M., FOSTER, Fess, TRUCKLE, J.S. and CHADWICK, T.H., 1996, Evidence for a genetic link between gold-silver telluride and porphyry molybdenum mineralization at the Golden Sunlight deposit, Whitehall, Montana: Fluid inclusion and stable isotope studies: Economic Geol., v. 91, p. 507-526. First author at Dept. of Geol. and Atmos. Sci., 253 Science I, Iowa State Univ., Ames, Iowa 50011.

The Golden Sunlight gold-silver telluride deposit, hosted primarily within the Mineral Hill breccia pipe is spatially related to a high-level, Late Cretaceous multiphase, alkaline to subalkaline porphyry system.

FI Th of primary and pseudosecondary aq L-V I (constant L to V ratios) in quartz-pyrite-molybdenite veins range from 131.8° to 398.2°C. Primary and pseudosecondary I with highly variable L-V ratios that coexist with rare three-phase CO_2-H_2O and multiphase I (one or more solid phases in addition to L and V) also occur in quartz-pyrite-K feldspar-molybdenite veins and indicate periods of intermittent boiling. Th for FI in stage I auriferous pyrite veins range from 145° to 345°C with sal of ≈1 to 10 wt% NaCl eq. Values of $\delta^{34}S$ for sulfides in the Mineral Hill breccia pipe, quartz-pyrite-K feldspar-molybdenite veins, Proterozoic sedimentary rocks, and distal base metal veins range from -12.2 to 3.1 per mil, -8.1 to 0.8 per mil, 0.7 to 6.1 per mil, and -8.9 to 9.5 per mil, respectively, and suggest a mixed magmatic-sedimentary sulfur source. Calculated $\delta^{18}O$ values for water in equilibrium with late-stage sericite at 170°C vary from 0.7 to 2.8 per mil, whereas δD water values range from -67 to -8 per mil.

Geologic, paragenetic, FI, and stable isotope studies are consistent with an early magmatic F, associated with quartz-pyrite-K feldspar-molybdenite veins, that subsequently mixed with meteoric water during stages I to IV breccia pipe-hosted and auriferous pyrite vein formation. Ore-forming components (e.g., Au, Ag, Te, Cu, Bi, Mo, and much of the S) were most likely derived from the Late Cretaceous intrusive system with possible contributions from the Proterozoic host rocks. (From author's abstract by E.R.)

STAROSTIN, V.I., 1996, Fluid dynamics of ore deposits: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Engl.), p. 9-17. Author at Moscow State Univ., Moscow, Russia 119899.

A review. (E.R.)

STASIUK, M.V., BARCLAY, J., CARROLL, M.R., JAUPART, C., RATTÉ, J.C., SPARKS, R.S.J. and TAIT, S.R., 1996, Degassing during magma ascent in the Mule Creek vent (USA): Bull. Volcanol, v. 58, p. 117-130. First author at Univ. Paris 7 et Inst. de Physique du Globe, 4, place Jussieu, F-5252 Paris Cedex 05, France.

The structures and textures of the rhyolite in the Mule Creek vent (New Mexico, USA) indicate mechanisms by which volatiles escape from silicic magma during eruption. Analyses of glass I in quartz phenocrysts from the lava indicate that the magma had a pre-eruptive dissolved water content of 2.5-3.0 wt% and, during eruption, the magma would have been water-saturated over the vertical extent of the present outcrop. However, the vesicularity of the rhyolite is substantially lower than that predicted from closed-system models of vesiculation under equilibrium conditions. To account for the discrepancy between observed vesicularity and measured water content, we conclude that G escaped during ascent, probably beginning at depths greater than exposed, by flow through the vesicular magma. Local channelling of G into the country rocks is suggested. In the central part of the vent, similar local channelling of G is indicated. These mechanisms of G loss may be responsible for the commonly observed transition from explosive to effusive behaviour during the eruption of silicic magma. (From authors' abstract by E.R.)

STEFANINI, Barbara and WILLIAMS-JONES, A.E., 1996, Hydrothermal evolution in the Calabona porphyry copper system (Sardinia, Italy): The path to an uneconomic deposit: Economic Geol., v. 91, p. 774-791. Authors at Dept. of Earth and Planet. Sci., McGill Univ., 3450 Univ. Street, Montreal, Quebec, Canada H3A 2A7.

The Calabona porphyry copper system is developed in a small, relatively deep seated (≈5 km) dacitic intrusions. Early hydrothermal alteration produced a potassic assemblage in the deep and central parts of the complex, and a peripheral propylitic halo.

The earliest F that circulated in the Calabona porphyry complex had high sal (40-60 wt% NaCl equiv), and is interpreted to have been exsolved directly from the crystallizing magma. However, major entrapment of this F only occurred after it had cooled to T of about 400°C. This F was responsible for potassic alteration and for precipitation of chalcopyrite and bornite. The circulation of a lower T (270°-330°C), Ca-enriched F of meteoric origin in the peripheral parts of the system caused propylitic alteration. At an intermediate stage of hydrothermal evolution, waters of external origin entered the central parts of the system along a network of late fractures (group 3 veins) or reopened group 2 veins. Partial mixing of this meteoric-formational water with the high-sal F already circulating in the system, created a F characterized by sal ranging from 2 to 23 wt% NaCl eq. Circulation of this mixed F at relatively low F/rock ratios along a prograde thermal path caused sodic alteration. The continuous in-flow of meteoric water, and the general T decrease in the system, produced progressively more oxidized and acidic F, which caused phyllic alteration and intense copper leaching.

The very low concentration of Cu in the Calabona deposit is surprising, in view of wall-rock alteration, style of mineralization, and a F evolution typical of those of many productive porphyry copper systems. We propose that this is mainly a consequence of the relatively deep level of emplacement of the intrusion and the dacitic composition of the magma. (From authors' 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, translated in Trans. (Doklady) Russian Acad. Sci., Earth Sci. Sect., v. 344, p. 213-217, 1996). Author at Buryat Geol. Inst., Siberian Div., Russian Acad. of Sci., Ulan Ude.

Abst. in FIR v. 28, p. 163. (E.R.)

STENINA, N.G. and GUBAREVA, D.B., 1996, Water speciation in quartz: TEM combined with IRS study (abst.): 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 490.

Water state in quartz is a problem which concentrated the efforts of many investigators for a long time. Are the H-related defects point defects or their associations, made up of only H_2O molecules or related to other impurities? Response to these questions cannot be given basing only the results of spectroscopic methods (IRS, NIR, NMR) as they present integral information over the whole volume of the sample but cannot resolve the defects of mineral real structure. TEM (Transmission electron microscopy) is a direct method for their study. Such facilities are necessary to understand water specification in quartz. TEM combined with IRS (room and –77°K T), x-ray microanalysis, EPR have been employed for the studies of quartz samples chosen from different generations of vein ore (gold)-bearing and non ore-bearing quartz. Analysis of the obtained data showed that there is a sharp difference between the form of water bonding in grey transparent ore-bearing quartz and white milky or sugar-like silica which is typical for veins without ore mineralization. Ore-bearing quartz contains water in the crystalchemical form, i.e., it is bonding in silica framework; whereas the second one has, mainly, free water entering G-L bubbles. This difference was established by every mentioned method independently. The character of water bonding in silica matrix was determined as indicator of ore-bearing capacity of vein quartz.

This model took the name of aquacomplex due to the central H_2O molecule which bonds left (SiO_2) and right (Me) parts together by weak donor-acceptor and hydrogen bonds. This model explains such characteristics of H-related defects as: simultaneous behavior both as OH-group and H_2O molecule, association with impurity defects (Na, Li, and Al), ability to form associations up to the "gel-like" defects. Besides it allows to understand why the problem of H-defects is valid only for quartz? Quartz is the unique silicate mineral which corresponds only to the left part of aquacomplex. The latter have a growth nature and express the structure of mineral-forming medium. Quartz forms as a result of disintegration of aquacomplex into SiO_2-H_2O, complex oxides, sulfides. Therefore, aquacomplexes fitted into the framework only in quartz may represent point defects and their associations [sic]. (From authors' abstract by E.R.)

STERN, L.A., KIRBY, S.H. and DURHAM, W.B., 1996, Peculiarities of methane clathrate hydrate formation and solid-state deformation, including possible superheating of water ice: Science, v. 273, p. 1843-1848. First author at U.S. Geol. Surv., Menlo Park, CA 94025, USA.

Slow, constant-volume heating of water ice plus methane G mixtures forms methane clathrate hydrate by a progressive reaction that occurs at the nascent ice/L water interface. As this reaction proceeds, the rate of melting of metastable water ice may be suppressed to allow short-lived superheating of ice to at least 276 kelvin. Plastic flow properties measured on clathrate test specimens are significantly different from those of water ice; under nonhydrostatic stress, clathrate undergoes extensive strain hardening and a process of solid-state disproportionation or exsolution at conditions well within its conventional hydrostatic stability field. (Authors' abstract)

STERNER, S.M. and FELMY, A.R., 1996a, FiT-iT_{aq} –a new computer program for thermodynamic analysis of experimental data on aqueous electrolyte solutions. Example: the system $CaCl_2$-H_2O (abst): 30th Int'l Geog. Cong., Abstracts, v. 1, p. 481. Authors at Battelle Pacific Northwest Laboratories, Richland, Washington.

See next abstract. (E.R.)

STERNER, S.M. and FELMY, A.R., 1996b, FiT-iT_{aq} - a new computer program for thermodynamic analysis of experimental data on aq electrolyte solutions. Example: the system $CaCl_2$-H_2O (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/ Shortcourse, Aug. 10-11, p. 8. (Note: this abstract was distributed at the I.G.C. Workshop/Shortcourse, but was not printed in the official 30th I.G.C. Abstracts volumes. E.R.) Authors at Battelle Pacific Northwest Laboratories, Richland, Washington 99352, USA.

A new computer program will be introduced which 1) evaluated aq electrolyte model parameters from P experimental data and simultaneously 2) provides graphical representations of the model predication suitable for publication and/or presentation. (From authors' abstract by E.R.)

STEVENS, G., BOER, R. and GIBSON, R., 1996, Metamorphism in the Witwatersrand Basin: a review of recent advances and some predictions on gold remobilization by metamorphic fluid flow: Economic Geol. Research Unit, Univ. of the Witwatersrand, Information Circular No. 303, 34pp.

Low-P, high-T peak metamorphic conditions were attained during the crustal thermal perturbation associated with the Bushveld Event. This study focuses on metamorphic F production from West Rand Group shales during this event. In an average West Rand Group shale composition, where peak metamorphic T were high enough for this model reaction to have run to completion (-450°C), 70 litres of hydrous F would have been produced per cubic metre of rock. Further breakdown of hydrous minerals in shales of this composition, to produce the peak metamorphic assemblage recorded in the collar of the Credefort Dome (-600°C), would have liberated an additional 69 litres of hydrous metamorphic F per cubic metre of rock. These calculations, coupled to the peak metamorphic thermal profile through the Basin and the known subout-crop limits of the West Rand Group suggest that the Wit-watersrand Basin lost at least 7.58×10^{14} litres of metamorphic F. FI studies in gold-bearing reef horizons of the Central Rand Group near the Basin margins indicate that these horizons experienced F flow close to the ~350°C metamorphic peak. Calculated gold solubility in the measured FI compositions is between 1 and 10 ppb. Thus, metamorphic F derived from within the lower portions of the Witwatersrand Supergroup had the potential to mobilise at least 7600 tons of gold. This F-flow event would have had the potential to generate major gold deposits on the Kaapvaal Craton outside the boundaries of the Wit-watersrand Basin. (From authors' abstract by E.R.)

STOLPOVSKAYA, V.N., SOKOL, E.V. and LEPEZIN, G.G., 1996, IR-spectroscopic study of hydrous natural cordierites (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 494. Authors at Inst. of Mineral. and Petrog., Novosibirsk, Russia.

The channel H_2O I- and II-type, CO_2 and alkali contents of 19 natural cordierites of different chemical compositions from a variety of metamorphic and pegmatite environments have been analyzed using a combination of powder IR-spectroscopy, electron-microprobe analysis and Penfield method. [table omitted]

The observation of the four bands in the fundamental stretching region (near 3600 cm^{-1}) and their correlation with the combination modes (near 1600 cm^{-1}) confirms the presence of the two different types of molecular H_2O in all samples. Position of these predominant bands and CO_2 peak (near 2300 cm^{-1}) is invariable in the spectra of cordierites of any chemical composition. O-H bands are controlled by variations only in the neighbouring cation environment of H_2O molecules (for example, Na+). Variations in the remote environment: substitutions $Fe^{(6)}$-->$Mg^{(6)}$, $Be^{(4)}$-->$Al^{(4)}$ and introduction CO_2 into cavity don't lead to the displacements of O-H bands. Besides stretching modes of water there are some subordinated bands in all spectra (v-3706, 3665, 3642, 3622, 3594 cm^{-1}). We propose that other minor (OHn)-groups in cordierite structure are situated in another cation coordination (namely Fe^{2+} and Fe^{3+}). The relative proportion of each type of H_2O was determined using the absorption-band intensity of v1 H_2O II-type and v3 H_2O I type and total H_2O content.

The least-squares solution to our data is following: $[H_2O\text{-II}]=2.05\,[Na+] - 0.01$ ($r = 0.977$). The nearly 2:1 ratio between H_2O II-type and Na+ in the samples from all geological environments suggests that most of the H_2O II-type molecules are connected with the Na+, while the concentration of type I water is an accurate reflection of the original H_2O fugacity in the mineral-forming processes. In addition the ratio $[Na]:[H_2O]=1:2$ may be suggested that the volatile loss at the regressive stage of the cordierite-forming processes was not essential. The obtained results allow to formulate a problem about the markedly distinctions between H_2O and II-type behavior (incorporation in cordierite structure or removing from it) in the geological processes. We believe that this distinction must be take into account in constructing of Na-Mg-Fe-Cordierite diagrams. (From authors' abstract by E.R.)

STOLZ, A.J., JOCHUM, K.P., SPETTEL, B. and **HOFFMANN, A.W.**, 1996, Fluid- and melt-related enrichment in the subarc mantle: evidence from MB/TA variations in island-arc basalts: Geology, v. 24, no. 7, p. 587-590. Authors at Max-Planck Inst. für Chemie, Abt. Geochemie, Postfach 3060, 55020 Mainz, Germany.

The single most distinctive feature of volcanic rocks from convergent-margin settings is a marked depletion of the high field strength elements (HFSE) Nb, Ta, and Ti relative to large ion lithophile and light rare earth elements when compared with basalts from mid-oceanic ridges (MORB) and the oceanic islands. A major impediment to a better understanding of this problem has been a lack of high-quality data for the HFSE (particularly Nb and Ta) that occur in very low concentrations in most volcanic rocks from convergent-margin settings. We report new analyses of Nb and Ta for a suite of island-arc volcanic rocks as well as some sea-floor sediments. Our data show that Nb/Ta values for relatively depleted island-arc volcanic rocks are similar to MORB and essentially chondritic (Nb/Ta ~ 17), whereas more potassic arc volcanics have substantially higher Nb/Ta values (up to 33). We interpret these high values as due to modification of the subarc mantle source by silicic M derived from the subducting slab, whereas enrichment of the source regions of the less potassic arc rocks involved a slab-derived F. (Authors' abstract)

STOWELL, H.H., LESHER, C.M., GREEN, N.L. , SHA, Peng, GUTHRIE, G.M. and **SINHA, A.K.**, 1996, Metamorphism and gold mineralization in the Blue Ridge, southernmost Appalachians: Economic Geology, v. 91, p. 1115-1144. First author at Dept. of Geol., Bevill Research Bldg., Univ. of Alabama, Tuscaloosa, Alabama 35487-0338.

Lode gold mineralization in the Blue Ridge of the southernmost Appalachians is hosted by metavolcanic, metaplutonic, and metasedimentary rocks.

Mineralogy, chemistry, and O and H isotope studies suggest that the three types of host rocks have undergone differing amounts and types of alteration during mineralization. Wall-rock alteration suggests that most deposits formed from F that were close to equilibrium with metavolcanic and metasedimentary rocks. Stable isotope compositions of the F calculated from vein minerals and vein selvages are consistent with a predominantly metasedimentary F source, but vary from deposit to deposit. Silicate mineral thermobarometry of vein, vein selvage, and wall-rock mineral assemblages indicate that mineralization and regional metamorphism occurred at greenschist to amphibolite facies. Oxygen isotope fractionation between vein minerals and selvage minerals consistently records equilibration T that are similar to or slightly lower than those estimated from silicate thermometry.

Auriferous veins contain numerous FI that were emplaced in several stages and can be subdivided into five compositional types based on salt and CO_2 concentrations. FI isochores for early formed I from these veins intercept the pressure and temperature conditions estimated from silicate mineral thermobarometry and stable isotope thermometry, and are compatible with entrapment at those conditions. These F exhibit significant variation in sal (X_{NaCl} eq. = 0.0-0.2) and CO_2 (X_{CO2} = 0.0-0.2), suggesting variation in F-wall-rock interaction that accompanied gold deposition during declining T. Less abundant and later F within the veins are dominantly CO_2.

The data indicate that the present distribution of gold is a result of metamorphism during progressive D_2-D_3 deformation. The implication is that the F were derived from metasedimentary and/or metavolcanic formations in the lower parts of the crystalline thrust stack (or possibly from underlying antochthonous sedmentary formations), ascended along permeable fault zones, and were emplaced as veins into dilatent areas in and adjacent to the fault zones. (From authors' abstract by E.R.)

STRASHIMIROV, S., SERAFIMOVSKI, T. and **KOVACHEV, V.**, 1996, Temperatures of the ore-forming processes in the Buchim porphyry copper deposit (Macedonia): Data from fluid inclusion studies: Geol. Ore Deposits, [Geolog. Rudnykh Mestor.], v. 38, p. 333-337 (in Russian, Engl. abst). First author at St. Ivan Rilski Univ. Min. and Geol., Sofia, Bulgaria.

This recent study is the first attempt to establish the T of the ore-forming processes on the basis of FI studies in the Buchim porphyry copper deposit, the largest deposit of this type in the territory of Macedonia. The observations are made on samples from quartz in association with ore minerals from the central part of the deposit (Tzetralni del). Typizaton of the I studied established a large presence of three phases of I, containing very often more than one solid phase as a dm. These I are significant by their relatively large sizes (10-30 micrometers) and very high Th (500-580°C). They are typical for an association with magnetite, hematite, and rutile. The Th for the two-phase I show four maximum ranges (490-460°C, 430-400°C, 370-320°C, and 200-180°C). These maximums probably mark the T ranges of the deposition of the main mineral assemblage in the deposit. The largest part of the copper mineralization was formed in the first and in the second T interval. Compared with similar copper deposits from the SE part of the Carpatho-Balkan region, the Buchim deposit is much closer to the Elatzite porphyry copper deposit (Panagiurishte ore region, Bulgaria) and the Maijdanpek porphyry copper deposit (Bor ore district, Yugoslavia). (Authors' abstract)

STRAUB, K.T., HAGEMANN, S.G., BROWN, P.E. and **YEATS, C.J.**, 1996, Fluid inclusion constraints on the mineralizing fluid from the composite VHMS and lode-gold deposits at Mt Gibson, western Australia (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 126-128. First author at Dept. of Geol. and Geophys., Univ. of Wisconsin, Madison, WI 53706.

The base-metal-rich Mt. Gibson gold-silver deposits are anomalous as they contain a highly varied sulfide assemblage, few discrete quartz veins and partially stratiform mineralization. The base-metal rich gold-silver mineralization is likely composite in nature, with early synvolcanic polymetallic volcanic hosted massive sulfide (VHMS) mineralization processes and subsequent overprinting by lode-gold style mineralization (Yeats and Groves, Econ. Geol. in press). A FI study was undertaken in an effort to understand the physico-chemical nature of the F present during the two separate mineralizing events.

Mt Gibson FI show five predominate types: (I) CO_2, (II) CH_4, (III) H_2O-salt ± G, (IV) CO_2-CH_4, and (V) CO_2-H_2O-salt ± G. All FI studied have been found in quartz; petrography of sphalerite, garnet and other transparent minerals (including zircon and feldspar) have revealed no preserved I.

Primary I of types I, III, IV and V occur in low-, high- and non-base-metal-bearing samples. Type I inclusions range in CO_2 density from 1.08 to 0.42 g/cm^3 (ave. = 0.67, n = 36). Type II inclusions have only been observed in non-ore mineral-bearing samples and average 0.29 g/cm^3 (stdev = 0.03 g/cm^3, n = 25). Type III inclusions generally contain at least one dm (some I show five distinct solid phases at room T). The sal of these I show ranges with three distinct groups at <10 eq. wt% NaCl (ave. = 7.2, n = 14), 10-20 eq. wt% NaCl (ave. = 17.0, n = 11), and >30 eq. wt. % NaCl (ave. = 47.1, n = 14). Eutectic T are also variable, ranging from –81 to –15°C. Three populations of H_2O-salt I are discernible from the freezing data: I whose Tm(ice) < –30.0°C, I with Tm(ice) ranging from –25.0 to 0.0°C, and I with final melting T at +10 to +30.0°C. Type IV inclusions comprise two sub-populations, type IVa: CO_2-CH_4 I with <10% CH_4, and type IVb: CH_4-rich I containing <10% CO_2 (as determined by homogenization between –70.0 and –82.6°C). Type IVa and IVb I have densities from 1.13 to 0.53 g/cm^3 (ave. = 0.74, n = 55). Type V inclusions are fairly rare containing relatively pure CO_2 (ave. X_{CH_4} <0.1 within the carbonic phase and bulk X_{CO_2} from 0.08 to 0.14). The Type V inclusions also contain a very saline aq component with eq. wt % NaCl from 10.9 to 42.3 (ave. eq. wt % NaCl = 22.3, n = 12). The eq. CO_2 density of the carbonic phase is calculated from 0.92 to 0.64 (ave. = 0.55, n = 12). Final homogenization and decrepitation temperatures for types III and V range from 213 to 600°C (stdev = 143°C). Decrepitation of types III, IV and V also occurred within this range, often prior to final homogenization (for types III and V only). I containing dm mostly experience final homogenization with dm dissolution and many I containing larger dm failed to homogenize at T < 600°C.

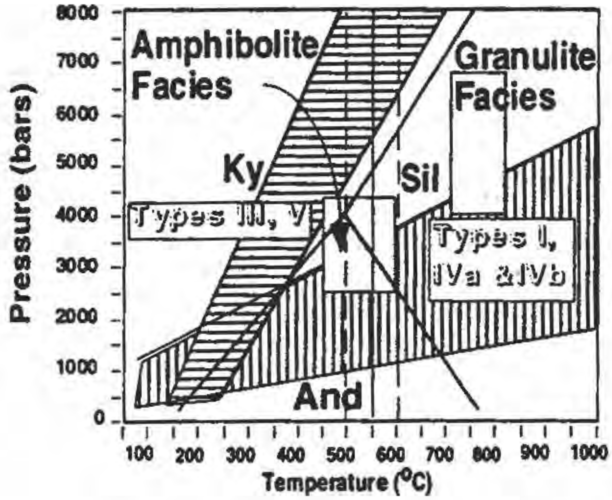


Figure 1. Isochores for the five fluid inclusion types observed at Mt Gibson. The vertical solid line and dashed lines represent the temperature of metasomatism as determined by garnet-biotite thermometry (Yeats and Groves, in press).

A comparison of FI data from low- and high-base-metal samples shows broadly similar physico-chemical properties. Petrographic evidence indicates that I types III and IV may occur in textural equilibrium and be the product of phase immiscibility. Whether this observation can be extended to include the origin of types I, II and V F is uncertain; the petrography is equivocal.

Preliminary geobarometric calculations are summarized in Figure 1. P data aside, the I analyzed also do not conform to expected FI compositions in VHMS systems. It is considered likely that most FI from the early VHMS hydrothermal system were modified or destroyed during the subsequent lode-gold event. The extremely high sal are suggestive of at least a major component of magmatic F. (From authors' abstract by E.R.)

STRUJKOV, S.F., RYJOB, O.B., ARISTOV, V.V., GRYGORIEV, Y.I.R., KOLESNIKOV, A.G. and **ABBOTT, G.J.**, 1996, Geological structure and ore mineralogy of the Julietta gold-silver deposit, northeast Russia: Int'l. Geol. Review, v. 38, p. 625-648. First author at Central Research Inst. of Geol. Prospecting for Base and Precious Metals (TsNIGRI), Varshavskoye sh., 129B, 113545 Moscow, Russia.

Julietta is a rich epithermal gold-silver deposit of the low-sulfidation, adularia-sericite type, located in the Cretaceous Okhotsk-Chukchi volcanic-plutonic belt 250 km northeast of Magadan.

Host andesite, andesite-basalt lava, corresponding subvolcanic bodies, and tuff are cut by Early Cretaceous quartz diorite stocks. Six vein zones occur in tensional and compression fissures. Ore mineralization was preceded by intense voluminous propylitization and linear sericitization (sericite + quartz + pyrite + ankerite). Orebodies occur within the low-T propylite (pyrite + calcite + quartz + chlorite + hydromica). Colloform-crustiform banded textures are commonly observed in the ore. Most of the ore minerals occur within thin, cyclically repeated, fine-grained bands of a hydromica-carbonate-adularia-quartz aggregate. Ore-bearing, fine-grained bands probably formed by periodic fracturing of the veins, whereas barren bands were deposited in relatively quiet conditions. "Micro-stalactites" and other gravitational textures demonstrate that minerals grew in open spaces. Ore-host structures gradually opened during mineralization.

Gangue minerals are primarily quartz, various carbonates and minor hydromica and adularia. Major ore minerals include pyrite, sphalerite, chalcopyrite, galena, tetrahedrite, silver sulfosalts, native gold, and custelite. Ore mineralization occurred in two stages–an early, post-volcanic stage and a late, post-granitoid stage. The early stage contains most of the precious metals and includes two substages–(1) gold-polymetallic (200-260°C) and (2) gold-silver-sulfosalt (90-200°C). The late stage also includes two substages–(1) carbonate-rhodonite-quartz (260-380°C) and (2) post-ore quartz-carbonate. F-I Th demonstrate complex T zoning. F composition was mainly aq, with Cl^-, HCO_3^-, Na^+, K^+, Ca_2^+, and a sal < 4-9%. The isotopic age of the deposit is 136 ± 3 Ma by the Rb-Sr method on adularia. The $^{87}Sr/^{86}Sr$ ratio is about 0.7075±0.0005, indicating a mixed crust-mantle source of the vein matter. Chloride complexes transported gold and silver. The G composition of the F suggests a near-surface, "closed" paleohydrothermal system. A major ore-forming factor could have been high seismic activity related to intrusion of the subvolcanic bodies. Breccias and multiphase veinlets may be related to relatively large-magnitude earthquakes, whereas cyclically banded ores may reflect local pH variations caused by smaller earthquakes. (From authors' abstract by E.R.)

STUART, F., BOYCE, A., FOXFORD, A., POLYA, D. and FALLICK, A., 1996, Constraints on the origin of low δD hydrothermal fluid inclusions from halogen and Ar isotopes: Evidence from Panasqueira W-Sn mine, Portugal (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 129-131. First author at Isotope Geosci. Unit, S.U.R.R.C., East Kilbride G75 0QF, UK.

Introduction

The subtly different chemistries of Cl, Br and I induce fractionation during evaporation, evaporite dissolution and F interaction with organic compounds which can be used to identify the source of sal, F mixing and water-rock interaction histories in contemporary groundwaters. The neutron irradiation-noble G mass spectrometry technique has proved useful for studying solid (halogens, K, Ca, Ba) and volatile (Ar isotopes) components of FI. We are using halogen and Ar isotope variations in quartz-hosted FI, which have previously been characterised by microthermometry and stable isotopes, to constrain ancient hydrothermal F histories.

Where high altitude meteoric recharge F can be ruled out, it has been proposed that low δD hydrothermal F (<–90‰) result from F interaction with organic compounds in sediments. The highly organo-philic nature of I leads to enrichments in hydrothermal F which allows the link between low δD and organic-fluid interaction to be tested. Hydrothermal I F from the Panasqueira Sn-W deposit are one example of where low δD hydrothermal F are ascribed to organic waters. We demonstrate that low δD F at Panasqueira are reflected in differences in halogen ratios which provide constraints on the source and history of the F which are unavailable from conventional stable isotopes.

Fluid inclusions and stable isotopes

A vug quartz crystal from the Main Sulphide Stage of mineralisation display growth zones that represent a time series of hydrothermal F. Primary FI have rather constant sal (7.3-8.7 wt.%), Th (254-260°C). and interzonal $\delta^{18}O_{fluid}$ variation is small. However, replicate measurement of δD_{fluid} exhibit variation from typically magmatic values in the earliest F (–65‰) to low values (–110‰) in the latest F. This range cannot be due to subtle changes of F T but must reflect changing F composition. A striking increase of $^{40}Ar/^{36}Ar$ with δD is due to an increased contribution of ^{36}Ar to the low δD_{fluid}. This is likely due to simply to atmospheric contamination. F from all zones display a limited range of $^{40}Ar^{*}/Cl$ (9 - 19 × 10^{-6}). This rules out boiling as a source of the interzonal δD variation.

Halogen data is on a Cl/Br *v.* I/Br plot (Fig. 2) which can be interpreted as a mixture between two F. The halogen (Cl/Br > 400; I/Br > 0.08) and δD values (–60 to –70‰) of the Br-poor component are consistent with a magmatic-hydrothermal source for this F. Thus the low δD F is enriched in Br relative to Cl and I relative to the magmatic F. Cl/Br lower than the seawater value (600) are generated by surface evaporation which is vigourous enough to induce halite precipitation. Due to the absorption of I on organic material, seawater has a low I/Br (0.0005). Thus the observed trend is consistent with a residual brine origin for the low δD F and there is no evidence for significant I-enrichment that might reflect an organic source. Permo-Triassic evaporites are regionally abundant and $^{40}Ar/^{39}Ar$ dating of the mineralisation is underway to ascertain whether the evaporites are chronologically significant.

If the halogen ratio variation does indeed reflect F mixing, the constancy of the F T and $\delta^{18}O_{fluid}$ requires a rather fortuitous similarity in the compositions of the two F. Further work is being undertaken to test this. (From authors' abstract by E.R.)

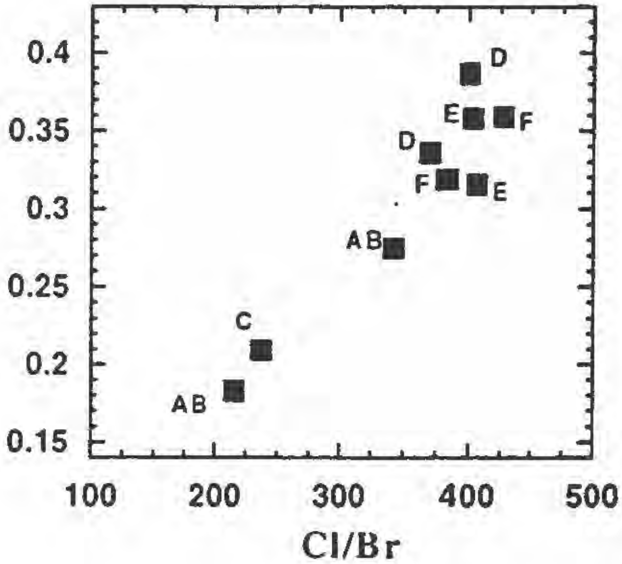


Figure 2. Halogen ratio variation in zones of Pa66 quartz. The zones charcterised by low δD fluids (A, B & C) are enriched in Br compared to the magmatic fluids.

STUART, F.M., BURNARD, P.G., TAYLOR, R.P. and TURNER, G., 1996, Tracing mantle volatiles in ancient hydrothermal fluids: He-Ar Isotopes in fluids inclusions from Dae Hwa W-Mo deposit, S. Korea (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 132-133. First author at Isotope Geosci. Unit, S.U.R.R.C., East Kilbride G75 0QF, UK.

We demonstrate the heat source and magmatic volatile contribution using a detailed study of the aq hydrothermal F trapped in gangue and ore minerals from the granite-related Dae Hwa W-Mo deposit in S. Korea.

F from the complete paragenesis at Dae Hwa record $^{3}He/^{4}He$ which can be considered as mixtures between mantle-derived He (1 × 10^{-5}) and radiogenic He produced by U-Th decay in the crust (3 × 10^{-8}). This provides unequivocal evidence that mantle melting was the heat source for granite formation and the subsequent mineralisation. While the FI composition, T and chemistry reflects a progressive dilution of magmatic F by meteoric water, I-hosted He isotopes show that the addition of juvenile volatiles into the hydrothermal system has been independent of evolution of the hydrothermal system. Mantle-derived He dominates the F hosted by pyrite, chalcopyrite and scheelite ($^{3}He/^{4}He$ ~5 × 10^{-6}) from the iron sulphide-scheelite stage (230-320°C). Hotter F (320-400°C) from the earlier wolframite-molybdenite stage have a significantly greater radiogenic crustal contribution ($1.5\text{-}5 \times 10^{-7}$). Correcting the measured $^3He/^4He$ using the previously identified coupling of ^3He and ^{40}Ar in F from iron sulphide-scheelite stage minerals, it appears that the low ^3He / ^4He of the early F is not due to the liberation of crustal radiogenic He during heating associated with granite intrusion.

A detailed study offF from individual zones of a large scheelite crystal demonstrates that the addition of magmatic (mantle-derived) volatiles to the hydrothermal system is episodic and un-related to changes in F composition. The progressive dilution of the magmatic F by meteoric waters, as described by decreasing $\delta^{18}O_{fluid}$ (+4 to –4‰) and FI Th (305-240°C) across the crystal, is not reflected in the He and Ar isotope systematics. A sharp $^3He/^4He$ increase is recorded by F from zone D which is correlated with Ar isotopes, but coincides with barely detectable shifts in $\delta^{18}O_{fluid}$ and F T. Spatial and temporal changes in He isotopes are seen in contemporary geothermal F which may be related to deep magmatic activity or F boiling. Evidence for the existence of a V phase in the hydrothermal F is clear, though it is no more so in zone D than elsewhere. It cannot be ruled out that the pulses of magmatic volatiles originate by episodic fracturing at depth. (From authors' abstract by E.R.)

STUART, F.M., ELLAM, R.M. and **TURNER, G.,** 1996, He and Pb isotope composition of oceanic massive sulfides and their bearing on hydrothermal fluid circulation (abst.): 1996 Fall Meeting American Geophysi-cal Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F767, November 12, 1996. Authors at SURRC, East Kilbride, G75 0QF, UK +44 1355-270138; e-mail (stuart@geology.gla.ac.uk)

The $^3He/^4He$ of sulfide-hosted IF from sediment-free ridges reflect local basalt values, typically 8±1 times the air ratio (Ra). Helium concentrations in IF (calculated from seawater-derived ^{36}Ar abundances) are indistinguishable from vent F ($2\text{-}4 \times 10^{-5}$ cc/cc). For such high concentrations to originate from seawater interaction with the crystalline oceanic crust requires rock-water ratios of $\sim 10^3$. Instead He is acquired from either hydrothermal seawater interaction with the basaltic crust or by volatile degassing during magma crystallization.

He and Pb in hydrothermal F are dominated by rock-derived components. Their isotopic compositions are linked by radiogenic isotope (^{208}Pb, ^{207}Pb, ^{206}Pb and ^4He) production from decay of U and Th. The behavior of chalcophile elements during hydrothermal seawater convection has been extensively studied. Combined FI He and host sulfide Pb isotopes provide constraints on how and where He was acquired during hydrothermal convection. F from Escanaba Trough, Gorda Ridge, (2-6.5 Ra) and Guaymas Basin (6.9-7.5 Ra) record varying sediment-derived He contributions (–0.02 Ra). Stratiform massive sulfides from O.D.P. Leg 139 at Middle Valley, Juan de Fuca Ridge, have $^3He/^4He$ (5.4-7.1 Ra) and Pb isotopes ($^{208}Pb/^{204}Pb = 18.37\text{-}18.9$) which identify contributions from oceanic crust and the sediment-sill complex. The Pb isotope range was large compared to chimney sulfides from other sites (including Middle Valley) suggesting that seafloor sulfides provide a spatially and/or temporally biased sample of the hydrothermal circulation. He-Pb isotopes are broadly correlated and plot along mixing lines at $(He/Pb)_{basalt}/(He/Pb)_{sediment} \sim 5$. This is consistent with source rock concentrations and implies that He hydrothermal F is derived by water-sediment interaction rather than diffusive loss from detrital grains or porewater mixing. Comparison will be made with chimney sulfides from Lau Basin, Escanaba Trough and Guaymas Basin. (Authors' abstract)

STUART, F.M., HARROP, P.J., KNOTT, R., FALLICK, A.E., TURNER, G., FOUQUET, Y. and **RICKARD, D.,** 1995, Noble gas isotopes in 25,000 years of hydrothermal fluids from 13° N on the East Pacific rise: *in* Hydrothermal Vents and Processes, Geol. Soc. Special Pub. no. 87, p. 133-143, L.M. Parson, C.L. Walker and D.R. Dixon (eds.). First author at Dept. of Geol., Univ. of Manchester, Manchester M139PL, UK

Noble G isotopes have been measured in FI in sulphides spanning 25,000 years of hydrothermal activity at 13°N on the east Pacific rise. The $^3He/^4He$ ratios are typical of mid-ocean ridge hydrothermal F, albeit slightly higher than contemporary vent waters, and reveal no temporal variation or correlation with the $\delta^{34}S$ of the host sulphide. The absence of radiogenic He in F from the 25,000 year old mineralization on the SE Seamount suggests that the hydrothermal circulation occurred within an active magmatic system and not within the underlying 130 ka oceanic crust. This implies that seamount volcanism and hydrothermal activity occurred simultaneously off-ridge, and that magmatic activity shifted approximately 5 km off-ridge at this time. Helium concentrations in FI from three samples are significantly greater than the end-member hydothermal F at mid-ocean ridges. Small excesses of ^{40}Ar in the included F demonstrate that mantle-derived ^{40}Ar has been degassed along with primordial helium. Both are consistent with the direct addition of magmatic volatiles into the hydrothermal system at times during the history of hydrothermal activity at the site. (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: Noble Gas Geochem. and Cosmochem., Matsuda, J. (ed.), Terra Scientific Publishing Company, Tokyo, 1994, p. 261-277. First author at Geol. 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. $^3He/^4He$, $^3He/^{36}Ar$ and $^{40}Ar/^{36}Ar$ decrease from the core to the edge reflecting the mixture of a ^3He-rich magmatic F with ancient meteoric F with low $^3He/^4He$ and $^{40}Ar/^{36}Ar \sim 385$. This is consistent with FI T_H, $\delta^{18}O$ and δD variations. The $^3He/^4He$, $^3He/^{36}Ar$ 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 ^3He 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 ($^{40}Ar/^4He=0.67$). This suggests that Cretaceous granite magmatism in Korea occurred in response to basaltic intrusion or underplating of mantle M.

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.,** 1996a, Melt inclusion microthermometry: petrologic constraints from the H_2O-saturated haplogranite system: Petrologiya, v. 4, no.3, p. 228-239, (in Russian, translated in Petrol., v. 4, no. 3, p. 209-220). Authors at Dept. of Geological Sci., Fluids Research Laboratory, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, 24061 USA.

A model is presented which predicts the *P-V-T-X* evolution of crystalline M I during heating and cooling. In the model, hydrous haplogranite M (*Ab-Or-Qtz-* H_2O) are trapped as Is in quartz, and then allowed to cool and crystallize. Mass and volume relationships for phases (melt-solid-volatile) in the I during cooling and heating are calculated based on available phase equilibria and *P-V-T-X* data for the haplogranite system. The calculated *P-T* path followed by the I during heating from room T is the reverse of the path followed during cooling following entrapment. As a result of second boiling during crystallization and cooling, the trapped M released exsolved H_2O into the I cavity. A positive volume change is associated with the release of water from the M, and during cooling to solidus T, the internal P within the I can increase significantly. This overpressure can cause I decrepitation during cooling. The calculated *P-T* path and the increase in internal P is highly dependent upon the values for the partial molar volume of H_2O_{total} in the melt $V^M_{H_2O_{total}}$) used in the model, and several values for $V^M_{H_2O_{total}}$ have been selected (0.0, 17.0, and 22.0 cm^3/mol) which span the range of reported values in the literature.

Three different trapping scenarios for haplogranite minimum M compositions have been described at 500 and 2000 bars total P, including: (1) H_2O-saturated M entrapment, (2) immiscible H_2O+H_2O-saturated M entrapment (mixed entrapment), and (3) H_2O-undersaturated M entrapment. The P at the time of trapping fixes both the minimum M composition and T. Phase relationships during the homogenization process can distinguish each trapping scenario. For the H_2O-saturated examples, total homo-genization occurs with the simultaneous consumption of quartz, feldspar and vapor by the M. The entrapment T (T_t) is determined by the T of complete melting of feldspar and quartz (T_{msil}) and the V-M homogenization T (T_h), which are both equal to T_t. In the mixed scenario, total homogenization occurs by V-M homogenization (T_h) at unreasonably high T and does not correspond to (T_t). In the mixed trapping scenario, the T of complete melting for felspar (T_{mfeld}) corresponds to (T_t) at a T lower than V-M homogenization (T_h). Initial M compositions for the H_2O-undersaturated scenarios are determined for an activity of water in the M ($a^M_{H_2O}$) equal to 0.5. The minimum entrapment T for these H_2O-undersaturated melts can be determined by the T of complete melting of feldspar and quartz (T_{msil}). In this case, T_h occurs at a lower T than T_{msil} and T_h defines the water-saturated liquidus T. (Authors' abstract.)

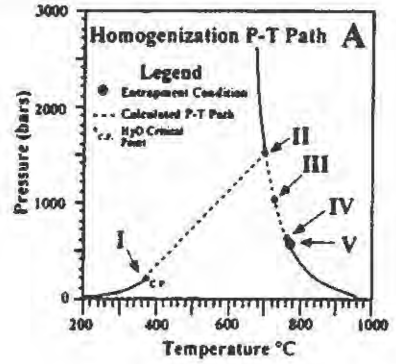
See also adjacent items (E.R.)

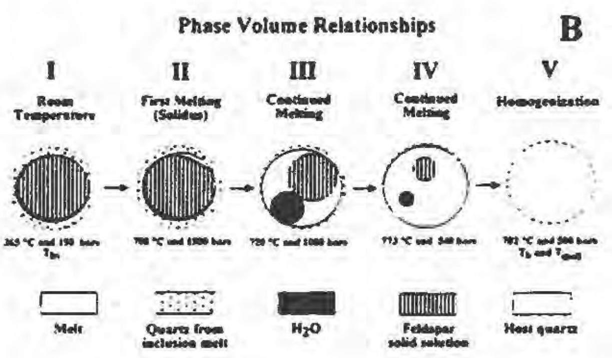
STUDENT, J.J. and **BODNAR, R.J.,** 1996b, Modeling the P-V-T-X properties of haplogranite melt inclusions during heating and cooling (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 134-135. Authors at Dept. of Geological Sci., Fluids Research Laboratory, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, 24061, U.S.A.

A model is presented which predicts the P-V-T-X evolution of crystalline M I during cooling and heating. In the model, hydrous haplogranite melts (Ab-Or-Qtz-H_2O) are trapped as I in quartz, then allowed to cool and crystallize. Mass and volume relationships for melt-solid-volatile phases in the I during cooling and heating are calculated based on available phase equilibria for the haplogranite system. As a result of second boiling during crystallization and cooling, the trapped M releases exsolved H_2O into the I cavity. A positive volume change is associated with the release of water from the M, and during cooling to solidus T, the internal P within the I can increase significantly. This overpressure can cause I decrepitation during cooling.

Six different trapping scenarios are described. Both minimum and non-minimum haplogranite M compositions are considered, and for each of these, H_2O-saturated, H_2O-undersaturated, and mixed trapping (H_2O + H_2O-saturated M) are considered. Each of these six scenarios is further described for trapping P 500, 2000, 5000 bars. Phase relationships during the homogenization process can distinguish each trapping scenario.

As an example of the results predicted by the model, we have calculated the homogenization P-T path and phase volume relationships for an H_2O-saturated minimum M I trapped at 500 bars and 782°C, using a partial molar volume of H_2O_{total} in the M of 22.0 cc/mole. During heating, the P-T path follows the H_2O L-V curve until the water phases in the bubble homogenize to the V phase at 365°C (Fig. A, point I). With continued heating the path follows the H_2O isochore to the haplogranite minimum M curve were first melting begins (Fig. A, point II). During heating from room T to the T of first melting, no changes in the phase volumes of the solids in the I are recognized. Note, however, that the I volume at room T is less than the original I volume, owing to precipitation of quartz on the I walls (Fig. B, I & II). The amount of M shown at the first





melting T (Fig. B, II) is greater than the actual amount of M generated in order to facilitate its graphical representation. With continued heating, the P-T path follows along the H_2O-saturated solidus and the internal P decreases as H_2O dissolves in the M (Fig. A, path II, III, IV, V). Similarly, the quartz and feldspar phases are reduced in size as they melt (Fig. B, III & IV). Total homogenization occurs at the trapping conditions with the simultaneous consumption of H_2O (T_h) and feldspar-quartz (T_{msil}) by the M. During cooling from trapping to ambient conditions, the P-T path followed by the I is the reverse of the path followed during homogenization. (From authors' abstract by E.R.)

See also adjacent item (E.R.)

STUDENT, J.J. and **BODNAR, R.J.**, 1996c, Synthetic silicate melt inclusions from the H_2O-saturated haplogranite system at 800° C and 2000 bars: Experimental techniques and fluid inclusion microthermometry (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 136. Authors at Dept. of Geological Sci., Fluids Research Laboratory, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, 24061, U.S.A.

Silicate M I in rock forming minerals can provide valuable information for constraining the PTX conditions associated with magma petrogenesis. However, there are many aspects of the trapping behavior and significance of information obtained from M I and coexisting aq I, that are poorly understood. In order to advance this understanding, we have initiated a study of synthetic silicate M I and coeval aq I.

Partial melting experiments have been conducted to produce synthetic M and coeval aq FI trapped under known PTX conditions. These I have been used to characterize M I types and mechanisms of M entrapment in quartz and to evaluate microthermometric results and interpretations obtained from M and coeval aq FI. Experiments were conducted in the H_2O-saturated haplogranite system (Albite-Orthoclase-Quartz) within the quartz stability field at 800°C and 2000 bars. Starting materials included albite, orthoclase and silica gels, and quartz core. The starting aq F composition was 10 wt.% NaCl. These parameters were chosen to simulate conditions inferred for the formation of M I which have been found in quartz phenocrysts from calc-alkaline rocks associated with porphyry copper systems.

Quartz core from the experimental run products contains S aq FI, M I, and planes of silicate glass, all within healed fractures. Primary M I occur at the interface between the quartz core and quartz overgrowths and within synthetically grown β-quartz phenocrysts. The quench glass contains clear regions of I- free glass, white frosted regions containing minute (< 1.0 µm) bubbles, β-quartz phenocrysts, isolated aq FI, feldspar crystallites, and miarolitic cavities which contain quartz, feldspar, and glass. I, mineral and glass textures produced in the experimental run products are similar to textures observed in natural calc-alkaline rocks.

An NaCl eq. sal of 11.9 wt.% was determined by ice melting T from aq FI in the quartz core. The increase in aq F sal can be explained by the larger partitioning coefficient of H_2O into the M relative to Cl^-. Isochores (iso-T_h lines) for the aq I pass through the experimental trapping conditions. Homogenization of silicate M I trapped within quartz, determined using standard heating stage techniques, exceeded the maximum run conditions by as much as 39°C. In spite of this difference, coeval aq FI isochores and M I Th constrain the original entrapment P-T conditions with a high degree of accuracy (Figure 1). (Authors' abstract)

See also adjacent items.

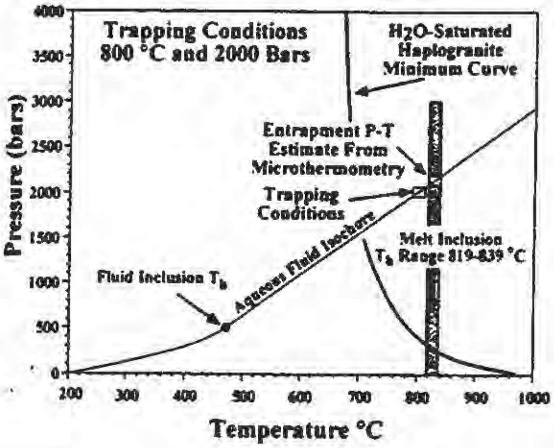


Figure 1. Entrapment conditions (819-839°C, 2080-2200 bars) of coeval aq and M I estimated from microthermometric data compared to actual experimental trapping conditions (800° C, 2000 bars). The isochore corresponding to the Th of the aq I (474°C) and the H_2O-saturated haplogranite minimum M curve are also shown for reference. (E.R.)

STUDNICNA, Blanka and **ZACHARIAS, Jiri**, 1996, The porphyry ore deposit with Au-Cu-W mineralization on the Petrackova hora Mt. near Vacikov: *in* Gold deposits in Bohemia, Petr Moravek (ed), Czech Geol. Survey, p. 57-58.

Indexed under FI (E.R.)

SU, Li and **SONG, Suguang**, 1996, The study of inclusions in various types of ultrabasic masses in the northwestern China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 485. Authors at Xi'an Inst. of Geol. and Mineral Resources, CAGS, Xi'an 710054, P.R.China.

The I have been examined in five famous ultrabasic masses, the Jinchuan Cu-Ni-bearing Intrusion in Gansu, the Bijigou Layered Complex and the Songshugou Perdotite in Shaanxi, Bachu Kimberlite in Xinjiang, and the Yushigou Peridotite in Qinghai.

Except for the Yushigou Peridotite, P magmatic I, occurring isolated in olivines, pyroxenes, plagioclase, phlogopite and apatite, have been discovered in all the other four ultrabasic masses. They are circular and negative crystal in shape, 5~20 µm in size, and characterized by complicated internal phases which consist of various silicate and metallic dm occasionally with minor silicate glass and L beads. They are all the typical evolved magmatic I. In the Bijigou layered cumulus complex, the composition of the magmatic I in host minerals from various layers shows directly that the relic M evolves towards the direction of SiO_2 increasing, MgO decreasing, and volatile component enriching. In Bachu kimberlite, the magmatic inclusions include dm of chrysolite, monticellite, phlogopite, apatite, perovskite and ishkulite [sic] and minor silicate glass. The P-T condition of initial crystallization of giant olivine is estimated about 1150° and 4.5 GPa [from Th]. In the Songshugou peridotite which remains some different opinions on petrogenesis, the typical magmatic inclusions, including daughter minerals of olivine and minor pyroxene, chromite, brucite, anthophyllite and H_2O-CO_2 L drop, have been found in host olivines in all rock types of coarse grain dunite, harzburgite and dunitic mylonite. They provide the convincing evidence for magmatogenesis of the Songshugou peridotite.

In contrast with the four masses above, magmatic inclusions have not been observed in minerals from the Yushigou peridotite, the basal part of ophiolite suit. However, a very important discovery is the well-developed silicate inclusions formed by intragranular partial melting, which we named as "Incipient Melting Inclusion" (IMI), in olivines. The IMIs, having various irregular shapes, occur as isolated and banded in the host olivines. All IMIs are composed of Fe-rich (FeO 29~34%) and Ca+Al-rich (CaO 13~19%; Al_2O_3 3~5%) immiscible M. The concentration of readily melted components is intimately associated with plastic flow of the host minerals. It infers the existence of dynamic partial melting in mantle. Besides, we have also found some isolated and girdle-shaped FI in which the CH_4-content is high up to 70~90%, with the minor components of CO_2, H_2, H_2S, N_2 and C_3H_6 [sic] etc. measured by laser Raman spectra, suggesting the existence of CH_4-rich F in the deep mantle where plastic flow in olivines occurs. (From authors' abstract by E.R.)

SUCHY, V., ROZKOSNY, I., ZAK, K. and **FRANCU, J.**, 1996, Epigenetic dolomitization of the Pridoli formation (Upper Silurian), the Barrandian basin, Czech Republic: Implications for burial history of Lower Paleozoic strata: Geol. Rundsch, v. 85, p. 264-277. First author at Mineralogisch-Petrographishes Inst. der Univ. Basel, CH-4067 Basel, Switzerland.

Stratabound epigenetic dolomite occurs in carbonate facies of the Barrandian basin (Silurian and Devonian), Czech Republic. The most intense dolomitization is developed in bioclastic calcarenites within the transition between micritic limestone and shale-dominated Pridoli and Lochkov formations deposited on a carbonate slope. Medium-crystalline (100-400μm), I-rich, xenotopic matrix dolomite ($\delta^{18}O$=-4.64 to -3.40‰ PDB; $\delta^{13}C$=+1.05 to +1.85‰ PDB) which selectively replaced most of the bioclastic precursor is volumetrically the most important dolomite type. Coarse crystalline saddle dolomite ($\delta^{18}O$=-8.04 to -5.14‰ PDB; $\delta^{18}C$+0.49 to +1.49 PDB) which precipitated in fractures and vugs within the matrix dolomite represents a later diagenetic dolomitization event. In some vugs, saddle dolomite coprecipitated with petroleum I-rich authigenic quartz crystals and minor sulfides which, in turn, were post-dated by semisolid asphaltic bitumen. The interpretation of the dolomitization remains equivocal. Massive xenotopic dolomite, although generally characteristic of a deeper burial setting, may have been formed by a recrystallization of an earlier, possibly shallow burial dolomite. Deeper burial recrystallization by reactive basinal pore F that presumably migrated through the more permeable upper portion of the Pridoli sequence appears as a viable explanation for this dolomitization overprint. Saddle dolomite cement of the matrix dolomite is interpreted as the last dolomitization event that occurred during deep burial at the depth of the oil window zone. The presence of saddle dolomite, the FI composition of associated quartz crystals, and vitrinite paleogeothermometry of adjacent sediments imply diagenetic burial T as high as 160°C. Although high geothermal gradients in the past or the involvement of hydrothermally influenced basinal F can account for these elevated T, burial heating beneath approximately 3-km-thick sedimentary overburden of presumably post-Givetian strata, no longer preserved in the basin, appears to be the most likely interpretation. This interpretation may imply that the magnitude of post-Variscan erosion in the Barrandian area was substantially greater than previously thought. (Authors' abstract)

SUGISAKI, Ryuichi, ITO, Takamori, NAGAMINE, Koichiro and **KAWABE, Iwao,** 1996, Gas geochemical changes at mineral springs associated with the 1995 southern Hyogo earthquake (M-7.2), Japan: Earth and Planet. Sci. Lett., v. 139, no. 1-2, p. 239-249. First author at Dept. of Earth and Planetary Sci., Nagoya Univ., Nagoya, 464-01, Japan.

G concentrations monitored at a mineral spring in central Japan over the past 15 years showed similar changes before and after two large earthquakes, a concurrent and abrupt drop in all three G ratios, He/Ar, N_2/Ar, and CH_4/Ar, several months before the events. (From authors' abstract by E.R.)

SUN, Isaoming, XU, Keqin, REN, Qijiang and **KEAYS, R.R.,** 1996, Water-rock interactions and chemical compositional variations during ductile deformation of the NW-striking shear zone in the Jiapigou Gold Belt, China: Chinese J. of Geochem., v. 15, no. 4, p. 331-343 (in Engl.). First author at Geol. Dept. of Zhongshan Univ., Guangzhou, 510275.

FI study shows that the T and P of the ore-forming F are 245-292°C and 95.4-131.7 MPa respectively; the sal is 12.88-16.33 wt.% NaCl; the F-phase is rich is Ca^{2+}, K^+, Na^+, Mg^{2+}, and F^- and Cl^-, while the gaseous phases are rich in CO_2 and CH_4. The δD and $\delta^{18}O$ values of the ore-forming F are -84.48‰ to -91.73‰ and -0.247‰ to +2.715‰ respectively, suggesting F is composed predominantly of meteoric water. (From authors' abstract by E.R.)

See also adjacent item (E.R.)

SUN, Lina, WANG, Ende, HOU, Jinfan and **SHI, Cheng,** 1996, Metallogenesis geochemistry on Ban Kuan gold deposit (abst.): 30th Int'l Geol.. Cong., Abstracts, v. 2, p. 805. Authors at Shen Yang Inst. of Gold Tech., China.

Ban Kuan mesothermal gold deposit is located in a migmatic complex. H_2O and CO_2 are higher in FI of gold-bearing quartz. Na^+/K^+ range from 11.16 to 935, $Na^+/Ca^{++}+Mg^{++}$ from 3.49 to 22.6 and F^-/Cl^- from 0.025 to 1.502. T of gold-bearing F range from 210°C to 290°C, P from 290 to 520 bar and from 800 to 1000 bar, sal from 2.9 to 12.7 NaCl percent, mean value is 5.61 NaCl percent, pH range from 4.99 to 7.03. (From authors' abstract by E.R.)

SUN, Xiaoming, 1996, Structural geochemistry and gold mineralization in ductile-brittle shear deformation: a case study on the Jiapigou gold mine, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 582. Author at Dept. of Geol., Zhongshan Univ., Guangzhou, P.R.C.

Two kinds of mylonitic series rocks, felsic and mafic, occur at the Jiapigou gold mine. Strong F-rock interactions yielded sericitization and albitization in the plagioclase; chloritization in the dark minerals, and extensively carbonatization, besides, the $\delta^{13}C$ of the carbonatization minerals are -3‰ ~ -5.6‰, suggesting a deep source of carbon. FI studies show that the T and P of the auriferous fluid accompanying the ductile deformation are 245~292°C and 95.4~131.7 Mpa, the sal is 12.88~13.78 wt% NaCl, the F phase is rich in Ca^{2+}, K^+, Na^+, Mg^{2+} and F^-, Cl^-, while the content of CO_2 and CH_4 in the gaseous phase is quite high. The δD_{H_2O} and $\partial^{18}O_{H_2O}$ of the ore-forming fluid are -84.83‰ ~ -91.73‰ and -0.247‰ ~ 2.715‰ respectively, suggesting a high percentage of meteoric water. (From author's abstract by E.R.)

See also adjacent items. (E.R.)

SUN, Xiaoming, CHEN, Jingde and CHEN, Binghui, 1996, Changkeng: A newly-discovered sediment-hosted superlarge-scale Au-Ag deposit in China: IAGOD Newsletter 1996, p. 45-46. Authors at Dept. of Geol., Zhongshan Univ., Guangzhou 510275, P.R. China.

Changkeng is a new type superlarge-scale Au-Ag deposit, newly discovered. It is composed of a large-scale gold deposit and an isolated superlarge-scale silver deposit, both of them are strictly controlled by the same fault zone, within which the former occupied upper part, while the latter is under the former. The gold and silver deposits are separated each other and only locally connected. No kinds of igneous rocks have been found. The predominant ore type of gold deposit is auriferous siliceous rocks, fine-grained chalcedony and some clay minerals such as illites, dickite and hydromuscovites. Besides, realgar, orpiment, stibnite, pyrite, barite, gypsum and fluorite, but no Hg minerals such as cinnabar, have been found in the gold ores. Native gold, the predominant Au mineral, is very fine grained (mostly 0.05-0.075 µm in diameter) and is of high finenesses (995.4‰). The gold ores contain high content of organic carbon, which may reach as high as 3.53%. FI and isotopic studies show that the ore-forming F of gold deposit [were] rich in Ca^{2+}, Na^{+}, K^{+}, and CO$_2$, and the ore-forming T and pressure are 175-280°C and 200-400 MPa; the sal is about 2.0 wt% NaCl; the δ^{34}S of the F varies between 35.4~+8.98‰, averaging +2.02‰ (n=22); the δ^{13}C is -16.62~-16.98‰; the δ^{13}O and δD are -7.82~+6.75‰ (averaging -2.42‰, n=6) and -118.7~-30.0‰ (averaging 60.32‰, n=6) respectively, suggesting that the ore-forming F of gold deposit is composed mainly of meteoric water.

The major ore type of the silver deposit is base metal sulfide-calcite-quartz stockwork, within which the ore minerals include sphalerite, galena, pyrite, and occasionally chalcopyrite and arsenopyrite, while the major vein minerals are calcite and quartz. The silver minerals are quite complicated and include aerosite, freibergite, andorite and argentite. Au grade in the silver ores is low, only 0.39 $\times 10^{6}$. FI and isotopic studies show that the ore-forming F of silver deposit [was] rich in Ca^{2+} and CO$_2$; the T varies between 250-300°C; the δ^{34}S is -7.21~+6.41‰, averaging +2.8‰ (n=23); the δ^{13}C is -6.68~-0.63‰; the δ^{18}O and δD are -4.12~+8.84‰ (averaging -1.315‰, n=4) and -58.7~-44.45‰ (averaging 50.15‰, n=4) respectively, suggesting that the ore-forming F are a mixture of meteoric and magmatic water. Observation under microscope show that intensive boiling had taken place during silver mineralization. Some thought that it's a Carlin type gold deposit, but we have found many differences. (From authors' abstract by E.R.)

SUN, Xiong, MA, Zongjin and HONG, Hanjing, 1996, Preliminary discussion on "Structure Fluid Dynamics": Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 138-144. Authors at Inst. of Geol., State Seismological Bureau, Beijing 100029.

The paper proposes to study the relationship between earth F and tectonic activities in the shallow crust. (From authors' abstract by E.R.)

SUSHCHEVSKAYA, T.M., DURISOVA, J., YEROKHIN, A.M., KNYAZEVA, S.N., KOKINA, T.A., KALINICHENKO, A.M., LOKHOV, K.I. and PRISYAGINA, N.I., 1995, A study of the chemical characteristics of the medium of cassiterite-quartz-type tin mineralizations based on the fluid inclusions in minerals: in Geokhimiya, 1995, no. 6, p 809-828 (in Russian, translated in Geoch. Int'l., v. 33, no.3, p 1-22, 1996). Authors at Vernadskiy Inst. of Geoch. and Analytical Chem., Russian Acad. of Sci., Moscow.

The chemical setting of ore deposition at deposits of the cassiterite-quartz type of association has been studied by using information on the deposits in the Iul'tin (Iul'tin and Svetloye) and in the Rudne Hory (Cinovec and Krupka) tin-ore regions. We used bulk methods of analysis of the composition of the FI in minerals from the preore and ore assemblages. The results are compared with data previously obtained by microthermometry on individual FI. These vein-greisen deposits, which lie in metamorphosed sandy-shale strata and are associated with leucocratic granite stocks were formed as the T fell from 400°C from low-sal H$_2$O-CO$_2$ solutions under conditions of heterogenization at the stage of tin-tungsten. The composition of the mineralizing solutions is characterized by predominance of NaCl up to 1 M, together with an elevated fluorine background, an elevated role for lithium in the Rudne Hory deposit solutions, and a high level of S(II) concentration up to 10^{-12} M and ΣAs up to $10^{-1.7}$ M. The formation of the Sn-W mineralization was favored by an increase in the alkalinity and state of oxidation of the medium, which was due not only to local boiling but also to a considerable extent to the mixing of magmatic F with considerable volumes of infiltrating meteoric water in long-lived hydrothermal systems. (Authors' abstract)

SUSHCHEVSKAYA, T.M., IGNAT'YEV, A.V., YU, M., SPASENNYKH, A.L., DEVIRTS, A.L., LAGUTINA, Y.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: Dok. Ross Akad., v. 339, no. 3, p. 391-395 (in Russian, translated in Trans. (Doklady) Russian Acad. Sci., Earth Sci. Sect., v. 342, p. 168-175, 1996) Authors at Vernadskiy Inst. for Geoch and Analytical Chem., Russian Acad. of Sci., Moscow.

Abst. in FIR v. 28, p. 167 (E.R.)

SUSHCHEVSKAYA, T.M., SPASENNYKH, M.Yu., EROKHIN, A.M., and MATVEYEVA, S.S., 1996a, Involvement of fluids of different genetic types in Sn, W ore formation, associated with granites (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 552. First author at Vernadsky Inst. of Geochem. and Analytical Chem., Moscow, Russia.

Chemical (FI) and isotopic (O, H) data were correlated to obtain information about genetic peculiarities of F, having formed Sn-W, W ores of the large deposits Iultin, Svetloe (NE of Russia) and Akchatau (Central Kasakhstan). The studied hydrothermal systems are associated spatially and genetically with leucogranites of Upper Cretaceous (Iultin, Svetloe) and Permian (Akchatau) age. The suites of aleurolites, peltic schists and sandstones were altered in the course of contact and hydrothermal processes. The same general sequence of mineral associations and geochemical features are found for these deposits, with the exception of more wide distribution of greisens in the case of Akchatau and difference in metal productivity.

F which formed mineral associations of veins and greisen bodies were heterogeneous. In spite of different level of their sal, they have the same trends of chemical evolution. Early NaCl solutions gave way to more dilute, more alkaline bicarbonate-Cl ones. In the process G components have been essentially taken from metamorphosed sedimentary wall rocks. The F data may be interpreted as possible result of coming exterior waters (initially of meteoric origin) into the studied systems.

O and H isotope composition of F in the discharge zones of the deposits bears witness to the presence of meteoric waters from the early stages of mineral-forming process for Iultin and Svetloe, while in the case Akchatau it is typical only for post-greisens stages. O isotope composition of wall rocks of Iultin and Svetloe deposits shows distinctly that they underwent strong influence of meteoric waters. The wall granites of Akchatau interacted predominantly with magmatogeneous F at higher Ts than those of Iultin.

The different grade and different time of participation of exterior waters during the formation of the studied deposits imply the different physical chemical mechanisms for cassiterite and wolframite ore accumulation, with different role of mixing and boiling processes. (Authors' abstract.)

SUSHCHEVSKAYA, T.M., SPASENNYKH, M.Y., EROKHIN, A.M. and **MATVEYEVA, S.S.**, 1996b, Involvement of fluids of different genetic types in Sn, W ore formation, associated with granites (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 30-31. First author at Vernadsky Inst. of Geochem. and Analytical Chem.

FI and isotopic data were correlated to obtain information about genetic peculiarities of F, having formed Sn-W, W ores of the large deposits Iultin, Svetloe (NE of Russia) and Akchatau (Central Kazakhstan).

F which formed mineral associations of veins and greisen bodies were heterogeneous. In spite of different level of their sal, they have the same trends of chemical evolution. Early sodium-chloride solutions gave way to more dilute, more alkaline bicarbonate-chloride ones. In the process, G components have been essentially taken from metamorphosed sedimentary wall rocks. The F data may be interpreted as possible result of exterior waters (initially of meteoric origin) going into the studied systems.

Oxygen and hydrogen isotope composition of F in the discharge zones of the deposits bears witness to the presence of meteoric waters from the early stages of mineral-forming process for Iultin and Svetloe, while in the case of Akchatau, it is typical only for post-greisen stages. Oxygen isotope composition of wall rocks Iultin and Svetloe deposits shows distinctly that they underwent strong influence of meteoric waters. The wall granites of Akchatau interacted predominantly with magmatogeneous F at higher T than those of Iultin. (From authors' abstract by E.R.)

SUVOROVA, V.A. and **DUBININA, Y.O.**, 1995, Determining oxygen isotope compositions on small amounts of water: Geokhimiya, 1995, no. 10, p. 1516-1520 (in Russian, translated in Geochem. Int'l., v. 33, no. 10, p. 50-54, 1996). Authors at Inst. for Experimental Mineral., Russian Acad. of Sci., Chernogolovka.

Here we propose a method of introducing the L *in situ* into the vacuum system for fluorination and conversion of the oxygen into CO_2, in which form the mass spectrometric analysis is performed. (From authors' abstract by E.R.)

SZABÓ, Cs. and **BODNAR, R.J.**, 1996, Changing magma ascent rates in the Nógrád-Gömör Volcanic Field northern Hungary/southern Slovakia: evidence from CO_2-rich fluid inclusions in metasomatized upper mantle xenoliths: Petrologiya, v. 4, no. 3, p. 228-239 (In Russian, translated in Petrol., v. 4, no. 3, p. 209-220). First author at Fluids Research Laboratory, Dept. of Geol. Sci., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, USA.

Metasomatized upper mantle xenoliths from the Nógrád-Gömör Volcanic Field of north Hungary and south Slovakia contain two distinctly different occurrences of CO_2 I. An earlier generation of I shows re-equilibration textures produced by high internal P generated following trapping. These I were trapped below the MOHO at a depth of 30-50 km in the amphibole-bearing spinel lherzolite stability field, and their xenolith hosts were transported to the MOHO in ~36 hours at an ascent rate of 0.1 m/sec. At the MOHO, F lost from the earlier generation of CO_2 I during re-equilibration was trapped to form a younger generation of CO_2 I. The xenoliths containing the I were subsequently erupted from this depth to the surface in ~1.5 hours at an ascent rate of 5 m/sec. (Authors' abstract)

SZABO, Csaba, BODNAR, R.J., and **SOBOLEV, A.V.**, 1996, Metasomatism associated with subduction-related, volatile-rich silicate melt in the upper mantle beneath the Nograd-Gomor volcanic field, northern Hungary/southern Slovakia; evidence from silicate melt inclusions: European J. of Mineral., v. 8, no. 5, p. 881-899. Authors at Virginia Polytechnic Inst. and St. Univ., Dept. of Geological Sci., Blacksburg, VA, US.

See previous item (E.R.)

SZARAN, Janina, 1996, Experimental investigation of sulphur isotopic fractionation between dissolved and gaseous H_2S: Chemical Geol., v. 127, no.1-3, p. 223-228. Author at Inst. of Physics, Maria Curie-Sklodowska Univ., 20-031 Lublin, Poland.

TAGIROV, B.R. and **ZOTOV, A.V.**, 1996, Ionization of hydrochloric acid at 400-500°C and 500-2500 bar by the solubility method: Grokhimiya (1996) no. 6, p. 551-558 [in Russian, Engl. abstract].

The solubility of metallic silver in aq. solutions of NaCl (KCl) + HCl with controlled hydrogen fugacity is studied in the $Cl_2^- + HCl^0 = AgCl_2^- + 0.5H_2(g)$ are obtained and used to calculate $\Delta g^0_{t,p}(HCl^0)$ and dissociation constants of hydrochloric acid. At supercritical temperatures and an isothermal compressibility of the solvent $ß > 1.42 \times 10^{-4}$ bar^{-1}, $1gK_d^0$ as a function of T and logarithm of the solvent density obeys the equation,

$1gK_d^0 = 5.972 - 0.00936T(K) + 8.73\ 1g_{H_2O}$ (g/cm^3)

$1gK_d^0 = -5.405 + 3874.9 / T(K) + 14.93\ 1g_{H_2O}$ (g/cm^3) (Authors' abstract)

TAGUCHI, S., FUJINO, T., TAKAGI, H., SANADA, K., HAYASHI, M., SASADA, M., SAWAKI, T. and **UCHIDA, T.**, 1996a, Development of prospective technology of fractured-type geothermal reservoirs by NEDO–application of laser Raman microprobe analysis to fluid inclusions: Abstracts with Programs, 46th Annual Meeting of the Society of Resource Geology, p. 45 (in Japanese).

TAGUCHI, S., FUJINO, T., TAKAGI, H., SANADA, K., HAYASHI, M., SASADA, M., SAWAKI, T., and **UCHIDA, T.**, 1996b, Application of Laser Raman Microprobe (RAMANOR T64000) to gas analysis of fluid inclusions from active geothermal fields in Japan: separation and migration of gas components (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol.

Cong. Abstracts, v. 3, p. 550. First author at Fukuoka Univ., Japan.

NEDO has been developing prospective technology that explores fractured-type geothermal reservoirs. One of the NEDO's projects has introduced FI analysis such as microthermometry and laser Raman microanalysis.

The laser Raman microprobe introduced is RAMANOR T64000 by Jobin Yvon. The detection limits of the instrument are 0.35, 0.55, 0.15, and 0.21 bars for N_2, CO_2, CH_4, and H_2S. These values are much smaller than the detection limits reported by Wopenka and Pasteris (1987); 0.85, 1.33, 0.34, and 0.35 atm for RAMANOR U-1000.

We detected G components in FI from two geothermal fields: the Hohi field in Kyushu and the Kakkonda field in Northern Honshu, Japan. CO_2 and H_2S were detected in the Hohi, and CO_2, CH_4 and N_2 in the Kakkonda fields. All of the G-detected FI show the evidence of boiling of F, and the G compositions are very heterogeneous to one another. The difference of the G components may be due to the country rocks; the reservoir in the Hohi field is located in volcanic rocks and that of the Kakkonda mainly in Neogene sediments.

At Hohi, G were detected at only one place in Well YT-2, where is the upper part of the boiling zone and under the advanced argillic alteration zone. Although the advanced argillic alteration zone was recognized in another well, alteration mineral paragenesis of the well where the G were detected suggests the strong up-flow of geothermal F at the well site. Tm ice of the G-containing I is -0.4°C lower than that of L-rich I of -0.2°C. The difference in the Tm ice is eq. to 0.1 mol/kg H_2O of CO_2. These suggest that G in geothermal F were separated by boiling from geothermal F with less G contents, and migrated to shallow level to concentrate under the advanced argillic alteration zone, i.e. "G cap" was formed under the advanced argillic alteration zone because of strong up-flow and boiling of geothermal F.

At Kakkonda, FI which contain G are also distributed at the upper part of the boiling zone in the upper Kunimitoge Formation (Neogene sediments), and located below the Torigoeno-taki Dacite. The G were also separated by boiling and up-flowed to concentrate below the dacite. In this case, the Torigoeno-taki Dacite acted as a cap rock for the G components.

As mentioned above, G analysis of individual FI by laser Raman microprobe gives useful information on dynamic F behaviour and geothermal structures. (Authors' abstract.)

Also in IGC Abstracts, v. 1, p. 380. (E.R.)

TAGUCHI, S., FUJINO, T., TAKAGI, H., SANADA, K., HAYASHI, M., SASADA, M., SAWAKI, T. and UCHIDA, T., 1996, Application of laser Raman microprobe (RAMANOR T64000) to gas analysis of fluid inclusions from active geothermal fields in Japan: Separation and migration of gas components (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 21-22. First author at Fujuoka Univ., Japan.

See also Taguchi et al (1995) FIR v. 28, p. 168, and previous abstract (E.R.)

TAGUCHI, S., TAKAGI, H., MURAOKA, H. and UCHIDA, T., 1996, Relation between fluid inclusions and alteration in geothermal field (abstr.): Newsletter of the Japanese Assoc. Thermal Fluid Inclusionists, 1996, no. 7, p. 26 (in Japanese).

See FIR v. 28, p. 168 (E.R.)

TAKAGI, H., HAYASHI, M., TAGUCHI, S., SANADA, K., UCHIDA, T. and MURAOKA, H., 1996, Changes in homogenization temperatures of fluid inclusions with overheating (abstr.): Newsletter of the Japanese Assoc. of Geothermal Fluid Inclusionists, 1996, no. 7, p. 28 (in Japanese).

See FIR v. 28, p. 169 (E.R.)

TAKAHASHI, W. and MORIKIYO, T., 1996, Carbon isotopic compositions of CO_2 constrained in fluid inclusions in the pegmatitic quartz from Japan: Abstracts of the 103rd Annual Meeting of the Geological Society of Japan, p. 277 (in Japanese).

TAKAOKA, Nobuo, MOTOMURA, Yoshinobu and NAGAO, Keisuke, 1996a, Noble gases in tellurium and associated minerals and double-beta decay of ^{130}Te: J. Mass Spectrom. Soc. Jpn., v. 44, no. 1 (1996) p. 63-77. First author at Dept. of Earth and Planetary Sci., Kyushu Univ., Hakozaki, Fukuoka 812-81, Japan.

Tellurobismuthite, quartz and arsenopyrite minerals separated from a specimen of tellurium-bearing ores collected at the Oya mine have been analyzed for noble G isotopes. The Te minerals released abundant ^{4}H and ^{40}Ar. Quartz released large amounts of noble G, which are supposed to have been occluded in FI. It contains excess ^{40}Ar inherited from precursor materials. Arsenopyrite released abundant He and Ar. Argon is mostly of atmospheric origin. Definite excesses at ^{129}Xe, ^{130}Xe, and ^{131}Xe isotopes but no excesses at ^{134}Xe and ^{136}Xe are found for the Te minerals. Xe isotopic ratios for the quartz are atmospheric and give no evidence for inherited excess ^{130}Xe. Because the quartz, arsenopyrite and Te minerals were deposited from the same hydrothermal F, these indicate that the Te minerals contain inherited excess ^{40}Ar and the isotopic ratios of trapped Xe in the Te minerals is atmospheric. Hence the ^{130}Xe excess found in the Te mineral is attributable to the in-situ double-beta decay of ^{130}Te, and the excesses at ^{129}Xe and ^{131}Xe are to the neutron-captures on ^{128}Te and ^{130}Te, respectively. Besides, a quartz-calcite separate from a Te ore specimen collected at the Suwa mine is enriched in ^{4}He but the isotopic ratios of Xe is atmospheric, indicating the Xe contained in hydrothermal F at Suwa is atmospheric.

In order to decipher the chronological sequence of mineralization of Te ores and solidification of magma, we summarize the occurrences of sample minerals, the geology of sampling sites and their field relationships. Based on noble G data measured for the Te and associated minerals as well as geological considerations, we prefer $(7.9 \pm 1.0) \times 10^{20}$ years to 3×10^{21} years for the absolute half-life of ^{130}Te double-beta decay. From the excess ratio of ^{129}Xe to ^{131}Xe, we have 710n/cm^{2}y for neutron flux at the Oya mine. (Authors' abstract)

TAKAOKA, Nobuo, MOTOMURA, Yoshinobu and NAGAO, Keisuke, 1996b, Half-life of ^{130}Te double- ß decay measured with geologically qualified samples: Physical Review C, v. 53, no. 4 (1996) p. 1557-1561. First author at Dept. of Earth and Planetary Sci., Kyushu Univ., Hakozaki, Fukuoka 812-81, Japan.

Pertinent to analysis of rare G from Te minerals (E.R.)
See also previous abstract (E.R.)

TAKAOKA, N., NAKAMURA, T. and NAGAO, K., 1996a, A possible site trapping noble gases in Happy Canyon enstatite chondrite: microbubbles (abst.): Antarctic Meteorites XXI, Papers presented to the Twenty-first Symposium on Antarctic Meteorites (National Inst. of Polar

Research, Tokyo), June 5-7, 1996), p. 167-169. First author at Dept. of Earth and Planetary Sci., Kyushu Univ., Hakozaki, Fukuoka 812-81, Japan.

Primordial noble G can provide information on formation conditions of meteorites as well as their parent bodies. Carrier phases (or trapping sites) of primordial G for enstatite (E-) chondrites have not yet been identified; while those for carbonaceous and ordinary chondrites are now known to be carbonacious matter. The Happy Canyon (HC) E-chondrite is an impact-melt breccia formed probably from the EL-chondrite parent body [1]. We report here results on elemental and isotopic measurements of noble G released by crushing and by stepped heating pyrolysis of HC bulk samples, and propose microbubbles for a possible site trapping noble G. (From authors' introduction, by E.R.)

TAKAOKA, N., NAKAMURA, T. and **NAGAO, K.**, 1996b, Noble gases released by crushing from Happy Canyone E-chondrite (abstract): 27th Lunar and Planetary Science Conference, Abstracts, p. 1303-1304. First author at Dept. of Earth and Planetary Sci., Kyushu Univ., Hakozaki, Fukuoka 812-81, Japan.

See also previous abstract (E.R.)

TARMAN, D.W. and **JESSEY, D.R.**, 1996, Implications of fluid inclusion P/T data from Miocene hydrothermal barite deposits, central Mojave Desert, San Bernardino County, California (abst.): The Geological Society of American, 92nd Annual Cordilleran Section, 1996 Abstracts with Programs, v. 28, no. 5, p. 115-116, April 1996. Authors at Dept. of Geological Sci., California State Polytechnic Univ., Pomona, CA 91768; e-mail (dwtarman@csupomona.edu)

Central Mojave Desert silver-barite mineralization reflects regional early Miocene extensional ground preparation and the presence of hydrothermal systems driven by residual heat from syntectonic volcanism. Hosts for the mineralization are pre-Cenozoic metamorphic rocks, early Miocene volcanics and middle Miocene sedimentary rocks. Mineralization was at least partially contemporaneous with the deposition of the sedimentary rock. Hydrothermal vein barite yields a range of host-dependent FI T. Lowest T (average 180°C) were observed in sediment-hosted sites. Highest values (average 270°C) were observed in samples from volcanic rock with intermediate T averaging 230°C observed in samples from the metamorphic rocks. Geochemical and structural relationships constrain mineralization depths to a maximum of 1500 m in volcanics to 100-200 meters for the sediment-hosted barite with variable but generally intermediate depths indicated for the barite in metamorphic rock.

The barite in the metamorphic rock is characterized by very coarsely crystalline open-space filling textures. Brittle fracturing and open space development occurred after the formation of the mylonitic fabric. Some of the vein barite is sheared, implying that localized extension continued after the initiation of barite mineralization and after the mylonites had been nearly unroofed. Additionally, shallow stockwork barite mineralization in sedimentary material of middle Miocene age indicates mineralization persisted after extension had ceased.

In general, the derived FI T are supportive of a model which relates T to depth of barite emplacement. In this model unroofed basement and syntectonic volcanic and sedimentary rock placed into adjacent linked basins served as the disparate host sites for barite mineralization. Unroofed basement crystalline rocks have consistently lower T than stratigraphically higher, but structurally lower volcanics. T in sediment-hosted barite are consistent with shallow depths of emplacement. (Authors' abstract)

TARNOCAI, C.A. and **HATTORI, Kaiko** and 1996, Gold introduction during the peak metamorphism of greenschist-amphibolite grade at the Campbell Mine, Red Lake greenstone belt, Superior Province of Canada (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 765. Authors at Univ. of Ottawa, Ottawa, Canada.

The Campbell mine occurs in the eastern Red Lake greenstone belt. There are two main types of ore: arsenopyrite-silica rich lodes in proximity to the contact of mafic-ultramafic volcanic rocks, and silicified carbonate veins within basalts. The wallrock alteration in the upper and western portions of the deposit is characterized by a greenschist facies assemblage comprising of muscovite, chlorite, and carbonates, whereas the alteration in the eastern parts and deeper levels of the deposit is characterized by an amphibolite facies assemblage. The evidence indicates that auriferous hydrothermal activity was synchronous with the deformation and metamorphism.

P FI in quartz from low and high grade ores are predominately CO_2 of high density (0.85=0.88 g/cm^3) with minor (<7 mol%) CH_4. The I from high ore grades contain larger amounts (3-7 mol%) of CH_4 than those from low grade ores (<2 mol%). Th of the CO_2 I, 8-13°C, is consistent with the formation T of 350-400°C at 2.1 Kb, estimated from garnet-biotite thermometry.

Carbonates from the deposit are unusually enriched in ^{13}C ($\delta^{13}C = +0.7 - +3.8‰$). Especially ankerite from auriferous portions of veins have higher $\delta^{13}C$ by 0.5 to 2.7‰ than non-auriferous carbonates. The positive values suggest the enrichment of $\delta^{13}C$ by a loss of CH_4 from auriferous F or by an incorporation of metamorphic CO_2 V released from underlying rocks into the hydrothermal V. (From authors' abstract by E.R.)

TARTAROTTI, Paola, VANKO, D.A., HARPER, G.D. and **DILEK, Yildirim**, 1996, Crack-seal veins in upper layer 2 in hole 896A: in Alt. J.C., Kinoshita, H., Stokking, L.B., and Michael, P.J. (Eds.), 1996, Proceedings of the Ocean Drilling Program, Scientific Results, v. 148, p. 281-288. First author at Dipartimento di Geologia, Paleontologia e Geofisica, Univ. di Padova, Via Giotta 1, I-35157 Padova, Italy.

In this paper, we present a detailed description of the morphology and microstructure of fibrous and nonfibrous veins cross-cutting basaltic cores recovered from Hole 896A. The nonfibrous veins consisting of spheroidal smectite aggregates and blocky carbonate crystals indicate that minerals crystallized in open spaces during single-stage crack opening. Fibrous veins (mainly smectite + carbonate-bearing) indicate that fibers crystallized by a crack-seal mechanism, involving repeated increments of microcrack openings, followed by displacement-controlled crystal growth. We report descriptions of diagnostic features of the crack-seal veins studied. Finally, composite veins consisting of both nonfibrous and fibrous mineral infill are interpreted to result from recrystallization of fibrous minerals into blocky minerals, or to indicate a decreasing crystallization rate with respect to the fracture opening rate. (Authors' abstract)

Fluid Inclusions: Fibrous and blocky aragonite crystals filling the veins commonly contain SFI from 2 to 10 Êm in diameter, containing a single-phase, aq L, suggesting that the Tt was <50°C. Nineteen I in three samples were studied in detail to investigate their composition. A V phase was induced by deliberately overheating the samples on a heating and freezing (H/F) stage (a T between 250°C and 275°C was found to be sufficient). This procedure stretched the I, and, after cooling to room T, the I contained L plus V. Subsequently, measurements of the stable melting T of ice [T_m(ice)] ranged between -1.8°C and -2.3°C with an averate T_m(ice) of -2.0°C. The corresponding sal, expressed as equivalent weight percent NaCl (wt% NaCl eq.), was determined using published V-saturated freezing point depressions. The resulting values of NaCl eq. (in wt%) range from 3.87 to 3.06 with an average 3.5 wt% NaCl eq. The averate T_m(ice) for the FI nearly matches that of seawater [T_m(ice) = -2.1°C, corresponding to 3.5 wt% NaCl eq., for seawater]. The observed range in FI sal is ±14% relative to seawater, that is significantly less than the range observed in modern hot spring F, which can vary between about 0.4 and 7 wt% NaCl eq. (from 70% below to 200% above seawater concentration). Apparently there is no evidence in Hole 896A samples for extreme F sal variations, and hence no reason to invoke hydrothermal processes such as phase separation. (From authors' text by E.R.)

TAYLOR, T.R, and **LAND, L.S.,** 1996, Association of allochthonous waters and reservoir enhancement in deeply buried Miocene sandstones; Picarbon Field, Corsair Trend, offshore Texas: Soc. for Sedimentary Geol. Special Publication, v. 55, p. 37-48.

Indexed under FI (E.R.)

TAYLOR, W.R., CANIL, Dante and **MILLEDGE, H.J.,** 1996, Kinetics of Ib to IaA nitrogen aggregation in diamond: Geoch. Cosm. Acta., v. 60, no. 23 (1996) p. 4725-4733. First author at Research School of Earth Sci., Austialian National Univ., Canberra, ACT 0200, Australia.

TEBAR, H.J. and **NESBITT, B.E.,** 1996, The porphyry-epithermal transition, Eocene Nanika intrusive, central B.C. (Canada) (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A404. First author at Dept. of Earth and Atmospheric Sci., Univ. of Alberta, Edmonton, Alberta, Canada T6G 2E3.

The Equity Silver deposit, central B.C., hosts a porphyry Cu-Mo mineralization formed in a 58 Ma quartz monzonite Nanika Intrusive (with intensely phyllic-overprinted potassic core), and adjacent to it is a major phyllic-altered Ag-Cu-Au-Sb ore vein, grouped into south, central (nearest the porphyry) and north ore zones.

Primary FI in early formed quartz + calcite + sulfide veins and in quartz phenocrysts are dominated by coexisting V-rich and salt-bearing L-rich I. Average Th (L-V) values of P I in veins increase from 250 to 350°C (north to south ores) to > 400°C (porphyry Cu-Mo), but a later ~250°C F is also present. The sal (NaCl eq.) pattern closely mimics the Th trend (< 40 wt.%, north and central ores; > 40 wt.%, porphyry Cu-Mo), and is accompanied by a < 10 wt.% F in the ore vein.

The ore vein is enveloped by relatively low $\delta^{18}O$ volcanics (< 5" to 1.5" [sic, i.e., ‰), compared to values of 6" to 8" (unaltered units) and)" to 12" (other altered units). $\delta^{18}O$ values of quartz + calcite + sulfide veins decrease from 10.2" to 12.4" (ore vein) to 4.4" to 7.2" (porphyry), together with decreasing δDFI values from –126" to –152". The results document a hydrogeologically complex ore porphyry F evolution, beginning with shallow meteoric water circulation producing low $\delta^{18}O$ altered rocks, and later influx of deeper, hotter, more saline, mineralizing F from the plutonic system. These deeper F originated as meteoric water, but were enriched in $\delta^{18}O$ due to extensive water-rock interaction. (Authors' abstract)

TEICHMANN, T. and **BASU, A.R.,** 1996, Nd-Sr isotopic and trace element study of rocks and fluids from the continental deep drilling project (KTB), Germany: Geol Rundsch, v. 85 (1996) p. 162-171. Authors at Dept. of Earth and Environmental Sci., Univ. of Rochester, Rochester, NY 14627.

Geochemical analyses were interpreted on the dominant lithological units and on a deep crustal F from the Continental Deep Drilling Project (KTB) Pilot Hole. The strong geochemical and chronological similarities between the KTB metabasites and rocks from the Münchberg Massif suggest that these units belong to the same lithological complex. The high sal as well as the radiogenic ^{87}Sr / ^{86}Sr ratio of 0.709413 in the KTB F from 4000 m depth might be the result of migrating F reacting with the regional Permo-Mesozoic evaporite deposits, followed by extensive Sr isotopic exchange with the upper crust. (From authors' abstract by E.R.)

THEODORE, T.G., 1996, Geology and implications of silver/gold ratios of the Elder Creek porphyry copper system, Battle Mountain Mining District, Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 1557-1571. Author at U.S. Geol. Survey, Menlo Park, CA.

[During emplacement of] the porphyritic monzogranite of Elder Creek, hydrothermal alteration affected rocks belonging to the porphyry copper system in an area approximately 5 km wide. FI relations in quartz veins suggest association with boiling, highly saline F. No commercial concentrations of metal are presently known in the system. (From author's abstract by E.R.)

F represented by two-phase FI were boiling, probably at T >350°C (Natalya Gostyayeva, unpub. data, 1995). However, some stockwork veins host predominantly two-phase, L plus VFI, which suggests that there is some heterogeneity in distribution of F compositions in the system. In addition, there appears to be a heterogeneity in F composition between some of the FI in phenocrystic quartz and paragenetically later quartz veins (Natalya Gostyayeva, oral commun., 1994). Some phenocrystic quartz contains much more abundant halite-bearing FI, quite analogous with FI in many other porphyry systems.

Examination by SEM demonstrates the presence of relatively complex mineral assemblages including both trapped minerals and dm in FI cavities. Halite and sylvite commonly are present together in many FI, some of which also include an iron chloride phase. Typically, halite crystals are larger than the sylvite crystals in the cavities, although some contain only sylvite. A number of sulfide assemblages have also been detected in the FI cavities, including pyrrhotite alone; chalcopyrite, molybdenite, and pyrite [presumably trapped]; and trapped chalcopyrite and K-feldspar. Other minerals identified in FI cavities include manganese-bearing magnetite, barite, calcite, sphalerite, and calcium chloride. Preliminary studies suggest that relatively high-TF (many as high as 500 to 550°C) were circulating in the general area of the Morning Star Mine at the time of vein emplacement (Natalya Gostyayeva, written commun., 1995). These T are much higher than T recorded at some other gold-bearing quartz stockworks associated with porphyry systems elsewhere. (From author's text 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: p. xxx-xxx in Mineral Deposits: From Their Origin to Their Environmental Impacts: Pasara, Jan, Kribok, Bohdan, and Zak, Karel, eds. Proc. 3rd Biennial SGA Mtg., Prague, Czech Republic, 28-31 August 1995. Authors at Dept. Geol. and Atmospheric Sci., Iowa State Univ., Ames, Iowa.

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°C-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 mag-matic 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)

THIEBEN, S.E. and **SPRY, P.G.**, 1996, Epithermal gold-silver telluride deposits of Montana; geological, stable isotope and fluid inclusion studies: Geological Soc. of America Abstracts with Programs, v. 28, no. 4, p. 40. First author at Iowa State Univ., Dept. of Geol. Sci., Ames, IA, US.

Epithermal Au-Ag telluride deposits in Montana are spatially and genetically related to a variety of Cretaceous-Tertiary alkaline igneous rocks. Mineralization styles include bonanza veins, carbonate replacement at igneous/carbonate contacts, breccia pipe-hosted.

The ore mineralogy is complex and consists of Au-Ag tellurides, and in some deposits, Bi-tellurides and various Bi-, Au-, and Ag- sulfosalts. Alteration related to ore-stage F is localized primarily adjacent to veins and is characterized by silica ± fluorite ± adularia ± sericite ± illite ± kaolinite. FI studies suggest that gold mineralization was deposited from low-T (130-270°C), moderately saline (1-12 eq. wt.% NaCl), non-boiling, CO_2-poor, near neutral pH, relatively oxidizing F. Oxygen and hydrogen isotopes indicte that gold-silver telluride mineralization was deposited from meteoric water or by mixing of magmatic and meteoric waters. Sulfur isotope data suggest a variety of magmatic and/or sedimentary sulfur sources. These alkaline igneous-related gold telluride deposits, some of which contain molybdenite or are associated with Mo anomalies, may represent one end-member of a continuum with porphyry molybdenum deposits. (From authors' abstract by E.R.)

THOMAS, Rainer, 1996a, A link between melt inclusion studies and experimental petrology: exemplified by investigation on granitic rocks from the Erzgebirge, Germany (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 551. Author at GeoForschungsZentrum Potsdam, D-14473 Potsdam, Germany.

A review of the methods and results given by the author previously (FIR 27, p. 147). (E.R.)

THOMAS, Rainer, 1996b, Microthermometry of volatile-rich silicate melt inclusions in granitic rocks (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 139. Author at GeoForschungsZentrum Potsdam D-14473 Potsdam (Germany) ; e-mail (thomas@gfz-potsdam.de)

Melt I provide compositional information about granitic M which cannot be obtained by analysis of bulk rocks. This is particularly true for the volatiles, which are depleted in rocks, even some vitrophyres, because of loss by degassing. Most natural M I are too small for direct in-situ chemical analysis by FTIR or SIMS techniques, and it is difficult or impossible to find enough large I for a statistically significant number of measurements in a sample.

We discuss a simple method of estimating total volatile contents in granitic M from microthermometric measurement of M I as small as 5 µm, which eliminates the size problem and thereby permits collection of large numbers of data. The method works in analogy to FI microthermometry; however it takes into account the rate of melting reactions. We determine the beginning of melting T (solidus T_S) of I by a step-heating and quenching technique.

Homogenization in silicate M I is a diffusion-controlled process and this is the basis for determining volatile contents and viscosity. All heating runs are held for a constant duration; thus we can estimate the diffusion rate by measuring the size of the smallest I which has homogenized in a given run. Differences in diffusion rate, at constant T, P and bulk composition, are a measure of total "volatility" of the M (the most important contributors being H_2O, CO_2, F, P, Li). This "total volatility" in analogy to "total sal" of FI, is expressed by the equivalent concentration of the most abundant volatile species, H_2O and written "C_W as eq.-wt.% H_2O". As a by-product of the method, estimates of M viscosity can also be made.

We present values for volatile content (as eq.-wt.% H_2O), solidus T and the viscosity of M I in quartz and topaz from granitic and pegmatitic rocks of the Erzgebirge, Germany, the Slavkovsky les (Czech Republic) and the Massif Central, France. The volatile concentrations range from 5 to 12 eq. wt.% H_2O. Microprobe analyses show that fluorine and phosphorus are the main volatiles present apart from H_2O. Viscosity values derived from the data show Arrhenian behaviour in the T range of 500-1000°C. Some of the most F-rich M possess very low viscosities on the order of 10^1 to 10^3 Pa. at 800°C, which have important implications for the separation of residual M in silicate crystal-melt-(vapour) systems. (From author's abstract by E.R.)

See also adjacent items. (Author's abstract)

THOMAS, Rainer, 1996c, A link between melt inclusion studies and experimental petrology: Exemplified by investigation on granitic rocks from the Erzgebirge, Germany, (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 35-36. Author at GeoForschungsZentrum Potsdam, D-14473 Potsdam, Germany.

The exact determination of the solidus T (beginning-of-melting) of M preserved in MI takes up a great deal of time. Quenching experiments on silicate MI in minerals of granitic rocks offer an alternative, rapid way to estimate solidus T using experimental data from the haplogranite system Qz-Or-Ab-H_2O. Together with the determined water content we can calculate a model solidus using a $\mathrm{Ln}d_K$-1/T relationship (Thomas, 1994). Here, d_K is the critical diameter which is obtained as follows: after quenching from any T above the true T_h, the smallest MI will be completely homogenized, larger ones not, and some of intermediate size are just on the verge of homogenization. The latter are the "critical" I and their size (critical diameter

d_K) is carefully measured with a calibrated micrometer ocular. In practice, values for d_K at different run T are collected for each sample and plotted on a log scale against run T (l/T). The linear extrapolation of the general equation:

$$\mathrm{Ln}\ d_K = a^* \frac{10000}{T} + b \qquad (1)$$

to a d_K value of 1 μ ($\mathrm{Ind}_K = 0$) gives us the T_O. Using the algorithm for the calculation of viscosity from I and chemical data we can calculate the critical I diameter at different T from the bulk chemistry and different water concentration values C_W. For water concentrations C_W between 2 and 10 wt.%T_O varies from about 500 to 900°C. As an example of the method, we obtain the following relations of T_O, T_S and C_W using I data from the Kirchberg OG3 granite (Erzgebirge):

$$T_O = 1118 - 99.84{*}C_W + 4.08{*}(C_W)2 \qquad (2)$$
$$T_S = 788.6 - 0.61{*}T_O + 0.00065{*}(T_O)2 \qquad (3)$$

From the main I group in the OG3-sample a water content of 6.7±0.1 wt.% was determined. Using equations (2) and (3) T_O is 632°C and T_S is 663°C. According to Johannes (1992), we obtain a P at T_S of 2.8 kbar.

This method connects the results of experimental petrology with MI data and therefore forges a link between geology and experimental petrology. (Author's abstract)

THOMAS, Rainer, 1996d, Characteristics of pegmatitic magma produced by low-pressure crystallization of granites in the Erzgebirge, Germany: A melt and fluid inclusion study (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A95. Author at GeoForschungsZentrum Potsdam, Telegrafenberg A50, D-14473 Potsdam, Germany.

A wide range of solidus values and volatile contents is a general feature of MI in granites. Separate populations of MI in a single crystal reflect M trapped at different stages of evolution, which is more or less continuous. Extreme volatile enrichment occurs locally even in chemically unspecialized granites.

MI studies in quartz and topaz of the highly evolved Variscan postkinematic tin granites in the Central Erzgebirge have shown that the final crystallization in the apical parts of the intrusions took place at low P (~1 kbar) over a large T range of about 100°C. The magmatic evolution began with the main crystallization of a fine- to medium-grained, equigranular monzogranite near 700°C and ended with topaz-albite-granite (~650°C) and pegmatitic phases (marginal pegmatites, "Stockscheider," pegmatite-aplite dikes) down to 520°C. Connected with this evolution is a strong to extreme enrichment in H_2O, F and P. The volatile contents range from 5 to 12 eq. wt.% H_2O.

The generation of pegmatitic M starts with the formation of volatile-rich M fractions (~5 vol.% of the main granites) by extensive fractional crystallization. The pegmatitic bodies (Stockscheider, veins) are characterized by the coexistence of different types of MI (V-poor and V-rich MI) and different types of P KCl- and NaCl-rich FI, which show a more or less continuous transition from the silicate M to the hydrothermal stage.

Viscosity calculations based on the kinetics of MI homogenization show that some of the most F-rich M possess very low viscosities on the order of 10 to 1000 Pa.s at 800°C, in contrast to 100,000 to 1,000,000 Pa.s for near haplogranitic M. This large viscosity (and density) contrast might explain the efficient separation of late stage M from solidifying plutons, for example, by filter pressing or mechanical expulsion.

Microprobe analyses of more than 500 MI in quartz and topaz have shown that, at the time of trapping, the magma was a suspension of a F- and P-rich silicate M with minor immiscible droplets of extremely P-rich M, and crystals of quartz, feldspar, apatite, triplite, berlinite, topaz, cassiterite and other solids. (Author's abstract)

THOMAS, Rainer, 1996, A link between melt inclusion studies and experimental petrology: Exemplified by investigations on granitic rocks from the Erzgebirge, Germany (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 136. Author at GeoForschungsZentrum Potsdam, D-14473 Potsdam (Germany); e-mail (thomas@gfz-potsdam.de)

See adjacent items and Thomas, 1995b, in FIR v. 28, p. 17. (E.R.)

THOMAS, Rainer, RHEDE, Dieter, and **TRUMBULL, R.B.,** 1996a, Microthermometry of volatile-rich silicate melt inclusions in granitic rocks (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 483. Authors at GeoForschungsZentrum Potsdam, D-14473, Potsdam, Germany.

M I provide compositional information about granitic M which cannot be obtained by analysis of bulk rocks. This is particularly true for the volatiles, which are depleted in rocks, even some vitrophyres, because of loss by degassing. Most natural M I are too small for direct in-situ chemical analysis by FTIR or SIMS techniques, and it is difficult or impossible to find enough large I for a statistically significant number of measurements in a sample.

We discuss a simple method of estimating total volatile contents in granitic M from microthermometric measurement of M I as small as 5 μm, which eliminates the size problem and thereby permits collection of large numbers of data. The method works in analogy to FI microthermometry; however it takes into account the rate of melting reactions. We determine the beginning of melting T (solidus T_s) of I by a step-heating and quenching technique.

Homogenization in silicate M I is a diffusion-controlled process and this is the basis for determining volatile contents and viscosity. All heating runs are held for a constant duration; thus we can estimate the diffusion rate by measuring the size of the smallest I which has homogenized in a given run. Differences in diffusion rate, at constant T, P and bulk composition, are a measure of total "volatility" of the M (the most important contributors being H_2O, CO_2, F, P, Li). This "total volatility" in analogy to "total salinity" of FI, is expressed by the equivalent concentration of the most abundant volatile species, H_2O and written "C_w as eq.-wt% H_2O". As a by-product of the method, estimates of M viscosity can also be made.

We present values for volatile content (as eq.-wt% H_2O), solidus Ts and the viscosity of M I in quartz and topaz from granitic and pegmatitic rocks of the Erzgebirge, Germany, and Slavkovskyles (Czech Republic) and the Massif Central, France. The volatile concentrations range from 5 to 12 eq.-wt% H_2O. Microprobe analyses show that fluorine and phosphorus are the main volatiles present apart from H_2O. Viscosity values derived from the data show Arrhenian behaviour in the T range of 500° - 1000°C. Some of the most F-rich M possess very low viscosities on the order of 10^1 to 10^3 Pa.s at 800°C, which have important implications for the separation of residual M in silicate crystal-melt-(vapour) systems. (Authors' abstract.)

THOMAS, Rainer, RHEDE, Dieter, and **TRUMBULL, R.B.,** 1996b, Microthermometry of volatile-rich silicate melt inclusions in granitic rocks: Z.

geol. Wiss., v. 24, no. 3/4 (1996) p. 505-526. Authors at Potsdam (GFZ), Section 4.2, Telegrafenberg A50, D-14473 Potsdam, Germany.

M I provide compositional information about granitic M which cannot be obtained by analysis of bulk rocks. This is particularly true for the volatiles, which are depleted in rocks, even some vitrophyres, because of loss by degassing. Most natural M I are too small for direct in-situ chemical analysis by FTIR or SIMS techniques, and it is difficult or impossible to find enough large I for a statistically significant number of measurements in a sample.

This paper discusses a simple method of estimating total volatile contents in granitic M from microthermometric measurement of M I as small as 5 µm, which eliminates the size problem and thereby permits collection of large numbers of data. The method works in analogy to FI microthermometry; however it takes into account the rate of melting reactions. We determine the beginning of melting at the solidus temperature T_s of I by a step-heating and quenching technique.

We also demonstrate that H in silicate M I is a diffusion-controlled process, and use this as a basis for determining volatile contents and viscosity. Using a constant duration for each experiment, we estimate the diffusion rate by measuring the size of the smallest I which has homogenized in a given run. Differences in diffusion rate, at constant T, P and bulk composition, are a measure of total "volatility" of the M, the most important contributors being H_2O, CO_2, F, P, Li. This "total volatility" in analogy to "total sal" of FI, is expressed by the equivalent concentration of the most abundant volatile species, H_2O ($\pm OH^-$) and written "C_2 as eq.-wt% H_2O". As a by-product of the method, estimates of M viscosity can also be made.

We present here values for volatile content (as eq. wt% H_2O) solidus T and the viscosity of M I in quartz and topaz from granitic and pegmatitic rocks of the Erzebirge, Germany, the Slakovsky-les (Czech Republic) and the Massif Central, France. The volatile concentrations range from 5 to 12 eq.-wt% H_2O. Microprobe analyses show that fluorine and phosphorus are the main volatiles present apart from H_2O. Viscosity values derived from the data show Arrhenian behaviour in the temperature range of 500°C - 1000°C. Some of the most F-rich melts possess very low viscosities on the order of 10^1 to 10^3 Pa.s at 800°C, which have important implications for the separation of residual M in silicate crystal - melt - (vapour) systems. (Authors' abstract)

THOMPSON, T.B., 1996, Fluid evolution of the Cripple Creek hydrothermal system, Colorado: in Diamonds to Gold, I. State Line Kimberlite District, Colorado, II. Cresson Mine, Cripple Creek District, Colorado, Thompson, T.B. (Ed.) v. 26, p. 45-54, Guidebook Series for the Society of Economic Geologists Field Conferences, 1996. Author at Dept. of Earth Resources, Colorado St. Univ., Fort Collins, Colorado 80523.

The Cripple Creek district is known for its low-sulfide gold-telluride vein systems of great vertical range (~1,000 m) with virtually no change in ore grade; however, in the last 10 years shallow, low-grade, bulk-tonnage deposits have been recognized and developed. The deposits are hosted within a Tertiary (32.5-28.2 Ma); alkaline igneous diatreme-intrusive complex. The ore event (28.2-31.3 Ma) overlaps late-stage igneous activity, suggesting that the ore F may have been derived, in part, from that source.

Presented here are the results of research begun in the late Economic Geology Program at Colorado State Univ. in 1982, continuing up to the present. Summaries of mineralogy, wallrock alteration, FI data, and preliminary stable isotope data are presented for the hydrothermal system, ranging from deep-level veins up to the shallow, high-level bulk-tonnage ore systems. The results are preliminary but document the evolution of ore fluid chemistry through the vertical range of the mineral deposit system. The deep veins and shallow, bulk-tonnage systems are extreme ends of a continuum of fluid evolution as demonstrated by their similar, overlapping geochemical data. (Authors' abstract)

THORDARSON, T. and **SELF, S.,** 1996a, Sulfur, chlorine and fluorine degassing and atmospheric loading by the Roza eruption, Columbia River basalt group, Washington, USA: J. of Volcanol. and Geoth. Res., v. 74 (1996) p. 49-73. Authors at Dept. of Geol. and Geophys. and Hawaii Center for Volcanol., School of Ocean and Earth Sci. and Tech., Univ. of Hawaii at Manoa, Honolulu, HI 96822.

In this study we attempt to quantify the amount of S, Cl and F released by the 1300 km^3 Roza member (~14.7 Ma) of the Columbia River Basalt Group, which was produced by a moderate-size flood basalt eruption in the mid-Miocene. Our results are the first indication of the potential atmospheric SO_2 yield from a flood basalt eruption, and indicate the mechanism by which flood basalt eruptions may have seriously affected the environment. Glass inclusions in phenocrysts and quenched glass in products from various stages of the eruption were analyzed for concentrations of S, Cl and F and major elements. Glass inclusions contain 1965 ± 110 ppm S, 295 ± 65 ppm Cl and 1310 ± 110 ppm F. Groundmass glass of Roza dike selvages contains considerably lower concentrations: 1110 ± 90 ppm S, 245 ± 30 ppm Cl and 1020 ± 25 ppm F. Scoria clasts from near vent deposits containt 665 ± 75 ppm S, 175 ± 5 pm Cl and 950 ± 20 ppm F, and the groundmass glass of lava selvages contains 520 ± 30 ppm S, 190 ± 30 ppm Cl and 890 ± 55 ppm F. In crystalline lava, the concentrations are 195 ppm S, 100 ppm Cl and 830 ppm F. Volatile element concentrations in these samples represent the progress of degassing through the eruption and can be used to estimate the po-tential amount of the volatiles S, Cl and F released by the magma into the atmosphere, as well as to evaluate the amount liberated by various phases of the eruption. The total amount of volatiles released by the Roza eruption is estimated to have been ~12,420 Mt SO_2, ~710 Mt HCl and ~1780 Mt HF. The Roza magma liberated ~9620 Mt SO_2 (77% of the total volatile mass released), ~400 Mt HCl (56%) and ~1450 Mt HF (81%) at the vents and lofted by the eruption columns to altitudes of 7-13 km. Degassing of the lava is estimated to have released an additional ~2810 Mt SO_2, ~310 Mt HCl and ~330 Mt HF.

The Roza eruption is likely to have lasted for ~10 years, indicating an annual H_2SO_4-mass loading of ~1800 Mt. Thus, the atmospheric perturbations associated with the Roza eruption may have been of the magnitude predicted for a severe "nuclear" or "volcanic" winter, but lasting up to a decade or more. (Authors' abstract)

THORDARSON T., and **SELF, S.,** 1996b, Sulfur degassing and the nature of explosive activity during flood lava eruptions (abst.): Eos, Trans. Amer. Geophys. Union, v. 77, no. 22, May 28, 1996, p. W130. First author at Inst. of Geological and Nuclear Sci., Private Bag 2000, Taupo, New Zealand; e-mail (t.thordarson@gns.cri.nz)

We have measured sulfur in glass I in phenocrysts and groundmass glass in quenched products from four basaltic flood lava eruptions; 8500 BP Thjorsa (22 km^3), 934 AD Eldgja (15 km^3), and 1783 AD Laki (15 km^3) fissure eruptions in Iceland and the 15 Ma Roza member (1300 km^3) of the Columbia River Basalt Group, NW USA.

These eruptions are best known for large outpourings of lava (¿92% [sic] of total volume erupted), although they featured episodes of explosive activity producing scoria fall which constitute 2-8% of the total volume erupted. The sulfur content of glass I ranges from 1575-2200 ppm; groundmass glasses in partly degassed scoria clasts and lava selvages contain 350-665 ppm S and full degassed crystalline lavas contain 70-290 ppm S. Chemical and volcanological data from scoria and lava selvages indicate that 70 wt.% of the sulfur originally dissolved in the magma was released at the vents during periods of explosive activity, whereas 20 wt.% were liberated during cooling and crystallization of the lava. Similar results are obtained from limited data available on H_2O and CO_2 degassing by these eruptions. The high degree of degassing at the vents implies rapid and effective separation of G and magma during ascent and is attributed to development of a separated two-phase flow in the magma conduit which may explain the episodic explosive activity of these flood lava eruptions. (Authors' abstract)

THORDARSON, T., SELF, S., OSKARSSON, and **HULSEBOSCH, T.,** 1996, Sulfur, chlorine, and fluorine degassing and atmospheric loading by the 1783-1784 AD Laki (Skaftar Fires) eruption in Iceland: Bull Volcanol, v. 58 (1996) p. 205-225. First author at Dept. of Geol. and Geophys. and Hawaii Center for Volcanol., School of Ocean and Earth Sci. and Tech., Univ. of Hawaii at Manoa, Honolulu, HI 96822.

The 1783-1784 Laki tholeiitic basalt fissure eruption in Iceland was one of the greatest atmospheric pollution events of the past 250 years, with widespread effects in the northern hemisphere. The degassing history and volatile budget of this event are determined by measurements of pre-eruption and residual contents of sulfur, chlorine, and fluorine in the products of all phases of the eruption. In fissure eruptions such as Laki, degassing occurs in two stages: by explosive activity or lava fountaining at the vents, and from the lava as it flows away from the vents. Using the measured sulfur concentrations in glass inclusions in phenocrysts and in groundmass glasses of quenched eruption products, we calculate that the total accumulative atmospheric mass loading of sulfur dioxide was 122 Mt over a period of 8 months. This volatile release is sufficient to have generated ~250 Mt of H_2SO_4 aerosols, an amount which agrees with an independent estimate of the Laki aerosol yield based on atmospheric turbidity measurements. Most of this volatile mass (~60 wt.%) was released during the first 1.5 months of activity. The measured chlorine and fluorine concentrations in the samples indicate that the atmospheric loading of hydrochloric acid and hydrofluoric acid was ~7.0 and 15.0 Mt, respectively. Furthermore, ~75% of the volatile mass dissolved by the Laki magma was released at the vents and carried by eruption columns to altitudes between 6 and 13 km. The high degree of degassing at the vents is attributed to development of a separated two-phase flow in the upper magma conduit, and implies that high-discharge basaltic eruptions such as Laki are able to loft huge quantities of G to altitudes where the resulting aerosols can reside for months or even 1-2 years. The atmospheric volatile contribution due to subsequent degassing of the Laki lava flow is ony 18 wt.% of the total dissolved in the magma, and these emissions were confined to the lowest regions of the troposphere and therefore important only over Iceland. This study indicates that determination of the amount of sulfur degassed from the Laki magma batch by measurements of sulfur in the volcanic products (the petrologic method) yields a result which is sufficient to account for the mass of aerosols estimated by other methods. (Authors' abstract)

TITOV, A.V., VLADIMIROV, A.G., KRUK, N.N., and **PALESSKY, S.V.,** 1996, Petrogenesis and age of volcanic rocks of Kyzylrabat structure: Scientific Journal -- Geologiya i Geofizika, v. 37, no.5, p. 62-72 (in Russian; Engl. abst.).

The paper presents results of complex geochemical and isotopic, studies of M and FI in volcanic and subvolcanic tocks of Kysylrabat structure (andesite-basalts, trachyandesite-bassalts, quartz latites, trachydacites, trachytes, and rhyolites). The high-T (liquidus Ts > 1000°C) and low-T (liquidus Ts < 720°C) rock series are identified by studying M I. The evolutional trends of melts are analyzed. The Rb-Sr isotopic data allowed the Early Cretaceous age of the association and the initial Sr ratios for different types of rocks to be established. On the basis of complex analysis of thermobarogeochemical, geochemical, and isotopic data, the petrological model of formation of volcanic and subvolcanic rocks of the Kysylrabat structure is discussed. The mixing process between the P basic and anatectic acidic M on a low-crustal level and crystallization differentiation of hybrid magmas in intermediate reservoirs are believed to be the main petrogenetic mechanisms. (Authors' abstract.)

TONARINI, Sonia, D ORAZIO, Massimo, ARMIENTI, Pietro, INNOCENTI, Fabrizio and **SCRIBANO, Vittorio,** 1996, Geochemical features of eastern Sicily lithosphere as probed by Hyblean xenoliths and lavas: European J. of Mineral., v. 8, no. 5, p. 1153-1173.

Full paper for previous abstract (E.R.)

TONG, Qiangming, 1996, The characteristics of metallogeny of the Huangshaping lead-zinc ore deposit of southern Hunan (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 632. Author at Hunan Inst. of Geol., Chang Sha, China.

The Huangshaping lead-zinc ore deposit is distributed in an arcuate shape with the buried granite porphyry as the center. By the determination of Th, sal and compositions of the mineral I and the thermodynamic calculation, the ore-forming physico-chemical conditions are defined as follows: T 360-150°C, pressure $4x10^6$ - x 10^7Pa, $fs_2>10^{-24}$ - 10^{-14}, and $fo_2>10^{-32}$ - 10^{19}. The ore-forming hydrothermal F are weakly acidic to weakly alkalic. (From author's abstract by E.R.)

TONG, W.X. and **TOBISCH, O.T.,** 1996, Deformation of granitoid plutons in the Dongshan area, southeast China; constraints on the physical conditions and timing of movement along the Changle-Nanao shear zone: Tectonophysics, v. 267, no. 1-4, p. 303-316. First author at Univ. of California at Santa Cruz, Earth Sci. Dept., Santa Cruz, CA, US.

The average P (differs from 4.5 kb) suggests that the shear zone may have reached at least 16 km depth. FI studies referred from the corresponding P-T isochores indicate that the T of ductile deformation in the shear zone was differs [sic] from 740°C. Observations on intrusive relations between the various granitic phases and their relative degrees of deformation suggest that emplacement of the different magma phases may be closely related in time and to movement along the Changle-Nanao shear zone. (From authors' abstract by E.R.)

TORNOS, F., DELGADO, A., CASQUET, C., GALINDO, C., and **REYES, E.,** 1996, The isotopic evolution of fluids related with late and postvariscan hydrothermal cells of the Spanish Central System: IV Spanish Geological Congress, Universidad de Alcalá, 1-5 July, 1996, published by Geogaceta, v. 20, no. 7, p. 1501-1503 (in Spanish; Engl. abst.). First author at ITGE, c/Rios Rosas, 23, 28003 Madrid.

The late postvariscan hydrothermal activity of the Spanish Central System extends almost from ca. 300 Ma to the present. It consists of several independent stages that can be grouped in two different hydrothermal regimes. There is a first hydrothermal event (295 ± 15 Ma) spatially related with minor intrusions of Late Variscan peraluminous granitoids. Here, highly confined hydrothermal cells dominated by lithostatic pressure involve local fluids of complex composition and likely metamorphic origin; modified low-saline meteoric waters occur in the more distal manifestations only. Three recorded younger hydrothermal pulses (ca. 274±6, 150±5 and 100 Ma) involving low-saline waters were channelized along regional structures. Here waters of meteoric origin that infiltrate to a great depth into the basement, leading to a $\delta^{18}O$-shift of the F and a leaching of sulphur and metals from the host rocks. During upwelling, hydrothermal rocks are generated by F-rock interaction and boiling. In the shallow section of the system, the mixing with surficial complex brines led to the formation of fluorite-barite (Zn-Pb-Ag) veins, but no $\delta^{18}O$-δD variation could be detected. (Authors' abstract.)

FI data is discussed and related to isotope data. (HEB)

TORNOS, F., RIBERA, F., SHEPHERD, T.J., and **SPIRO, B.,** 1996, The geological and metallogenic setting of stratabound carbonate-hosted Zn-Pb mineralizations in the West Asturian Leonese zone, NW Spain: Mineral. Deposita, v. 31 (1996) p. 27-40. First author at Inst. Tecnológico GeoMinero de España, Rios Rosas 23, E-28003 Madrid, Spain.

FI in the chloritic breccia [ores] suggest that the ore formation took place at T higher than 200°C from low sal (up to 1.2%wt. NaCl eq.) water-rich ($H_2O > 99\%$) fluids. The premetamorphic mineralizations can be interpreted as similar to the widespread Mississippi Valley-type deposits found in the southern Hercynian Belt. The second group of deposits can be defined as syn- to postmetamorphic stratabound, carbonate-hosted Zn-Pb deposits, broadly similar to MVT but formed in an orogenic setting. Specific features such as the presence of chlorite, the F composition (low saline H_2O - NaCl fluids) and the T of formation above 200°C) are interpreted as characteristic of this tectonic setting (From authors' abstract by E.R.)

FI of likely P origin have only been recognized in the coarse calcite crystals of the chloritic breccia. Th to L range from 163 to 224°C (n = 16). Final ice melting T are of -0.9 to 0°C. ICP-OES decrepitation analysis of FI in selected calcite samples following the methodology of Thompson et al. (1980) gave Na (Na + K) ratios of 0.79-0.86. G analysis by crushing and mass spectrometry (Shepherd et al. 1991) shows that these FI are water-rich ($X_{H_2O} > 0.99$) with very minor amounts of CO_2 and only traces of CO, CH_4 and N_2. (From authors' text by E.R.)

TOROK, Kalman, 1996, High-pressure/low-temperature metamorphism of the Ko-hegy Gneiss, Sopron (W-Hungary); phengite barometry and fluid inclusions: European J. of Mineral., v. 8, no. 5, p. 917-925.

Full paper for previous abstract (E.R.)

A first record of Alpine high-P/low-T, blueschist-facies metamorphism is reported from a garnet-bearing orthogneiss in the vicinity of Sopron area, western Hungary, in the Grobgneiss series of the Eastern Alps. The high-P conditions are marked by phengite-3T with Si contents up to 3.49 atoms p.f.u., which is in close association with biotite, K-feldspar, quartz and grossular-rich garnet. Peak metamorphic P conditions were about 1.2 GPa at 450-500°C. Some of the white micas preserved low-Si (about 3.1 atoms p.f.u.) and high-Ti magmatic cores.

Four types of aq FI can be distinguished in the studied rock:

1. P, intermediate sal (10.9 - 12.4 NaCl eq. wt.%) NaCl - H_2O I in albite with Th = 178-217°C. This type may be the high-P F, reequilibrated at lower P.
2. S, intermediate sal (7.1 - 12.4 NaCl eq. wt.%) NaCl - H_2O I in quartz veins, cross-cutting the S_2 schistosity. Th range from 85 to 176°C.
3. S, high sal $CaCl_2$ - H_2O ± NaCl I (24 and 28.4 $CaCl_2$ eq. wt.%) in quartz veins, cross-cutting the S_2 schistosity. Th range between 61 and 171°C. The type 2 and 3 F are connected with retrograde metamorphism.
4. S, high sal NaCl - $CaCl_2$ - H_2O I with sal of about 20.4 and 22.2 NaCl eq. wt.% and Th between 64 and 99°C. (Author's abstract)

TOSSELL, J.A., 1996, The speciation of gold in aqueous solution: a theoretical study: Geoch. Cosm. Acta, v. 60, no. 1 (1996) p. 17-29. Author at Dept. of Chem. and Biochem., Univ. of Maryland, College Park, Maryland 20742.

TOUPIN, D., EADINGTON, P.J., PERSON, M., MORIN, P., WIECK, J., and **WARNER, D.,** 1996, Petroleum hydrogeology of the Cooper and Eromanga basins, Australia: some insights from mathematical modeling and fluid inclusion data: American Assoc. of Petroleum Geologists Bull., v. xx (1996) p. xx. First author at GEI Consultants, Inc., 1021 Main Street, Winchester, MA 01890.

Mathematical modeling and the analysis of FI data are used in this study to reconstruct the petroleum hydrogeology of the Cooper and Eromanga basins which together comprise Australia's most productive onshore petroleum province. Our analysis focuses on the development of topography- and compaction-driven ground-water flow systems, and their role on heat redistribution, petroleum generation as well as oil and brine migration during basin evolution. Finite-element models of basin transport processes are constructed along cross-sectional transects that more or less follow the present-day ground-water flow patterns through these basins.

Paleosalinity data from 43 FI measurements collected from three formations in four wells were used to help infer the timing of brine migration (flushing) out of the Cooper Basin. Analysis of FI data indicates that paleo formation waters near the southern end of the Cooper basin were relatively saline (up to 220,000 ppm) relative to present-day groundwater (3,000 to 10,000 ppm). The observed trend of decreasing salinities with increasing minimum Th suggests that the FI formed in a paleogroundwater discharge area. This observed decrease in groundwater sal through time is probably due to basin hydrodynamics since the minimum time required to transport salts out of the Cooper Basin by diffusion is longer than the age of the basin.

Model results indicate that the paleohydrology of the Cooper and Eromanga basins has been complex with several different periods of topography- and compaction-driven groundwater flow during the past 110 my. (From authors' abstract by E.R.)

TOURET, J.L.R., 1996a, LILE-depletion in granulites: myth or reality?: Petrology and geochemistry of magmatic suites of rocks in the continental and oceanic crusts, D. Demaiffe (Ed.) (1996) p. 53-72, Univ. Libre de Bruxelles, Royal Museum for Central Africa (Tervuren). Author at Dept. of Petrol. and Isotope Geol., Vrije Universiteit, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands.

A number of evidences, from field observation to mass balance evaluations, show that M extraction is only one, probably minor, mechanism among many others. Element mobility at the lower crustal level is dominated by F-rock interaction. Two major types of F are concerned, CO_2 and brines, which are generated by a number of processes: inheritage from sedimentary formation waters, F resulting from "V-absent melting," or introduced from external sources during and after peak-metamorphic conditions. These F, not granitic M, are responsible for most of the typical granulite features. Hypotheses are presented for the respective roles of both F: CO_2 could be involved in the transport of Zr and REE, brines in the control of alkali mobility. (From author's abstract by E.R.)

TOURET, J.L.R., 1996b, Melt remnants in plutonic rocks, a guide for the characterization of magmatic fluids (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 488. Author at Dept. of Petrol. and Isotope Geol., Free Univ., De Boelelaan 1085, 1081HV Amsterdam, The Netherlands.

TOURET, J.L.R., 1996c, Fluid inclusions in eclogites (a.o. Dabie Mountain, P.R. China) (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 17-19. Author at Dept. of Petrol. and Isotope Geol., Free Univ., De Boelelaan 1085, 1081 HV, Amsterdam, The Netherlands.

Eclogites are metamorphic rocks submitted to (relatively) moderate T (up to about 700°C) and extremely high P, in the range of 20-30 kb (depths to more than 100 km). These conditions correspond to retromorphic trajectories very different from most FI isochores in the P-T space, leading to a systematic reequilibration of I during uplift. But, if F density is reset to lower values, F movements in many cases do not exceed the scale of the host mineral, with the result that the chemical information of the F initially contained in synmetamorphic I is preserved. A good illustration of this principle is found in the eclogites from Dabie Mountains, Eastern China, in which 3 types of eclogites have been defined: Type I (Garnet-omphacite-(coesite-quartz)-Phengite-Zoizite-Rutile-Quartz), Type II (Garnet-Omphacite-Zoizite-Kyanite-Quartz) and Type III (Omphacite-Garnet-Rutile). P-T conditions steadily decrease from Type I (about 28 kb, 700°C) to Type III (22 kb, 600°C).

In Type I eclogites, I are observed in omphacite and quartz. Omphacite contains isolated, P aq I with several solids, notably carbonates (calcite). Microthermometric data are relatively homogeneous: initial melting = -44°C, intermediate melting = -20°C, final melting = -13.8 to -6°C, Th (liquid) = 250°C. These data correspond to an aq composition, with about 10 mole% $CaCl_2$, slightly less NaCl. Later, SI are also aq, with comparable microthermometric data, except lower Th (higher density). Quartz contains I similar to the SI in omphacite, but with traces of methane. Two distinct generations are observed, the later richer in Na.

FI in Type II and III eclogites are more complicated: omphacite contains mixed aq-gaseous I with many solids, comparable to I found in alpine eclogites. G are CH_4 and N_2 (no CO_2). CO_2 I (often in significant amount) are observed in kyanite, together with highly saline brines (mainly NaCl, halite frequent dm, $CaCl_2$ and $MgCl_2$ subordinate). Quartz contains a complicated range of aq-gaseous I (many generations) with CH_4-N_2 mixtures in the gas phase. Late clinozoisite contains an aq, G-free F, very poor in Ca, with variable NaCl content. Enclosing gneisses contain also an aq-gaseous F, but with a much higher CO_2 content than in eclogites.

Maximum F densities correspond to about 5-7 kb for a reference T of 600-700°C, far from P reached during eclogitisation. Local reequilibration is indicated by the homogeneity of F composition in each mineral phase (except for quartz). It is interesting to note that this reequilibration has not led to a preferential H_2O leakage, as the amount of G, in a general way, is minimal for most reequilibrated I. The results of this study compare well with observations on other eclogites, either in the Caledonides, Variscides, or the Alps: in all cases the synmetamorphic F are H_2O-rich, CO_2-poor (or free), CH_4 and N_2 are the dominant gaseous phases. CO_2, if present, derive from the enclosing gneisses, especially when they are metamorphosed in the granulite grade (Caledonides). Very significant in the Dabie Mountains is the progressive change of dissolved ions: early F are (relatively) Ca-rich, whereas Na dominates in later F. This change could reflect the F-solid interaction at decreasing P: Na is mostly contained in the mineral structure at very high P, Ca more easily accommodated in the structure of various minerals (notably clinozoisite) at lower P. (Author's abstract)

TRELOAR, P.J. and **COLLEY, H.**, 1996, Variations in F and Cl contents in apatites from magnetite-apatite ores in northern Chile, and their ore-genetic implications: Mineralogical Magazine, v. 60 (1996) p. 285-301. First author at School of Geological Sci., Kingston Univ., Penrhyn Rd., Kingston-upon-Thames, Surrey KT1 2EE, U.K.

Magnetite-apatite deposits associated with the Atacama Fault Zone of northern Chile are interpreted here, on field criteria, as being the products either of hydrothermal F with a strong magmatic signature, or of late-stage Fe-rich magmas mixed with an aq F. Even in the Chilean iron belt, apatite-rich magnetite deposits are a rarity. Variations in F- and Cl-contents in apatites, strongly zoned with respect to halogens, are indicative of P variations in f_{HF} and f_{HCl} in the hydrothermal F. Small variations in halogen fugacities in the aq F are capable of buffering large variations in halogen content within apatite crystals in equilibrium with that F. The recorded halogen zonation profiles are inconsistent with crystallization of the apatites simply from a volatile-rich, late-stage fractionation Fe-rich magma, or its derived magmatic V. It is more likely that they are the result of mineral-F buffering with a F that represents the mixing of a magmatically-derived aq F with a meteoric F that has variably scavenged Ca and Cl from within the country rocks. The source magma of the former is probably an Fe-P enriched acidic magma, derived by fractionation of P calc-alkaline basic magmas. (Authors' abstract)

TRITILA, J. and **CARDELLACH, E.**, 1996, Dolomitization at the base of the Landete Dolostones formation in Sierra de Espadán (Castellón province): isotopic geochemistry (C, O and Sr) and fluid inclusion data: Geogaceta, v. 20, no. 3 (1996) p. 666-669 (in Spanish; Engl. abst.). First author at Dept. de Cristallografia, Mineralogia i Diposits Minerals, Univ. de Barcelona, C/Marti Franquès s/n. 08028 Barcelona.

The dolomitization affecting the basal facies of the Landete Dolostone Formation in Dierra de Espadán (Castellón Province, Iberian Ranges) has been studied using FI, stable (C and O) and radiogenic (Sr) isotopes. Two different processes have been found: (1) a pervasive epigenetic dolomitization originated by mixing of two different F of contrasted composition, and (2) the generation of zebra-like rhythmic textures formed from hot (215°C), high sal (20-24 wt% eq. NaCl) connate F equilibrated with the enclosing dolostone ($\delta^{18}O_{H_2O}$ = 13.0‰). A link between this high T event and the presence of a Hg deposit in the area is proposed. (Authors' abstract)

TRITILA, J., CARDELLACH, E., and **HUERTA, J.,** 1996, Geochemistry of fluids associated to Mesozoic veins of the Talayuelas anticline (Cuenca, Iberian Ranges): IV Spanish Geological Congress, Universidad de Alcalá, 1-5 July, 1996, published in Geogaceta, v. 20, no. 7, p. 1563-1566 (in Spanish, Engl. abst.). First author at Depto. Cristalografia, Mineralogia i Dipósits Minerals, Universidad de Barcelona, Marti i Franques s/n. 08028 Barcelona.

In the Talayuelas anticline (Cuenca province, Iberian Ranges) many quartz-siderite and barite ± quartz veins associated to Mesozoic faulting are found. They reflect an intense hydrothermal activity dominated by upwelling hot F of ultimate surficial origin (150 to 160°C and up to 25% NaCl eq. sal) that mixed with colder, less saline, descending solutions. Barite sulfate is related to the leaching of evaporites of Triassic to Jurassic age. The F circulation was probably enhanced by the high geothermal gradient related to the graben stage during the development of the Iberian rift. (Authors' abstract.)

TRUMBULL, R.B., LIU, Hua, LEHRBERGER, Gerhard, SATIR, Muharrem, WIMBAUER, Timo and **MORTEANI, Giulio,** 1996, Granitoid-hosted gold deposits in the Anjiayingzi District of Inner Mongolia, People's Republic of China: Econ. Geology, v. 91 (1996) p. 875-895. First author at GeoForschungsZentrum Potsdam, Section 4.2, Telegrafenberg A50, 14473 Potsdam, Germany.

Gold deposits consist of quartz sulfide veins and alteration zones in faults and fractures within quartz monzonite. Hydrothermal alteration formed quartz-sericite-pyrite assemblages as vein selvages and propylitic assemblages which extend up to several decimeters outward from the selvages. Mineralizing F removed Na, Ca, Sr, and Ba from wall rock, and added Mn, K, Rb, S, CO_2, and the ore elements Au, Cu, Pb, and Zn. FI in vein and selvage quartz contain low-sal F with about 10 to 50 mole percent CO_2. Th total of 300° ± 30°C (2σ) are consistent with T estimates from chlorite geothermometry. I evidence of CO_2-H_2O unmixing fixes the trapping P at 0.5 to 1.1 kbars. F unmixing may have been a factor in causing gold precipitation. On various bases, we rule out the granitic intrusions as a source of ore elements or F. (From authors' abstract by E.R.)

TSENG, H-Y, ONSTOTT, T.C., BURRUSS, R.C. and **MILLER, D.S.,** 1996, Constraints on the thermal history of Taylorsville Basin, Virginia, U.S.A., from fluid-inclusion and fission-track analyses: implications for subsurface geomicrobiology experiments: Chemical Geology, v. 127 (1996) p. 297-311. First author at Dept. of Geological and Geophysical Sci., Princeton Univ., Princeton, NJ 08544-1003.

Microbial populations have been found at the depth of 2621-2804 m in a borehole near the center of Triassic Taylorsville Basin, Virginia. To constrain possible scenarios for long-term survival in or introduction of these microbial populations to the deep subsurface, we attempted to refine models of thermal and burial history of the basin by analyzing aq and gaseous F in I in calcite/quartz veins or cements in cuttings from the same borehole. These results are complemented by fission-track data from the adjacent boreholes. Th of S aq FI range from 120°C to 210°C between 2027- and 3069-m depth, with highest T in the deepest samples. The sal of these aq I range from 0 to ~ 4.3 eq wt% NaCl. Four samples from the depth between 2413 and 2931 m contain both two-phase aq and one-phase methane-rich I in healed microcracks. The relative CH_4 and CO_2 contents of these gaseous I was estimated by microthermometry and laser Raman spectroscopy. If both types of inclusions in sample 2931 m were trapped simultaneously, the density of the methane-rich I calculated from the Peng-Robinson equation of state implies an entrapment P of 360 ± 20 bar at the Th (162.5 ± 12.5°C) of the aq I. This P falls between the hydrostatic and lithostatic P at the present depth 2931 m of burial. If we assume that the P regime was hydrostatic at the time of trapping, then the I were trapped at 3.6 km in a thermal gradient of ~ 40°C/km. The results may imply that the microorganisms did not survive in situ, but were transported from the cooler portions of the basin sometime after maximum burial and heating. (From authors' abstract by E.R.)

TSYMBAL, S.N., 1996, Mineral inclusions in pyropes from sedimentary rocks of Ukraine (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 483. Author at Inst. of Geochem., Mineral. and Ore Formation, Acad. Sci. Ukraine, Palladin Ave., 34, Kiev-142, 252680, Ukraine.

Two different types of F and M I occur. Type 1: P glass I + CO_2 FI; these contain Cr-spinel and diopside dm, compositionally similar to those in dunite. CO_2 I (L+V at room T) have glass rims (10-30% of the volume), and are always re-equilibrated. Type I inclusions are remnants of the magma from which the dunites were formed.

Type 2: S silicate glass I and mixed silicate glass + carbonate I occur together with re-equilibrated CO_2 I along fractures originating from the complex network of late veinlets.

We propose that the fracture-bound ultramafic glass + carbonate I and the associated CO_2 I represent a single trapping episode of a volatile-rich CO_2-oversaturated ultramafic M which was present in the upper mantle during Canary Islands volcanism. This M correspond to a discrete episode of mantle metasomatism, but is apparently distinct from the erupted lava. The best estimate of the composition of this metasomatic system is a carbonate-rich M containing about 80% carbonate, 20% ultramafic glass, with a few % volatiles (H_2O and CO_2). This evolved through repeated episodes of magmatic immiscibility in distinct ultramafic and carbonate M. CO_2 was present as immiscible oxidising F phase, whereas H_2O remained dissolved in the ultramafic, Mg-Fe- rich melt. (Authors' abstract.)

TU, Guangzhi, 1996, The discussion on some CO_2 problems: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 53-62. Author at Inst. of Geochem., Chinese Acad. of Sci., Guiyang 550002.

CO_2 degassing processes are discussed and volcanic (magmatic), metamorphic and impact origins of CO_2 can be distinguished. Recent years have seen quantitative measurements of CO_2 emissions from subaerial volcanos, and semiquantitative geochemical modeling of metamorphic CO_2 from the Himalayan orogen and impact CO_2 release from the Cretaceous-Tertiary boundary at the Chicxulub basin, Mexico. The problems of relationship between palaeo-climate and CO_2 content as well as between metallogenesis and CO_2 are complex ones and await further intensive studies. (From author's abstract by E.R.)

TULLIS, J., YUND, R., and **FARVER, J.,** 1996, Deformation-enhanced fluid distribution in feldspar aggregates and implications for ductile shear zones: Geology, v. 24., no. 1 (1996) p. 63-66. Authors at Dept. of Geological Sci., Brown Univ., Providence, Rhode Island 02912.

Experiments at 900°C and 1.4 GPa show that the distribution of aq F in fine-grained feldspar aggregates changes from isolated pores under hydrostatic conditions to mostly wetted grain boundaries during deformation; the isolated pore distribution is rapidly regained during annealing following deformation. (From authors' abstract by E.R.)

TURNBULL, D.G., 1991, The geology and geochemistry of the Colebrook Hill skarn: Bachelor of Science thesis, Univ. of Tasmania, 78 pp and appendices.

The Colebrook Hill prospect is an axinite-bearing Sn-W-Cu skarn. The skarn system overlies the Colebrook Hill feldspar phyric S-type approximately 1034 m below the surface. Limestone beds do occur within the sequence but are predominantly completely replaced by the skarn assemblages. Prograde magnesioaxinite was deposited at T in excess of 450°C from a F of moderate sal (11.4 eq. wt.% NaCl). The prograde alteration phase most likely represents the replacement of limestone or impure limestone by volatile rich F emanating from the underlying granite. Following the total dissolution of the limestone units within the host sequence, the decreasing T of the hydrothermal system caused the precipitation of retrograde amphibole, quartz, calcite and associated sulphide minerals. Ore minerals include pyrrhotite, arsenopyrite, chalcopyrite, magnetite, pyrite, marcasite, sphalerite, galena and bismuth minerals. The sulphide minerals show a zoned distribution within the system with overlapping zones of Cu-W mineralization corresponding with zones of actinolite-chlorite alteration. Sn mineralization is spatially associated with the axinite alteration where it is contained within the crystal structure of axinite ($\leq 0.3\%$ SnO_2). Copper and tungsten distribution is controlled by the alteration assemblage and the closeness of the granite. Tungsten-rich zones (scheelite) occur at a greater depth than the copper (chalcopyrite) and arsenic zones. (From author's abstract by E.R.)

TYLER, Roger and **TYLER, Noel,** 1996, Stratigraphic and structural controls on gold mineralization in the Pilgrim's Rest Goldfield, eastern Transvaal, South Africa: Precambrian Research, v. 79, v. 1-2 (1996) p. 141-169. Authors at Univ. of Texas at Austin, Bureau of Economic Geol., Austin, Texas, U.S.

The gold-silver emplacement model for the Pilgrim's Rest Goldfield infers F derived from a deep-seated magmatic source. Oxygen-isotopic compositions of the mineralizing F, recalculated from delta ^{18}O quartz (+12.1 per mil to +19.5 per mil), point to a magmatic source and subsequent mixing with saline, evolved formation water. A magmatic origin is also supported by the high Th gradient displayed by the FI (100°C/km). The Bushveld igneous complex (Rustenburg Layered Suite) to the west of Pilgrim's Rest is thought to be the source of the auriferous hydrothermal solutions, and its emplacement was the driving mechanism of thrust-fault deformation in the Pilgrim's Rest Goldfield. (From authors' abstract by E.R.)

ULU, Yildiz, 1996, Fluid inclusion studies on the fluorite deposits of Kaman (Kirsehir) (abst.): Abstracts of the 49th Geological Congress of Turkey, 1996, p. 20, published by the Chamber of Geological Engineers of Turkey. Author at Orta Dogu Teknik Üniver., Jeoloji Mühendisligi Bölümü, Ankara.

FI in the fluorite deposits around Yeniyapan, Bayindir, Isahocalt, Villages and Alisar Yaylala in the Kaman region are studied. The study area lies to the northwest of Central Anaiolian Crystalline Complex. The deposits are of open space filling type and are hosted by alkaline syenite intrusions of probably Late Cretaceous age in Bayindir, Yeniyapan, Isahocalt and Lisar; some of the Alisar fluorites are also hosted by metamorphic rocks. Mineralization displays a poor paragenesis composed of fluorite and quartz which is accompanied by calcite in Yeniyapan and Alisar.

As a result of the microthermometric studies, performed separately on each color band in fluorites, average Th are determined as 130.3°C for Yeniyapan fluorites, 126°C for Bayindir fluorites, 144.6°C for Isahocalt fluorites and 147.3°C for Alisar fluorites. No difference is observed between the Th of the color bands. The Th obtained from the Yeniyapan and Bayindir fluorites are slightly lower than those of the Alisar and Isahocalt fluorites. Nevertheless, the T data indicates epithermal T conditions for the formation of all deposits. (Author's abstract)

VAGGELLI, G., GIACOBBE, A., and **DE VIVO, B.,** 1996, Silicate-melt inclusions in clinopyroxenes from prehistoric transitional to alkaline etnean lavas: inferences on magma evolution processes: Acta Vulcanologica, v. 8, no. 1 (1996) p. 99-106. First author at C.S. per la Minerogenesi e la Geochimica Applicata, C.N.R., Via La Pira, 4, 50121, Firenze, Italy.

P silicate-M I in clinopyroxene phenocrysts from a transitional basalt (MNA1) and an hawaiite (BVA2) lava have been analysed in order to characterise the physico-chemical conditions of the host magma. Th of both samples are similar and range from 1100±5°C to 1280±5°C. However, the determined Th seem too high for representing the crystallisation T of the clinopyroxenes. In particular, the measurements of 1200°C for the transitional basal MNA1 and over 1150°C for the hawaiite BVA2 are possibly over-estimated. Microprobe analyses of homogenised and unheated silicate-melt I have been performed, showing that the two rock samples come from chemically different parental magmas whose more primitive compositions have not been found. The alkaline magma result[s are] richer in alkali and in volatile phases and seem to evolve along a silica undersaturated trend direct toward phonolitic compositions. The transitional magmas, in-stead, appear to evolve along a silica saturated trend. The variation diagrams of major elements versus K_2O have been used to investigate on the differentiation processes of host magmas. In particular, the chemical compositions of homogenised silicate-melt I suggests the occurrence of a simple fractional crystallisation of femic phases for BVA2 sample and of a mechanism of crystal/liquid sorting (e.g. crystal cumulation, crystal floating, filter-press, etc...) for MNA1 magma. (Authors' abstract)

VALBRACHT, P.J., HONDA, M., MATSUMOTO, T., MATTIELLI, N., McDOUGALL, I., RAGETTLI, R., and **WEIS, D.,** 1996, Helium, neon and argon isotope systematics in Kerguelen ultramafic xenoliths: implications for mantle source signatures: Earth and Planetary Science Lett., v. 138, no. 1-4 (1996) p. 29-38. First author at The Australian National Univ., Research School of Earth Sci., ACT 0200, Canberra, Australia.

Our neon fusion results, together with helium and neon obtained by crushing, preserve evidence for a primitive mantle component in these Kerguelen xenoliths. This primitive component in the Kerguelen xenoliths may have been metasomatically introduced from the Kerguelen plume into upper mantle peridotite by CO_2-rich, silica-rich M, now represented by cogenetic M and FI in the xenoliths. (From authors' abstract by E.R.)

VALLEY, J.W. and **GRAHAM, C.M., 1996,** Ion microprobe analysis of oxygen isotope ratios in quartz from Skye granite: healed micro-cracks, fluid flow, and hydrothermal exchange: Contrib. Mineral Petrol, v. 124 (1996) p. 225-234. First author at Dept. of Geol. and Geophys., Univ. of Wisconsin, Madison, WI 53706.

Quartz grains in hydrothermally altered granites from the Isle of Skye are highly heterogeneous and not equilibrated in oxygen isotope ratio at the 20 Êm scale. Ion microprobe analysis of one grain shows a gradient of 13‰ over 400 Êm and a greater range in $\delta^{18}O$ than all quartz previously analyzed on the Isle of Skye. Other crystals from the same outcrop are homogeneous. Digitized CL images reveal patterns of magmatic zoning and brittle fracturing not otherwise detectable. The ion proble analysis correlates low $\delta^{18}O$ values on a micro-scale to one set of healed cracks. Thus, quartz exchanges oxygen isotopes primarily by solution and reprecipitation along fractures, in contrast to more reactive feldspar that appears to exchange from the grain boundary inward. Macroscopic models of isotope exchange are not realistic for these rocks; the flow of hydrothermal F was heterogeneous, anisotropic and crack controlled. (Authors' abstract)

VALLIS, F. and **SCAMBELLURI, M.,** 1996, Redistribution of high-pressure fluids during retrograde metamorphism of eclogite-facies rocks (Voltri Massif, Italian Western Alps): Lithos, v. 39 (1996) p. 81-92. Authors at Dipartimento di Scienze della Terra, Corso Europa 26, 16132 Genova, Italy.

High-P clinopyroxenes in metasomatic mafic rocks (rodingites and metagabbros containing titanoclinohumite) and eclogites from the Voltri Massif (Ligurian Western Alps) retain P, two-phase aq I (H_2O + NaCl ± KCl). In the metasomatized rocks the inclusions align with the *c* axes and the cleavage planes of diopside. The eclogites display mylonitic textures: P FI are hosted in early porphyroclasts of omphacite (omphacite I) and are absent in later fine-grained omphacite (omphacite II) that forms the mylonitic foliation. Omphacite I has been frequently replaced by retrograde symplectites (clinopyroxene + plagioclase ± amphibole); in such cases the FI are either absent, or occur in much lower number. The textural observations suggest that formation of the symplectites has been controlled by availability of the FI inside omphacite I. The symplectites have been in turn overgrown by glaucophanic and winchitic amphiboles, indicating that breakdown of the omphacite I to symplectites still occurred at relatively high-P. Post-entrapment changes have caused a large range of densities in the analyzed I. Although the textural evidence constrains the entrapment of FI to high-P conditions, the highest density isochores in the eclogites indicate P-T conditions (8 kbar and 550°C) lower than those attained during the high-P stage. Such *P-T* estimates approach those of symplectite formation after omphacite I. Thus, the FI preserved in omphacite were formed by low-P reequilibration of a F presumably trapped at eclogite-facies conditions. The I kinetically triggered the retrograde breakdown of the eclogitic clinopyroxenes. The compositional overlap between the analyzed I and those related to the latest (greenschist) evolutionary stage, suggests further redistribution of the high-P F and close-system behaviour of these rocks during their overall exhumation path. (Authors' abstract)

Van HAREN, J.L.M, AGUE, J.J. and **RYE, D.M.,** 1996, Oxygen isotope record of fluid infiltration and mass transfer during regional metamorphism of pelitic schist, Connecticut, USA: Geoch. Cosm. Acta, v. 60, no. 18 (1996) p. 3487-3504. Authors at Dept. of Geol. and Geophys., Yale Univ., New Haven, CT 06520-8109.

We present petrologic and oxygen isotopic evidence for the interaction of deep crustal F with hyanite zone pelitic schist during amphibolite facies metamorphism of the Wepawaug Schist, south central Connecticut. We suggest, in agreement with earlier petrologic studies (Ague, 1994b), that the selvages were zones of significant F infiltration and that the region now occupied by the quartz vein was the major F conduit. Quartz in veins surrounded by selvages from five other localities throughout the amphibolite facies have $\delta^{18}O$ that is statistically indistinguishable from that of the bulk of the quartz in MBW-1. Thus, we conclude that the amphibolite facies portion of the Wepawaug Schist was a zone of major, channelized outflow of metamorphic fluids down the regional T gradient. (From authors' abstract by E.R.)

van MOORT, J.C., HOTCHKIS, M.A.C, and PWA, Aung, 1995, EPR spectra and lithogeochemistry of jasperoids at Carlin, Nevada: Distinction between auriferous and barren rocks: J. of Geochem. Exploration, v. 55, p. 283-299. First author at Geol. Dept., Univ. of Tasmania, G.P.O. Box 252-C, Hobart, Tasmania 7001, Australia.

The acid insoluble residue of twenty-nine gold-bearing and ten barren jasperoids from Carlin, Nevada, were analysed by electron paramagnetic resonance powder spectroscopy (EPR), and by simultaneous proton-induced X-ray emission (PIXE) and proton-induced gamma ray emission (PIGME) spectroscopy. The mineralised samples are characterised by high Li, F, Al, K, Ti, Rb, V, Y, and Zr values in general and by significantly higher Rb/Al and V/Al ratios in particular. The chemical differences are largely caused by the abundance and type of sericite present [and possibly FI?]. Significant differences in EPR intensity exist between the mineralised and barren jasperoids. (Authors' abstract)

van MOORT, J.C., RUSSELL, D.W., BAILEY, G.M., PWA, Aung and NAND, A.S., 1996, The use of chemical analysis of bulk samples in exploration lithogeochemistry by simultaneous PIXE/PIGME spectroscopy: *in* Proceedings, International Workshop on Applications of Ion Beam Analysis, Lucas Heights, Sydney, February, 1995, paper no. 7, 4 pp. First author at Geol. Dept., Univ. of Tasmania, GPO Box 252-C, Hobart, Tasmania 7001.

Simultaneous quantitative PIXE/PIGME analysis provided since 1990 characteristic, often unexpectedly, information on the trace element composition of quartz associated with different types of orebodies. Because of the restricted availability of quartz for many types of ore deposits the analytical technique was extended to include acid-leached rock-pulps consisting of quartz with minor sericite and feldspar. (Authors' abstract)

Found ≤ 200 ppm Ge in the L of FI in pegmatitic quartz, using PIGE. (Unpublished personal comm., J.C. van Moort, 1998. (E.R.)

Van THOURNOUT, F., SALEMINK, J., VALENZUELA, G., MERLYN, M., BOVEN,

A., and **MUCHEZ, P.**, 1996, Portovelo: a volcanic-hosted epithermal vein-system in Ecuador, South America: Mineral. Deposita, v. 31 (1996) p. 269-276. First author at Heesterlaan 7, 8200 Brugge, Belgium.

The Portovelo epithermal vein-system results from hydrothermal processes close to a Miocene volcano which pro-duced an andesitic to dacitic sequence followed by collapse and post-collapse rhyolitic activity which generated most of the alteration and mineralization. Alteration, textures and mineral assemblage, including a quartz-calcite gangue, sulfides, abundant sulfosalts and free gold (electrum), are quite typical of an adularia-sericite epithermal deposit. Spatially, the mineralization is arranged in three zones. In addition, three successive stages can be distinguished. The bulk of economic mineralization was deposited during the second stage, in association with a clear quartz and calcite gangue.

Tm-ice and Tm-clath data of FI in the clear quartz indicate a high sal (~10.5 eq. wt% NaCl). The Th of FI in the gangue minerals and in the altered host-rocks vary between 180° and 310°C. Quartz $\delta^{18}O$-values from hydrothermally altered wall-rocks reflect the original isotopic values of the latter. These values show a narrower range in vein quartz (δO^{18} between +7.7‰ and +11.5‰ SMOW). In addition the δO^{18} values of the vein quartz increase systematically with decreasing Th. This suggests that quartz was in equilibrium with a large reservoir of water of constant ^{18}O / ^{16}O composition at decreasing equilibrium temperatures. The estimated isotopic composition of the fluids from which milky quartz and calcite of the main mineralization stage precipitated, lies around -1% SMOW. This value indicates a meteoric rather than a magmatic origin of the ambient F. Clear quartz of the second stage seems to have formed from a F with a $\delta^{18}O$ of +3‰ SMOW. This higher value can be due to a more intense water-rock interaction or to mixing of meteoric with magmatic water. (From authors' abstract by E.R.)

VANKO, D.A., HUNER, M.A., RHODES, G.B. and **DOWLING, S.M.,** 1996, Fluid inclusions in vein minerals (calcite, quartz, and gypsum) of the southeast Piedmont, U.S.A. (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 140. Authors at Dept. of Geol., Georgia State Univ., Atlanta, Georgia, USA, 30303.

Core samples from boreholes in the metamorphic basement between the Savannah River Site (SRS) in South Carolina yield evidence of the history of F-rock interaction and possible mineralogic controls on ground water geochemistry. A prolonged history of F-rock interaction extending from the peak of lower amphibolite grade metamorphism about 300 Ma ago is recorded in numerous and widespread veins. Early foliation-parallel "metamorphic" veins reveal a P generation of L+L+V H_2O-CO_2 I. Later cross-cutting vein sets include successive generations involving quartz, calcite, laumontite and gypsum.

Chemical modeling of water analyses suggests that most samples are equilibrated with calcite, laumontite, feldspar, quartz, and gypsum. This illustrates that present-day groundwater chemistry is effectively buffered by the minerals occupying the permeable and porous fracture systems.

Preliminary sulfur isotopic analyses for gypsum and barite, suggest the possibility of a Triassic seawater origin for the sulfate. (From authors' abstract by E.R.)

VANKO, D.A., LAVERNE, Christine, TARTAROTTI, Paola and **ALT, J.C.,** 1996, Chemistry and origin of secondary minerals from the deep sheeted dikes cored during Leg 148 (Hole 504B): Proceedings of the Ocean Drilling Program, Scientific Results, v. 148, Alt, J.C., Kinoshita, H., Stokking, L.B., and Michael, P.J. (Eds.), 1996. First author at Dept. of Geol., Georgia State Univ. Atlanta, GA 30303-3083.

The S mineralogy of altered diabase in the lower sheeted dikes cored during Leg 148 comprises an earlier high-T assemblage of amphibole, diopside, anorthitic plagioclase, chlorite, titanite, and apatite, overprinted by a subsequent alteration at lower T that led to actinolite, albite, chlorite or chlorite-smectite, talc, epidote, and hydrous calc-silicate (now laumontite).

In practically every instance, the S plagioclase is more calcic than the P igneous plagioclase. The S plagioclase is also clouded with solid and FI, contains depressed concentrations of MgO and FeO, and exhibits bright CL.

Geothermic evidence suggests that the earliest alteration assemblage of hornblende plus calcic plagioclase represents high T (Ū400°C) characteristic of the mid-ocean-ridge reaction zone. Later generations of actinolite + chlorite + albite and epidote + quartz most likely formed at lower T during the waning of axial hydrothermal activity. The presence of calcic plagioclase in the high-T alteration assemblage challenges the widely held notion, based upon oft-sampled altered basalts, diabases, and spilites, that the dominant plagioclase of the mid-ocean-ridge reaction zone is albite. Evidence from Hole 504B, as well as recent experimental studies, suggests that albite is a later plagioclase in the reaction zone, which formed during waning hydrothermal conditions. (From authors' abstract by E.R.)

VAPNIK, Ye, 1996, Melt inclusions in a dike of peralkaline rhyolite (Nahal Shlomo area, Southern Israel): N. Jb. Miner. Mh., no. 8 (1996) p. 365-376. Author at Beer-Sheva, Israel.

Silicate M I were investigated in quartz phenocrysts of an iron-rich peralkaline rhyolite dike using high T microthermometry and scanning electron microscopy (SEM).

A very low incipient melting T of about 500°C indicates addition of a few percent of fluorine to the magmatic volatile phase. Volatile saturation conditions of magma genesis were assumed. The following data were obtained on the initial conditions of magma crystallization: liquids T, 750-830°C; upper limit of P, 2-1 kbar; upper limit of magma water content, 6-4wt%.

SEM analysis of M I revealed an ongonite-rhyolite composition with an evolutionary trend from alkaline potassium-sodium to peralkaline perpotassic composition. The characteristic potassium enrichment of peralkaline magmatism in the Arabian-Nubian Shield was confirmed in the Nahal Shlomo area.

It was shown that high SiO_2 contents of M I were partly connected with host-quartz effect on SEM analysis and with partial enrichment of M I in SiO_2 during heating experiments. (Authors' abstract).

VARELA, M.E., CLOCCHIATTI, R. and **SCHIANO, P.,** 1996, Evolution of metasomatic melts in sub-continental upper mantle beneath northern Patagonia, Argentine: A silicate melt inclusion study (abst.): 16th Reunion des Sci. de la Torre, Orleans, 10-12 avril 1996, Program p. 102 (in Engl.) First author at Univ. Nacional del Sur-CONICET-Dpto. de Geologia, San Juan 670 (8000) B. Blanca, Argentina.

Ultramafic xenoliths from Northern Patagonia, Argentina contain three types of genetically related I: CO_2 FI, silicate M, and carbonate M I, hosted in both olivine, orthopyroxene and clinopyroxene. Thermometric results suggest that the trapped F is almost pure CO_2. The CO_2 density of FI varies from 0.9-1.1 g.cm^3 (early I) to 0.75-

0.8 g/cm^3 (late I) suggesting that CO_2 FI were trapped at upper mantle depths. Silicate M I occur relatively isolated or as trails of S I along fracture planes and deformation lamellae limits. This observation suggests that infiltration of the M is contemporaneous with deformation events. M I are composed of glass, or a combination of glass and crystal phases, as Ti-rich clinopyroxene, apatite, ilmenite, chalcopyrite and a Cu-Fe-Ni sulphide. They form a paragenesis clearly different to that of the host peridotite. Silicate M occur[s] together with carbonated M and sulphide droplets inside a single I. The relationships between the different types of M I [and] the forsterite content of the host olivine suggest the following temporal sequence: (1) high silica (68 wt%) and alkali rich (NaO_2 + K_2O = 11wt%) M are trapped as isolated I in olivine Fo_{91-92} (2) lower SiO_2 an higher Na_2O M content occur as interstitial glass (3) silicate M I with enriched composition in FeO, MgO, Na_2O and Cl are trapped in olivine Fo_{92} synchronous with deformation and similar I occur in olivine in Fo_{91-92}. Such M are also trapped during transformation suffered by Cr-rich spinels. Correlation observed in binary diagrams (e.g. K_2O / Na_2O and Cl / Na_2O) indicate that the variation of the chemical composition of the M can be related to the mixing of several L/F. The change in the chemical composition of the M are accentuated after the deformation of xenoliths, suggesting that this deformation event allow[ed] the metasomatic M to invade the upper mantle beneath Patagonia. (Authors' abstract)

VARFALVY, Veronika, HÉBERT, Réjean and **BÉDARD, J.H.,** 1996, Interactions betwen melt and upper-mantle peridotites in the North Arm Mountain massif, Bay of Islands ophiolite, Newfoundland, Canada: Implications for the genesis of boninitic and related magmas: Chemical Geol., v. 129 (1996) p. 71-90. First author at Départ. de Géologie et Génie Géologique, Univ. Laval, Ste-Foy, Qué. GIK 7P4, Canada.

VEKSLER, I.V., NIELSEN, F.D. and **KRIGMAN, D.,** 1996, The role of volatiles in the genesis of melilitolites (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 435. First author at GEOCHI, Russia.

VELIVETSKAYA, T.A. and **IGNATIEV, A.V.,** 1996, Evolution of Au-Pb-Zn deposits: Study of stable isotopes and fluid inclusions (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 30. Authors at Far East Geological Inst., Far Eastern Branch, RAS, Russia.

VENNEMANN, T.W. and **O'NEIL, J.R.,** 1996, Hydrogen isotope exchange reactions between hydrous minerals and nolecular hydrogen: I. A new approach for the determination of hydrogen isotope fractionation at moderate T: Geoch. Cosm. Acta, v. 60, no. 14 (1996) p. 2437-2451. Authors at Dept. of Geological Sci., Univ. of Michigan, Ann Arbor, MI 48109-1063.

The new equilibrium fractionation factors determined in this study do not unambiguously resolve serious conflicts in data published by previous workers, but do provide some important constraints on the direction and magnitude of the D/H fractionation factors between water and the common rock-forming minerals. (From authors' abstract by E.R.)

VERGNIOLLE, Sylvie, 1996, Bubble size distribution in magma chambers and dynamics of basaltic eruptions: Earth and Planetary Sci. Lett., v. 140, no. 1-4 (1996) p. 269-279. Author at Inst. of Theoretical Geophysics, Dept. of Applied Maths and Theoretical Physics, 20 Silver Street, Cambridge CB3 9EW, U.K.

VERNIKOVSKAYA, A.E. and **VERNIKOVSKY, V.A.,** 1996, Change of fluid parameters under the formation of gold deposits within various metamorphic zones (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 719. Authors at UIGGM, Russia.

Gold-quartz deposits from the Yenisei Ridge are localized within schist sequences related to a thrust. Most of deposits are from greenschist and garnet zone of epidote amphibolite facies of regional metamorphism. F parameters of gold-bearing quartz veins, veinlets and their hosting schists were studied. The methods of atomic absorption, spectral chemistry, gaseous chromatography, FI homogenization and cryometry were applied, added by Raman-spectroscopy study of individual I. The similarity of element and gaseous component composition of the F from host rocks and quartz veins was found. The main gaseous components of solutions are H_2O and CO_2, less, CH_4 and N_2, rarely H_2 and H_2S. Thermobarogeochemistry of quartz veins and veinlets confirms the metamorphic redistribution of components during hydrothermal processes. Dense I with L CO_2 containing the relics of metamorphic F were found inside early pre-ore quartz. Metamorphic recrystallization of pre-ore quartz into ore quartz resulted in the capturing of new type I and proceeded under the simultaneous decrease of T, P, density of solutions and their multiple changes, i.e in the regressive stage of metamorphism. Metamorphic F has mainly chloride composition. The metamorphic stage is characterized by 200-400°C and 2.5 kbar parameters. (From authors' abstract by E.R.)

VIETS, J.G., HOFSTRA, A.H., EMSBO, Poul and **KOZLOWSKI, Andrzej,** 1996, The composition of fluid inclusions in ore and gangue minerals from the Silesian-Cracow Mississippi Valley-type Zn-Pb deposits Poland: genetic and environmental implications, *in* Prace Panstwowego Instytutu Geologicznego, Carbonate-hosted zinc-lead deposits in the Silesian-Cracow area, Poland, v. 154, p. 85-104. First author at U.S. Geol. Survey, P.O. Box 25046, Mail Stop 973, Denver, Colorado 80225.

The composition of F extracted from ore and gangue sulfide minerals that span most of the paragenesis of the Silesian-Cracow district was determined using a newly developed ion chromatographic (IC) technique. Ionic species determined were Na^+, NH_4^+, Ca^{2+}, Mg^{2+}, K^+, Rb^+, Sr^{2+}, Ba^{2+}, Cl^-, Br^-, F^-, I^-, PO_4^{3-}, CO_3^{2-}, HS^-, $S_2O_3^{2-}$, SO_4^{2-}, NO_3^-, and acetate. Mineral samples included six from the Pomorzany mine and one from the Trzebionka mine which are hosted in the Triassic Muschelkalk Formation, and two samples of drill core from mineralized Upper Devonian strata. Nine paragenetically identifiable sulfide minerals occur throughout the Silesian-Cracow district. These include from earliest to latest, early iron sulfides, granular sphalerite, early galena, light-banded sphalerite, galena, dark-banded sphalerite, iron sulfides, late dark-banded sphalerite with late galena, and late iron sulfides. Seven of the minerals were sampled for FI analysis in this study. Only the early iron sulfides the last galena stage were not sampled.

Although the number of analyses are limited to nine samples and two replicated and there is uncertainty about the characteristics of the FI analysed, the data show clear temporal trends in the composition of the F that deposited these minerals. FI in minerals deposited later in the paragenesis have significantly more K^+, Br^-, NH_4^+, and acetate but less Sr^2 than those deposited earlier in the paragenesis. The later minerals are also characterized by isotopically lighter sulfur and significantly more Tl and As in the solid minerals.

The change in ore-F chemistry is interpreted to reflect a major change in the hydrologic regime of the district. Apparently, the migrational paths of ore F from the Upper Silesian basin changed during ore deposition and the F which deposited early minerals reacted with aquifers with very different geochemical characteristics than those that deposited late minerals. The early F may have reacted primarily with Devonian and Lower Carboniferous carbonate aquifers deeper in the basin, whereas the later F appear to have had extensive contact with organic-rich rocks, probably the shallower Middle and Upper Carboniferous flysch associated with coal measures. High concentrations of toxic Tl and As occur in the readily oxidized marcasite and pyrite minerals deposited by the later F. In general, the geochemistry of both the early and late F may be explained by an evaporite related origin or by water-rock modification of a saline basinal brine.

When compared to the composition of FI in Mississippi-Valley-type (MVT) ore minerals from the Ozark region of the United States, FI in minerals from Silesian-Cracow are fundamentally different, containing more Ca^{2+}, Mg^{2+}, NH_4^+, Br^-, Sr^{2+} and acetate, in all mineral stages with significantly more K^+ in later stage minerals. The differences in ore F chemistry between the two regions are consistent with the lithologic differences of the respective basins, thought to be the source of the mineralizing brines. (Authors' abstract)

VILA, Tomás, LINDSAY, Nicholas and **ZAMORA, Richard,** 1996, Geology of the Manto Verde copper deposit, northern Chile: A specularite-rich, hydrothermal-tectonic breccia related to the Atacama fault zone: *in* "Andean copper deposits: new discoveries, mineralization, styles and metallogeny," Soc. Econ. Geologists Special Publication No. 5, Camus, F., Sillitoe, R.H. and Petersen, R., eds., 1996, p. 157-170. First author at 626 Highgate, Dunedin, New Zealand.

The Manto Verde copper deposit is associated with specularite-rich breccias emplaced during extensional tectonism. District-wide chloritization and K-silicate alteration, characterized by microcline replacement and veining of the andesitic country rock, is recognized. Superimposed sericitic alteration is localized by the MVF and neighboring fracture zones. This later alteration event accompanied the main deposition of specularite and associated copper(-gold) mineralization dated by the K/Ar method at 121±3 and 117±3 Ma.

Preliminary studies indicate a predominance of three-phase FI as well as the coexistence of V-rich and L-rich, two-phase I evidencing boiling. Th for two and three-phase I in translucent quartz veinlets and fragments accompanying early iron - copper - (gold) mineralization range between 180 and 320°C, although they are mainly between 180 and 250°C. Sal for the three-phase I vary from 30 to 47 wt.% NaCl eq., although a decrease in F sal (14-21 wt.% NaCl eq.) is detected in two-phase I from late-mineralization, chalcopyrite-bearing calcite veins.

The geologic features of the Manto Verde deposit suggest a common magmatic-hydrothermal origin with the apatite-bearing magnetite deposits of the CIB. Manto Verde probably represents the copper-rich, specularite-dominated, and possibly younger end member of a continuum of deposits that extends to copper-poor, magnetite-dominated deposits at the other extreme. (From authors' abstract by E.R.)

VINDEL, E., LOPEZ-GARCIA, J.A., GARCIA, E., BOIRON, M.C. and **CATHLINEAU, M.,** 1996, Fluid inclusions study in microfissured granites: application to W-Sn veins from the Spanish Central System, IV Spanish Geological Cong., Universidad de Alcala, 1-5 July, 1996, published by Geogaceta, v. 20, no. 7, p. 1558-1560 (in Spanish; Engl. abst.). First author at Dto. de Cristalografia y Mineralogia, Univ. Complutense, 28040, Madrid.

The geometry of the ore F migration was investigated in the (W-Sn) mineralized granites of the Spanish Central System. Based on microthermometry, Raman microprobe and textural relationships, six types of FI have been distinguished: 1) Magmatic hypersaline aq F represented by Lw-s I. 2) Metamorphic aquo-carbonic F represented as different types of FI: (I) H_2O-CO_2-(CH_4) F represented by Vc-w three phase I at room T; (ii) H_2O-CO_2-CH_4 F showing two-phase at room T with a low density volatile phase displaying a large variation of the CH_4/CO_2 ratio; (iii) H_2O-CH_4 F represented by Lw-m two-phase I with a volatile phase entirely dominated by CH_4. 3) Aq F are shown by (iv) Lw1 and (v) Lw2 two phase I with low to moderate sal. F trapping occurred in the granites by means of a complex succession of opening and reopening of microfracture network. NE-SW ductile-brittle cracks contain quartz-wolframite thus connected with FIP bearing aq-carbonic F. A later drop in CO_2 is recorded in N140° - 150°E, N100° - 110°E, N-S and E-W. A latest F is represented by aq F crosscutting the precedent FI planes. (Authors' abstract)

VITYK, M.O. and **BODNAR, R.J.,** 1996, Plastic flow vs. brittle deformation: Do fluid inclusions in high temperature metamorphic environments decrepitate? (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 141-142. Authors at Fluids Research Laboratory, Dept. of Geol. Sci., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA, U.S.A., 24061

In the laboratory, the response of FI to stress usually involves two types of behavior: elastic behavior, where I strain is recoverable, and permanent deformation which occurs when the stress exceeds some critical value. Permanent deformation accompanied by fracturing of the host due to high effective and/or differential pressure is well known as I *decrepitation* or *brittle deformation*. Permanent deformation whereby strain is distributed uniformly throughout the I walls is termed *stretching* or *plastic deformation*. There is a common belief that FI reequilibrated under conditions of high internal overpressure deformed by decrepitation. In nature, however, deformation of FI at conditions of high T and low loading rates includes considerable plasticity accommodated by dislocation mechanisms (glide, climb, multiplication and interaction of dislocations). Plastic deformation of FI might allow the internal stress of the FI to be reduced gradually, thus preventing the I from decrepitating.

To test this idea we conducted a series of decompressional high T (600-700°C) and pressure (2-5 kbar) experiments using synthetic aq I in natural quartz. With up to 1 kbar of internal overpressure the I deform elastically. Once the yield point (elastic limit) for the I is passed the I walls start to flow. Under conditions of inter-nal overpressure, I flow causes a permanent increase in the I volume (increase in strain). The increase in I strain reduces the internal stress of the FI, shifting (reducing) I density towards the final re-equilibration isochore. We found that this partial "recovery" of the I from high internal stresses is a relatively rapid process and can be achieved over one month duration. Each reequilibration experiment produced a unimodal Th histogram with low variability and no cor-relation between I size and density. After each run, the estimated internal overpressure for the I at the conditions of reequilibration was about 1 kbar. This amount of internal overpressure closely approximates the amount of overpres-sure at which the I start to flow. Additional time (up to 270 days at the reequilibration conditions) had little effect on I density, suggesting that some apparent state of volu-metric equilibrium had been achieved by most FI after about 30 days.

Our results clearly indicate that even fast experimental loading rates allow the I volume to adjust such that internal stresses never reach the point where the I fail in a brittle manner. The internal overpressure required to initiate plastic deformation of FI corresponds to the internal overpressure that the I can hold over geological time. The driving force for recovery of the I from the internal stresses arises from plastic deformation of the I walls. Assuming that I deformation occur in a similar way in nature, we conclude that for most of high P and T natural conditions, decrepitation of the I is unlikely to occur. The only condition where decrepitation might take place is in the low T, high strain metamorphic environment. (From authors' abstract by E.R.)

VITYK, M.O., BODNAR, R.J. and **DUDOK, I.V.,** 1995, Natural and synthetic re-equilibration textures of fluid inclusions in quartz (Marmarosh Diamonds): Evidence for refilling under conditions of compressive loading: Eur. J. Mineral., v. 7, no. 6, p. 1071-1087. First author at Dept. of Geol. Sci., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, USA.

Hydrocarbon I in quartz crystals (Marmarosh Diamonds) from calcite-quartz fissures in flysch deposits of the Ukrainian Folded Carpathians display unusual morphological features (scalloped textures) that have been related to post-trapping re-equilibration. Tectonic models for the evolution of the region are consistent with P-T paths that would generate internal overpressures in the I during uplift. However, based on a comparison of laboratory produced FI re-equilibration textures with textures in natural hydrocarbon I in Marmarosh Diamonds, we have concluded that the latter were produced by leakage and refilling under conditions of compressive loading.

Multi-stage laboratory re-equilibration of natural hydrocarbon I in Marmarosh Diamonds under conditions of internal underpressure (compressional loading) at 500°C and 2, 3, 4, and 5 kb of confining P shows that I density remains relatively constant ≤~3 kb internal underpressure (4 kb of confining P). In most I that have been re-equilibrated in the laboratory, F density increased after re-equilibration at ~4 kb underpressure (5 kb of confining P) as a result of a decrease in I volume due to plastic deformation. (Authors' abstract)

VITYK, M.O., BODNAR, R.J. and **DUDOK, I.V.,** 1996, Fluid inclusions in "Marmarosh Diamonds": evidence for tectonic history of the Folded Carpathian Mountains, Ukraine: Tectonophysics, v. 255 (1996) p. 163-174. First author at Fluids Research Laboratory, Dept. of Geological Sci., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061.

Fissures in the nappes of the Folded Carpathians contain euhedral quartz crystals known as Marmarosh Diamonds. Study of Marmarosh Diamonds collected from the nappes in the Ukrainian part of the Carpathians showed that these quartz crystals contain abundant P syngenetic methane-rich and aq inclusions. Many of the early I show evidence of "explosion" (decrepitation under conditions of internal overpressure), caused by tectonic uplift of the enclosing sediments during Miocene times. Regional mapping of morphologic and microthermometric characteristics of I indicates that the decrepitated inclusions display characteristic textural features and Th patterns within the different nappes, suggesting that the various nappes have experienced significantly different burial-uplift histories. Thus, inclusions reveal an increase in depth of burial from the inner regions of the Folded Flysch Carpathians towards the outer regions: about 2 km for the Marmarosh nappe, 5 km for the Rahiv nappe, 7 km for the Porculec and Chornogora nappes and 10 km for the Krosno zone. The corresponding average geothermal gradients decreased from about 40-45°C / km for the Marmarosh nappe to about 20-25°C /km for the Krosno zone. It is also concluded that the Marmarosh nappe followed a *P-T* path close to the original I isochore, because I from quartz crystals collected within this nappe show no evidence of decrepitation. On the other hand, I in quartz from the Krosno zone show very intense explosion features and the highest F densities that have been recorded for the region, suggesting that the Krosno zone was the most buried part of the Ukrainian Folded Carpathians during formation of the I. (Authors' abstract)

VITYK, M.O., BODNAR, R.J., HRYN, John and **MAVROGENES, J.A.,** 1996, Determination of phase equilibria in the system H_2O-NaCl-KCl-$MgCl_2$ using synthetic fluid inclusions, with application to fluid inclusion studies (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 143. First author at Fluids Research Laboratory, Dept. of Geol. Sci., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA, U.S.A. 24061.

The synthetic FI technique was used to determine the phase relations in a portion of the system H_2O-NaCl-KCl-$MgCl_2$ under V saturated conditions. These experiments were designed to evaluate the effect of small amounts (2-10 wt.%) of $MgCl_2$ on the solubilities of halite and sylvite. Compositions studied ranged from 30-50 wt.% NaCl+KCl, with NaCl/KCl ratios of 1:1 and 3:1. Data collected in this study have been regressed to generate a set of equations describing total sal as a function of salt dissolution T and $MgCl_2$ contents.

Addition of small amounts of $MgCl_2$ (2-10 wt.%) to H_2O-NaCl-KCl solutions decreases the solubility of halite and sylvite, compared to their solubilities in the H_2O-NaCl-KCl system at the same T. This in turn leads to overestimation of the relative amounts of NaCl and KCl in solution, if the halite and sylvite dissolution T are interpreted using phase equilibrium data for the H_2O-NaCl-KCl system. For example, if an I containing 30 wt.% NaCl+ KCl also contains 10 wt.% $MgCl_2$, the NaCl+KCl content in the I may be in error by as much as 7.3 wt.% salt if data for H_2O-NaCl-KCl are used to intepret the halite and sylvite dissolution T. For I containing 5 wt.% $MgCl_2$ the error ranges from about 3.8 wt. % for I containing 30 wt.% NaCl + KCl, to about 2 wt.% for the I containing 50 wt.% NaCl + KCl. For a given $MgCl_2$ concentration, the error diminishes as the concentration of NaCl+KCl increases. Our results suggest that for I containing concentrated NaCl-KCl brines (> 50 wt.%), the NaCl+KCl concentrations estimated from halite and sylvite dissolution T may be in error by as much as 4 wt.%. The effect of $MgCl_2$ appears to be stronger in solutions with low NaCl:KCl (1:1) than solutions with higher NaCl:KCl (3:1). (Authors' abstract)

VOLFINGER, M., CHOÏ, C.G., EDON, M. and **RAMBOZ, C.,** 1996, The nuclear microprobe, an instrument for the non-destructive analysis of enclosed fluids (abst.): 16th Earth Sciences Meeting, (Abstracts), pub. by

Soc. Géol. Fr., Paris, p. 211 (in French). First author at CRSCM-CNRS, Orléans, France.

A review of PIXE and PIGE for FI analysis. For I in quartz detection limits of 30 ppm for Zn, Sr, Br and Pb, and of 4000 ppm for Cl with x-rays are estimated. With the same dose the detection limits are 50 ppm for Li, 150 ppm for B, F and Na, and 200 ppm for Al with γ-rays. (From authors' abstract by E.A.J. Burke).

VOLLBRECHT, A., SCHILD, M., REUTEL, Ch, SIEGESMUND, S., CHLUPAC, T. and **WEISS, T.**, 1995, Healed microcracks in granites from the HDR drillholes EPS-1, Soultz-Sous-For Ts. - paleostress directions, paleofluids and crack-related VP-anisotropy (abst.): Bol. de la Soc. Española de Mineralogia (ECROFI XIII), v. 18-1, p. 267-268. First author at Inst. Geologie u. Dynamik der Lithosphäre, Univ. Göttingen, Germany.

Complete 3D analyses of microcrack orientations were carried out by U-stage microscopy using three mutually perpendicular thin sections from reoriented core samples. The crack population is dominated by healed cracks in quartz forming an orthogonal pattern of three sets with strong preferred orientation. The microstructural characteristics point to thermal contraction during cooling and uplift of the granites to be the main driving force for crack propagation.

FI petrography reveals that different paleofluids can be related to certain crack generations (inter- and intragranular cracks, grain boundary cracks).

The distribution of P-wave velocities (Vp) was measured by using the pulse transmission technique on a vacuum-dried spherical sample. The strong geometric relationship between the Vp-diagram, and the crack pole figure indicates that the Vp-anisotropy is mainly caused by the observed crack fabric. The present study points out that FI data should be directly related to microfabrics which makes a more detailed reconstruction of the tectonothermal history possible. (From authors' abstract by E.R.)

VOLTAGGIO, M., BARBIERI, M., BRANCA, M. CASTORINA, F., TADDEUCCI, A., TECCE, F., TUCCIMEI, P., TURI, B. and **VESICA, P.**, 1995, Calcite filling fractures in volcanic environment (Vulcano Island, Italy): Contribution of geochronological and isotopic studies to volcanotectonics (abst.): European Union of Geosci., EUG 8, 9-13 April, 1995, Strasbourg, Abstracts; published in Terra Nova, v. 7, suppl. no. 1, p. 337.

Part of the present caldera at Vulcano Island (Aeolian Island, Italy) is interested [intersected?] by a network of fractures filled mostly with calcite and with a minor amount of chalcedony, both deposited from hydrothermal solutions, as results from the study of FI. Both $^{87}Sr/^{86}Sr$ and $^{234}U/^{238}U$ ratios indicate that sea water was not involved in the hydrothermal system, in agreement with the study of FI, which did not document the presence of NaCl.

The O isotopic composition excludes a post-depositional interaction with meteoric water and suggests a T of deposition consistent with the T obtained from the study of the FI (~170°C), assuming equilibrium conditions and an isotopic composition of the F close to the present steam emissions. The positive correlation between the U content and the C isotopic composition indicates a fast variation of the CO_2 P during the calcite deposition. This is consistent with a fast ascent of the F, likely connected with two phases of the La Fossa Caldera collapse. The ages of the calcites indicate the time of activation of the fracture systems connected to the above-mentioned phases of the caldera collapse. (From authors' abstract by E.R.)

VREELAND, R.H., PISELLI, A., SHILLING, L., FORTIS, L., POGUE, C., ANGELINI, S. and **GHERNA, Robert**, 1995. Distribution of halophilic bacteria in the 250 million year old Salado Formation: Recovery of cultures and comparison to isolates from surface sources (abst.): Geol. Soc. Am. Absts. with Programs, v. 27, no. 6, p. 305-306.

Indexed under FI (E.R.)

VROLIJK, P.J., POTTORF, R.J. and **MAZE, W.B.**, 1996a, Record of source-generated overpressures, Venezuela: American Assoc. of Petrol. Geologists Annual Meeting Abstracts, v. 5, p. 145. First author at Exxon Production Research Company, Houston, TX, US.

FP affect migration of oil, G, and water in continental margins. Burial and thermal history models describe the degree to which undercompaction or thermal expansion of F contribute to FP histories, but it is more difficult to evaluate how source-terms, such as oil yield or mineral dehydration reactions, impact paleo-FP. In this study, we document how a thick, maturing source rock helped create near-lithostatic FP that generated overpressures in reservoir rocks. We analyzed abundant oil-filled and rare aq FI in calcite-filled fractures in the La Luna Fm. source rock and in the underlying Cogollo Gp. carbonate; reservoir in the W. Maracaibo Basin, Venezuela. Th of oil-filled I range from 25-42°C in the La Luna Fm. and from 25-105°C in the Cogollo Gp., and associated gravities (determined from fluorescence properties) range from 28-43° API and 17-45° API, respectively. Integration of Th with the burial and thermal history of the conclusion that fractures in the La Luna Fm. formed under near-lithostatic F P conditions in in the presence of a G-charged oil. Th values from fractures in the Cogollo Gp. are higher than in the La Luna Fm. and become more variable with increasing depth below La Luna. We interpret those fractures to have formed under lower FP conditions and/or with a less G-charged oil than for La Luna. This interpretation of the distribution of paleo-FP is supported by the observation of modern inverted FP gradients between upper and lower Cogollo Gp. reservoirs. Thus late expulsion of a G-charged oil created near-lithostatic FP in the La Luna Fm. source rock, and those FP bled downward through fractures into the adjoining reservoir rocks, contributing to the overpressures we observe today. (Authors' abstract)

See also adjacent item. (E.R.)

VROLIJK, P.J., POTTORF, R.J. and **MAZE, W.B.**, 1996b, Overpressure history of fractures, West Maracaibo Basin, Venezuela: American Assoc. of Petrol. Geologists Bulletin, v. 80, no. 8, p. 1344. First author at Exxon Production Research Company, Houston, TX, US.

Prediction of density of natural fractures in reservoir rocks requires evaluation of many factors, including the effective stress and thus FP conditions through time. In this study we use analyses of FI in calcite-filled fractures with burial and thermal history models to assess the FP history and the causes of overpressure in the West Maracaibo Basin. We analyzed abundant oil-filled and rare aq FI in calcite-filled fractures in the La Luna Fm. source rock and in the underlying Cogollo Gp. carbonate reservoir. Our analyses of FI Th and fluorescence properties lead us to the interpretation of near-lithostatic paleo-FP in La Luna Fm. and near-lithostatic to hydrostatic FP in the Cogollo Gp. fractures. Maturation and expulsion of oil from the La Luna Fm. source rock is required to generate the large inferred excess P as compaction disequilibrium and thermal expansion of pore F from rapid Miocene burial are insufficient to achieve near-lithostatic conditions. This hypothesis is supported by the observation of decreasing paleo- and modern FP with depth beneath the La Luna Fm. Thus based on the wide occurrence of oil-filled I in calcite-filled fractures and the high FP associated with trapped oils, we infer extensive rock fracture under overpressured conditions near maximum Miocene burial, during inferred late source rock yield, and during Miocene growth of structural traps. (Authors' abstract)

See also adjacent item. (E.R.)

WAGNER, C. DELOULE, E. and **MOKHTARI, A.**, 1996, Richterite-bearing peridotites and MARID-type I in lavas from northeastern Morocco; mineralogy and D/H isotopic studies: Contrib. to Mineral. and Petrol., v. 124, no. 3-4, p. 406-421.

Indexed under FI (E.R.)

WALLACE, Paul, ANDERSON, Alfred, LORENZ, David and **BROWN, Nathaniel,** 1996, Magma degassing at Kilauea volcano: constraints from H_2O contents of melt inclusions and scoria glasses (abst.): 1996 Fall Meeting American Geophysical Union, published as a supplement to Eos, Transactions, AGU v. 77, no. 46, p. F807, November 12, 1996. First author at Ocean Drilling Program and Dept. of Geol. and Geophysics, Texas A&M Univ., College Station, TX 77845.

Degassing at Kilauea volcano is inferred to occur in two stages that are related to subsurface storage and transport of magma (Gerlach and Graeber, 1985, *Nature*). To understand degassing processes in greater detail, we have used IR spectroscopy to analyze dissolved water contents of MI and co-erupted scoria glasses from (1) the 1959 Kilauea Iki picrite, (2) the 1984 East Rift Zone (ERZ) eruption, (3) the 1919 summit lava lake, and (4) the 1919 eruption of Mauna Iki on the SW Rift Zone. For the 1959 Kilauea Iki picrite, MI in olivine from the first eruptive episode, before lava lake magma drained back into the vent, have an average H_2O content of 0.7 ± 0.2 wt.% (this study; Anderson and Brown, 1993, *Am. Min.*). In contrast, the water contents of MI from summit-differentiated magmas erupted in 1919 and 1984 are much lower. I from the 1984 ERZ eruption have H_2O contents of 0.10 to 0.28 wt.%. The two analyzed MI from the summit eruption of 1919 contain only 0.1 wt.% H_2O, comparable to the water contents of glassy fountain spatter. Similarly low water contents were also found in the two MI that we analyzed from the 1919 Mauna Iki eruption, which was fed by magma draining along the SW Rift Zone from the summit lava lake. Such low values require that prior to crystallization, degassing occurred at P substantially less than those in Kilauea's summit magma reservoir. We interpret the low H_2O contents in these MI as evidence that olivine phenocrysts crystallized from surface degassed magma that had drained back down the vent, and in the case of the 1984 ERZ eruption, had partially remixed with less degasssed magma at depth. Such a process was postulated by Dixon et al. (1991, J. *Geol.*) to explain volatile contents of submarine lavas on the ERZ. Many I from the later eruptive episodes of Kilauea Iki have H_2O contents that are lower than those from the first episode, consistent with mixing between surface dgassed and undegassed magma prior to crystallization. These data demonstrate that degassing and shallow-level crystallization at Kilauea are complex processes in which drainback of surface degassed magma plays a major role. (Authors' abstract)

WALSHE, J.L., HALLEY, S.W., ANDERSON, J.A. and **HARROLD, B.P.,** 1996, The interplay of groundwater and magmatic fluids in the formation of the cassiterite-sulfide deposits of western Tasmania: Ore Geology Reviews, v. 10, p. 367-387. First author at CSIRO Div. of Exploration and Mining, c/o Div. of Information Tech., GPO Box 664, Canberra, ACT 2601, Australia.

The cassiterite-sulfide deposits of western Tasmania are spatially and temporally related to Devonian granitoids. The stable isotope and FI data of these deposits are best explained by a genetic model in which Sn is leached from the granites by reduced, non-magmatic F mixed with late-stage magmatic F. These F mineralize the overlying dolomite horizons and subjacent faults by a combination of wallrock and boiling induced reactions. The model requires co-incidental release of volatiles and ingress of groundwaters to sustain the leach mechanism.

Sal of FI from the deposits show a restricted range (around 5 to 15 wt.% NaCl eq.). It is suggested that the wide range of sal in the granites is generated in the critical region of the NaCl-H_2O system at T around 400 to 500°C and pressures around 400 to 500 bars. The limited range of sal in the deposits reflects cooling to sub-critical conditions. Cooling through the critical region promotes homogenization of groundwater and magmatic V and brine. Condensation of magmatic volatiles within this zone of mixing maintains acidity and promotes F-rock reaction.

The geochemistry of the granites underlying the Renison Bell area is interpreted in terms of two granites. The geological relationships indicate the more mafic phase, the Renison Granite, was intruded by the more fractionated Pine Hill Granite. F from the Pine Hill Granite sericitised and tourmalinized both the Renison Granite and Pine Hill Granite along their mutual contact, generating a broad north-east trending zone of alteration. (From authors' abstract by E.R.)

WALTER, M.R. and **SWART, R.,** 1996, The Neoproterozoic to Cambrian Nama Basin, Southern Africa, and its petroleum prospectivity: Geological Soc. of Australia Abstracts, v. 41, p. 455.

Indexed under FI (E.R.)

WANG, Alian, PASTERIS, J.D., MEYER, H.O.A. and **DELE-DUBOI, M.L.,** 1996, Magnesite-bearing inclusion assemblage in natural diamond: Earth and Planetary Sci. Lett., v. 141, no. 1-4, p. 293-306. First author at Dept. of Earth and Planetary Sci., Washington Univ., St. Louis, MO 63130, USA.

The occurence of this syngenetic multiphase I assemblage in a natural diamond provides unambiguous evidence for the existence in the Earth's mantle of magnesite, which has been proposed as a major carbon reservoir in most of the mantle. (From author's abstract by E.R.)

WANG, Baoqing, 1996, The fluid-vapor inclusions of filling calcite cements in Ordivician paleokarst carbonate rocks on the eastern margin of Ordos Basin (abst.): 30th Int'l Geol. Cong., Abstracts, v. 3, p. 22. Author at Xi'an Petroleum Inst., P.P. China.

Ordovician Majiagou Formation on the eastern margin of Ordos Basin consists of dolostone and limestone, and is overlain pseudo conformably by Middle Carboniferous Benxi Formation. The carbonate rocks of the Majiagou Formation have been reformed by the karstification. During the karstification meteoric and subsurface water, which was unsaturated with carbonate, dissolved carbonate rocks, creating abundant solution pores, caves, fissures and fractures. The brecciation is common in the Majiagou

Formation. While dissolution occurs and creates or enlarge opening, precipitation happens in response to CO_2-degassing or evaporation in another place, producing filling calcite cements. The L-V I in filling calcite cements from 45 samples have been analyzed. The I are all large (3 to 40 µm) isolated P FI and two phase with 3 to 30% visually estimated V phase. 318 Ths and 83 final Tm have been obtained.

The Th range 52 to 289°C with a mean of 157°C. Above 80% Ths fall within 100 to 200°C. Above 80% filling calcite cements formed at 2154-5231 m depth, assuming a 3.25°C/100 m geothermal gradient and a surface T 30°C. This coincides with the regional tectonic history. Burial conditions benefit the formation of filling calcite cements. In general, Th of the I for early filling calcite cements are less than 150°C, while Ths of the I for late filling calcite cements are above 150°C.

The final Tm of FI range -11.3 to -0.5°C with a mean of -3.4°C, corresponding to sal ranging from 0.8 to 15.3 wt % NaCl with a mean of 5.4 wt % NaCl. The water, which precipitated filling calcite cements, originally was meteoric. Under burial conditions the water sal had been increased. (Author's abstract.)

WANG, Bixiang and **SHI, Rendeng**, 1996, The mineralization characteristics of gold deposits in volcanic areas of China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 650. Authors at Inst. of Geol., Beijing, China.

In the Babaoshan epithermal gold deposit in Zhejiang, the mechanism of gold deposit formation is as follows: the formation T are mainly 140-330°C, belonging to the intermediate to low range; the oxygen fugacity f_{o2} is low, about 10^{-38} - 10^{-41}; the ore-formng solutions is of the KCl-$NaCl$-$CaSO_4$-H_2O system; the sal is low, being 0.7-2.5 wt% eq. NaCl; the δD (‰) and $\delta^{18}O_{H_2O}$ (‰) of the FI are -58.5 to -91.1 and +3 to -9, respectively, indicating that the ore-forming solutions are composed of a mixture of meteoric water and magmatic hydrothermal F. To sum up, gold mineralization should be concentrated in areas where the stress field, energy field, thermal flow field, geochemical field and geophysical field coincide. (From authors' abstract by E.R.)

WANG, Haishan, 1996, Geological and geochemical characteristics of mineralization related to hot brine in Fengtai Pb-Zn orefield, Shaanxi, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 736. Author at NW. Nonfer. Geol. Inst. Xian, China.

According to the data of FI the range of ore forming T is 256-275°C, and sal of ore-forming F is 4.6 wt% NaCl. The F belongs to Ca^{2+}-Mg^{2+}-Na^+-Cl^--$SO_4{}^{2-}$-K^--F^- type with CO_2, CH_4 higher. The δD(-74.1 to -116.6‰), $\delta^{18}O$(-9.6 to -15.3‰). These indicate the mineralization is of hydrothermal type of the meteoric water in the Mesozoic Era The meteoric water has been transformed into the hot brine of oilfield type through underground circulation and heated by magmatism in the neighbouring area. (From author's abstract by E.R.)

WANG, Jiyang, 1996, Low-medium termperature geothermal system of convective type: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 96-103. Author at Inst. of Geol., Academia Sinica, Beijing 100029.

Low-medium T geothermal systems of convective type are widely distributed in nature and in China. This sort of geothermal system is of significant importance in understanding tectonic activity, the formation and distribution of geothermal resources, as well as the water-rock interaction and the concentration of ore-forming elements in the study region. In this paper, the characteristics and genesis model of these geothermal systems, the distribution of the system and case history from Zhangzhou area. Fujian Province of SE China are given briefly. (Author's abstract).

WANG, Linjiang, 1994, The genesis of the Muli antimony deposit, Yunnan: J. of Guilin College of Geol. (Guilin Yejin Dizhi Xueyuan Xuebo), v. 14, no. 4, p. 350-354. Author at Dept. of Resource Engineering, Guilin Inst. of Tech.

Silicalite is the host rock of the Muli Sb deposit. Ore bodies and silicalite are of the same occurrence. The silicalite is rich in SiO_2, Fe, Mn, and K_2O, but poor in Na_2O and Al_2O_3. The composition of Pb isotope is stable with mostly lead from the earth crust. The characteristic of REE ore-bearing silicalite is LREE-rich type. The anomaly parameters of Eu and Ce are weak-depleted. The total amounts of REE are relatively low. There are many syndiagenesis fabrics in the ores. It is believed that the silicalite and antimony ores are formed as a result of hydrothermal-sedimentation and reformation by later tectonic processes. (Author's abstract)

Presents G ratio and Th data for FI. (H.E.B.).

WANG, Liping, ZHANG, Youxue and **ESSENE, E.J.,** 1996, Diffusion of the hydrous component in pyrope: American Mineralogist, v. 81, p. 706-718. Dept. of Geological Sci., Univ. of Michigan, Ann Arbor, Michigan 48109-1063, U.S.A.

Dehydrogenation experiments have been performed on natural pyrope megacrysts ($Py_{70}Alm_{16}Gr_{14}$) containing 22-112 ppm total H_2O by weight (H/Si is from 0.00035 to 0.0018).

The diffusion-out diffusivities of the hydrous component are seven to eight orders of magnitude greater than the Fe-Mg interdiffusivities. They are so large that the OH content of a pyrope crystal can adjust to changing environmental conditions on a time scale of hours at T as low as 800°C. Pyrope crystals from the mantle may dehydrogenate during ascent. Caution should be exercised in using OH content in natural pyrope crystals to infer conditions of the source region. (From authors' abstract by E.R.)

WANG, Ruihu, 1996, Geological characters and genesis of the gold deposits in north Guangxi (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 743. Author at Guangxi Geol. Inst. for Nonferrous Met., CHN.

The north Guangxi gold-As-Ag deposits are situated in tuffaceous sandstone and hydrothermal deposition rocks, turbidite of Danzhou group. The wallrock alteration includes weak silicification, chloritization, calcitization and pyritization. Studies on the geological and geochemical features of ore deposits, fluid inclusions and isotopes indicate [this] ore is a geothermal water lixiviation gold deposit. The water source is made of meteoric water. The sulfur comes from the lower crust, carried by deep fractures to ore-forming hydrothermal solution mixed with a large amount of marine forming sulfates or deposition sulfides. The ore-forming F that is dilute solution of K^+-Na^+-Ca^{2+}-$SO_4{}^{2-}$-H_2O belongs to low sal, low density F. Its average sal is 8.78 wt%, the density is 0.95 g/cm^3. The T of mineralization ranges mostly 130~230°C, the P of mineralization is approximately 230~700 [bar?]. (From authors' abstract by E.R.)

WANG, Lijuan, FANG, Nian and **JANG, Renyi,** 1996, The study of fluid inclusions from one gold deposit and the deep prospecting of its periphery mineral occurences in eastern Liaoning (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 654. Authors at Beijing Inst. of Geol. for Mineral Resources, Beijing, China.

Close-spaced foggy I groups, greyish-black in color and microcrystalline in shape, are often recognized in quartz from the Weizi gold deposit in eastern Liaoning. The I are rich in CO_2, and often contain $CaCl_2$ dm or organic matter. A number of F-melting I are discovered with clear boiling. The ore-forming T ranges from 300 to 380°C. The ore F is neutral, indicating a slightly reducing environment and generally belong to $CaCl_2$-CO_2-H_2O system. The sal calculated by the content of K^+ and Na^+ is from middle to lower. The FI have regular changement in characteristics from its top to bottom, from center to edge [and] from shoot to poor seat.

In the paper, the features and changed rule of FI in this gold deposit have been mainly studied for the 300 m elevation. This gold deposit is a remelted magmatic hydrothermal gold deposit genetically.

In addition, the mineralization have been predicted of deep seated quartz veins in the surrounding with the aid of special characteristic of the FI and other geological feature and then the best prospecting are outlined. (From authors' abstract by E.R.)

WANG, Ping'an, CHEN, Yuchuan and **WANG, Quanming**, 1996, Ore-forming conditions and genesis of the Laochang lead-zinc deposit, Northeastern Quangxi, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 633. Authors at Chinese Acad. of Geological Sci., Beijing, China.

The Laochang lead-zinc deposit is a giant vein deposit in the famous Nanling tectono-metallogenic zone, south China. The ore veins occur in about 15 extensional fractures and are characterized by brecciated structures. (2) This deposit has relatively simple mineralogy, with galena and sphalerite as the main ore minerals, accompanied by pyrite and/or marcasite. Barite and chalcopyrite appear in some districts. Galena is low in silver (mean 49.3 ppm) but high in Se/S ratio (mean 7.0 x 10^{-4}), sphalerite is high in cadmium (mean 8933 ppm) and copper (mean 299 ppm). The gangue minerals are mainly quartz, calcite, dolomite and/or ferrodolomite. (3) Studies of FI within quartz and sulfides have established several important facts: (a) mineralization T ranged from mainly 180°C to 370°C; (b) mineralization pressures ranged from 3.5 x 10^6 Pa to 5.1 x 10^7 Pa; (c) sal of the ore-forming F were comparatively low (mean 8.01 wt% NaCl); the estimated densities ranged from 0.84 g/cm^3 to 0.97g/cm^3, and the F were Na-K-Ca-Cl type. These features are similar to those of magmatic F; (d) H, O and C isotopes for H_2O and CO_2 in FI within quartz suggest a mixture of magmatic hydrothermal and geothermal F. (4) Sulfur isotopes from sulfides display granite magmatic values (∂^{34}S mainly from -2‰ to +6‰), whereas sulfur from barite is heavy (∂^{34}S = +19.8‰). (5) Pb isotopic composition for K-feldspar from the granite is consistent with those for sulfides in ores. (6) U - (Th) - Pb isotopic age provides a date of 268 Ma for a single zircon grain from the granite. Rb-Sr isochron age provides a date of 165 ± 5 Ma for the FI within quartz from the ore veins. So the deposit was formed in the Late Paleozoic associated genetically with granitic magmatism, and the process of hydrothermal circulation driven by the heat of the granite was important for the formation of this deposit. (From authors' abstract by E.R.)

WANG, Su, GREEN, H.W. II, and **DOBRZHINETSKAYA, Larissa,** 1996, Inclusions in olivine and garnet in the Alpe Arami peridotite massif, Switzerland (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 484. Authors at Inst. of Geophysics and Planetary Physics and Dept. of Earth Sci., Univ. of California, Riverside, CA 92521, USA.

Our previous work suggested that the Alpe Arami peridotite massif of the Swiss Alps may have come to the surface from greater depth than any other rock body currently known, conceivably from as deep as the mantle transition zone that lies between 400 and 670 km depth. The morphology of microscopic Ti, Fe oxides and spinel microscopic inclusions found in the first generation of olivine couples with an unexplained pattern of lattice [details of composition and crystallographic orientation are given (E.R.)] preferred orientation that is different from that displayed by any other peridotite and inconsistent with the crystal plasticity of olivine are suggestive of an unusually great depth of origin.

The garnets of the rock in question here also exhibit abundant I. We focused our TEM study on the multiphase I in the garnet. SAED analysis demonstrated that the multiphase I are composed of Ca-rich amphibole and enstatite-spinel symplectite. There is a narrow zone of transition between the Ca-rich amphibole and its neighbor enstatite located in the symplectite. However, there are questions unanswered. One question is where the water stored in amphibole came from. Did it come from outside of the massif, or stored in the original phase of the inclusions when they were at very high P? Another related question is what reaction was involved in formation of the multiphase I. (From authors' abstract, by E.R.)

WANG, Xianbin, LIU, Gang, CHEN, Jianfa, ZHANG, Chengjun and **XIA, Xinyu,** 1996, Fluid in the earth: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 105-118. Authors at Lanzhou Inst. of Geol., Chinese Acad. of Sci., Lanzhou, 730000.

[After a review of F in the earth], the research results discussed in this article mainly include: (1) the study of rare G isotopic geochemistry; (2) the study of G geochemistry in magmatic and volcanic activity; (3) the study of G geochemistry of modern tectonic and seismic activity; (4) the study of G geochemistry of mantle intrusion in basalt. (From authors' abstract by E.R.)

WANG, Yanxin, WEN, Dongguang, SHEN, Zhaoli and **ZHONG, Zuoxin,** 1996, Origin of deep groundwater and its ore-forming processes: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 274-281. First author at China Univ. of Geosci., Wuhan, 430074.

This paper shows how to determine the origin of groundwater by using the isotopic data of groundwater and G. Paleohydrogeological analysis of ore-forming processes and chemical features and origins of sedimentary basinal waters are also illustrated. (From authors' abstract by E.R.)

WANG, Yunshuen, SASAKI, Munetake, SASADA, Masakatsu and **CHEN, C.-H.,** 1996, Fluid inclusion studies of the Chinkuashih gold-copper deposits, northern Taiwan (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 144-145. First author at Central Geol. Survey, P.O. Box 968, Taipei, Taiwan; e-mail (rcjeng@ms2.hinet.net)

The Chinkuashih Au-Cu deposits include high-sulfidation types of the Penshan and Tsushihshan-Changjen groups, and low-sulfidation types of the Chiufen-Wutanshan group. FI data are as follows:

Group	Th °C	Sal %	Processes Evident
Penshan	162-298	0-8.14	Boiling and mixing
Tsushihshan-Changjen	196-267 307-484	0.88-4.96 30-59	Inclusions of brine
Chiufen	197-302	0.71-6.88	
Watanshan	231-280	0.71-3.55	

Quadrupole mass spectrometer analyses show CO_2 is 0.27 to 0.52 mol%, and minor CH_4, N_2 and SO_2 (in high sulfidation type). Gas chemistries reflected different F sources, and were also modified by deep rock interaction and shallow mixing. (From authors' abstract by E.R.)

WANG, Zhengrun, LUO, Xianchang, WU, Yanzhi and **YANG, Mu,** 1996, Mineralization and genesis of Xianghualing nonferrous rare-polymetal ore field, Hunan, China (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 631. Authors at Central South Univ. of Tech., Changsha, 410083, China.

Xianghualing ore field is related to granitic bodies rich in fluorine and ore-forming trace elements and considered as the main source of ore-forming material. The mineralization T ranges from 149 to 442°C, and the P from 292×10^5 Pa to 443×10^5 Pa, $\delta^{34}S$, -1.196‰ to +5.56‰. The isotopic Pb in ore is normal Pb and the Pb model age ranges from 66.5 Ma to 125 Ma. (From authors' abstract by E.R.)

WANG, Zhenzhong and **HOU, Wei,** 1996, Genetic mechanism and metallogenic model of Ag-Au deposit in the In Shanmen, Siping area, Jilin Province: Jilin Geol. (Jilin Dizhi), v. 15, no. 1, p. 1-11 (in Chinese; Engl. abst.). Authors at Jilin Inst. of Geol. Sci., Changchun 130012.

FI data are presented. (H.E.B.)

WANG, Zhinong, LI, Hui, and **YUAN, Yuexiao,** 1996, The ideal models about gaseous and ionic halos in inclusions of gold deposits (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2., p. 798. Authors at Geophysical Exploration Bureau of M.M.I., Baoding, Hebei, China.

In order to establish the marks and methods of predicting blind gold deposits by I geochemistry, we have systematically studied the vertical geochemical zones in more than 20 gold deposits. The result is that there are clear gaseous halos of CO_2, CH_4 (in G phase) and ionic halos of F^- and Cl^- (in L phase) in I of front of gold ore body, but the anomaly of Mg^{2+} and Ca^{2+} in I which exist both in the lower part and in the rear halo of gold ore body.

According to the characteristic of hydrothermal gold deposits which are formed from thermal Ly reiteration many times, we have summed up the models about gaseous and ionic halos in I of gold deposits. The models have four different forms. And we have established the marks which apply for predicting blind orebodies. When there is Au<0.n g/t in quartz vein and there appear the gaseous halos of CO_2, CH_4 and ionic halos of F^-, Cl^- in I, it indicates that a blind ore body exists at depth. If there is Au<0.n g/t in the quartz vein and there are ionic anomalies of Ca^{2+}, Mg^{2+}, then it indicates that there is no ore body at depth. If the gaseous anomaly of CO_2, CH_4, and ionic anomaly of F- and Cl- coexist which the ionic anomaly of Ca^{2+} and Mg^{2+}, then it indicates that a blind ore body exists at depth. By using the models about gaseous and ionic haloes in I of gold deposit, we have predicted blind ore bodies in eastern Shandong. And we have achieved good result (sic). (Author's abstract.)

WANG, Zongqi and **TANG, Yaoqing,** 1996, A new studying subject of tectonics–geofluid activities in orogenesis: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 131-137. Authors at Inst. of Geol., Chinese Acad. of Geol. Sci., Beijing 100037.

[These] problems [should] be studied: (1) what is the pattern of geofluid migration in orogenesis [and] can it be reconstructed, (2) what are the relationships between tectonic framework and districts of F activities of an orogen, (3) what are the links between characteristics of a geochemical field and the flow paths of geofluids, (4) how to distinguish what degree the geofluids influence the sedimentation, magmatism, metamorphism, metallogenesis, oil and G formation, structural deformation and terrain accretion during orogenesis, (5) what are the links between the analyses of the geofluid history and orogenesis process. (From authors' abstract by E.R.)

WATANABE, T. and **MATSUEDA, H.,** 1990, Rheology of metamorphic rocks and fluid inclusions: Gekkan Chikyu (Earth Sciences), v. 12, p. 597-601 (in Japanese; translation coutesy of T. Sawaki).

Phenomena of crustal flow are represented by fold structures of metamorphic rocks and intrusive structures of igneous rocks. In 1960's, experimental results showed that F phase plays an important role in crustal flow. Studies of Tt, chemical compositions and formation processes of FI hold critical keys to the important role of the F in crustal flow. (Authors' abstract)

WATANABE, Yasushi, AOKI, Masahiro and **NAKAJIMA, Nobuhisa,** 1996, Age and style of epithermal gold mineralization in the Minamikayabe area, southwestern Hokkaido: Resource Geol., v. 46, no. 6, p. 317-326. First author at Geol. Survey of Japan, Mineral Resources Dept., Higashi, 1-1-3, Tsukuba, 305 Japan.

Epithermal gold mineralization in the Minamikayabe area located on the Kameda peninsula, southwestern Hokkaido, includes the Mitsumoriyama high-sulfidation and Hokko-Minami low-sulfidation systems. The Mitsumoriyama high-sulfidation system consists of advanced argillic alteration which is subdivided into alunite and kaolinite zones. This advanced argillic alteration grades into propylitic alteration laterally, and with a sericite alteration overprint in, and near to the advanced artillic alteration. The Hokko-Minami low-sulfidation system consists of adularia-bearing quartz veins with adularia alteration envelopes. K-Ar ages of alunite, sericite and adularia indicate that the Mitsumoriyama high-sulfidation system was formed at approximately 6.5 Ma, and that the sericite alteration followed on from the advanced argillic alteration at 6.0 Ma, possibly due to an evolving hydrothermal system caused by an intrusion of quartz porphyry beneath the advanced argillic alteration zone. The Hokko-Minami low-sulfidation quartz veins formed at 3.9 Ma, which suggests no direct, genetic relation with the Mitsumoriyama high-sulfidation system. The high- and low-sulfidation epithermal systems in the Minamikiayabe area occurred during periods of normal and oblique subduction of the Pacific plate beneath the northeast Japan arc, respectively. Thus, the change in style of the epithermal gold mineralization in the Minamikayabe area from high-sulfidation to low-sulfidation may have been related to a change in the subduction mode of the Pacific plate. (Authors' abstract)

Th of FI in quartz from a quartz veinlet exposed at the surface vary from 240°C to 290°C (Aoki and Watanabe, 1995). [This is an internal report, in Japanese] (From authors' abstract by E.R.)

WATKINSON, D.H. and **JONES, P.C.,** 1996, Platinum-group minerals in fluid inclusions from the Marathon deposit, Coldwell Complex, Canada: Mineral. and Petrol., v. 57, p. 91-96. Authors at Dept. of Earth Sci., Ottawa-Carleton Geosci. Centre, Carleton Univ., Ottaway, Canada.

Platinum-group minerals (PGM) project into FI that occur in chalcopyrite and cubanite from the Marathon deposit, Two Duck Lake gabbro, Coldwell Complex, Ontario. Semi-quantitative analyses of the micron-sized PGM were made by SEM-EDS; they reveal Ag-bearing intermetallic compounds of Pd_3Sn-Pd_3Pb-Pd_3Te (i.e., atokite-zvyagintsevite-keithconnite) and telargpalite (Pd_2AgTe) on broken, irregular surfaces of the Cu-Fe-S minerals. Halite dm and quenched brine occur in and around some opened FI. These data confirm the hypothesis based on petrography and mineral compositions that sal F remobilized PGE, Cu, and other elements and precipitated them well after crystallization of sulfide and silicate magmas in the Marathon deposit. (Authors' abstract)

WATKINSON, D.H. and **MOLNAR, Ferenc,** 1996, Remobilization of platinum-group elements by saline fluid: Evidence from fluid-incusion studies at the Lindsley Mine, Sudbury, Ontario (abst.): Geol. Soc. Canada/Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A101. First author at Dept. of Earth Sci., Ottawa-Carleton Geosci. Centre, Carleton Univ., Ottawa, K1S 5B6.

The Lindsley 4B ore deposit, South Range, Sudbury, occurs in "Sudbury-Brecciated" granite and is relatively enriched in Cu, Ni and the precious metals. Ore-body contacts with metasomatized and quartz-veined granite reveal that at least four different kinds of F occur as I in quartz, feldspar and sulfides. Early F were trapped in feldspar at T of at least 320-380°C, and overgrown quartz contains F trapped in the range 120-270°C. Both F were extremely saline solutions; freezing was difficult with some I freezing only below –70°C and with common metastable behaviour. Some early polyphase I contain crystals of NaCl, $CaCl_2$, KCl, Mn-Fe hydroxychlorides, $BaCl_2$, $PbCl_2$ and other accidential minerals as revealed by SEM-EDS. Later F were CO_2-bearing and are clearly in S structures.

At Lindsley, sulfide magma is interpreted to have segregated from silicate magma, and migrated into brecciated footwall rocks; heated saline F from basement rocks reacted with the crystallized igneous material and breccia, remobilizing base and precious metals. Precipita-tion in veins at intermediate T and zone refining of lithified sulfide accumulations, produced footwall ores enriched, especially, in Cu, Au, Ag and PGE. (Authors' abstract)

WAYNE, D.M., MILLER, M.F., SCRIVENER, R.C. and **BANKS, D.A.,** 1996, U-Pb and Rb-Sr isotopic systematics of fluids associated with mineralization of the Dartmoor granite, southwest England: Geoch. Cosmo. Acta, v. 60, no. 4, p. 653-666. First author from Dept. of Earth Sci., Univ. of Leeds, Leeds LS2, 9JT, UK.

Quartz veins from early hydrothermal mineralization within the 280 Ma Dartmoor granite contain abundant FI, which were sampled using crush-leach techniques and analyzed for Rb, Sr, U, and Pb content and isotopic ratios. The present-day lead isotopic signature of some of the crush-leach F is similar to that of granitic alkali feldspars from Dartmoor and other localities in southwest England, although some F samples contain a more radiogenic Pb component. The more radiogenic F fell into, or near, the granitic K-feldspar field upon correction of the present-day F Pb ratios for in situ U decay over ca. 280 Ma, but the lead isotope ratios of the less-radiogenic F became significantly lower than that of the granitic K-feldspars. The apparent overcorrection may be real, or may reflect either F mixing due to leaching of secondary FI, differential leaching of U and Pb, the presence of an undetermined U-rich included phase (or fracture-filling) within the quartz, or a combination of the above. The variation of F U/Pb ratios also suggests some complications regarding either the selective retention of U and Pb on quartz surfaces, or the presence of submicroscopic U-rich I. Therefore, we suggest that in situ decay corrections to lead isotopic data contained using crush-leach techniques be applied with great caution.

The F $^{87}Rb/^{86}Sr$ values vary little (1.40-1.74), as do their present-day strontium isotope signatures ($^{87}Sr/^{86}Sr$ = 0.71814-0.71968). When corrected for in situ ^{87}Rb decay over 280 Ma, the F contain significant excess radiogenic Sr (Sr_i = 0.7118-0.7141), relative to the Dartmoor granite Sr_i (=0.7101). If the Sr in the F is derived exclusively from the granite, or some granite-related source, and closed-system evolution of the Rb-Sr isotopic system is assumed, the amount of excess ^{87}Sr is a function of the time difference between Sr closure in the granite and Sr closure in the vein. Age estimates from the intersection of granite and FI Sr evolution curves are in agreement with published ^{40}Ar-^{39}Ar ages of late dikes and sericitic alteration at Birch Tor-Vitifer. Our results further suggest that the F related to quartz-tourmaline-cassiterite mineralization within the Dartmoor granite are themselves related to granite-derived, late-stage aplitic M. (Authors' abstract)

WEBSTER, J.D., BURT, D.M., and **AGUILLON, R.A.,** 1996, Volatile and lithophile trace-element geochemistry of Mexican tin rhyolite magmas deduced from melt inclusions: Geoch. Cosmo. Acta, v. 60, no. 17, p. 3267-3283. First author at Dept. of Earth and Planetary Sci., American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024-5192, USA.

We have investigated the petrology and geochemistry of whole rocks from two small-volume, Sn- and F-mineralized rhyolitic dome complexes of the Mexican tin rhyolite belt, Cerro el Lobo and Cerro el Pajaro,to determine volcanic degassing and mineralizing processes in felsic igneous systems. The abundance and distribution of volatiles (H_2O, B, F, and Cl) and lithophile trace and ore elements (Li, Rb, Cs, Be, Sr, Y, Ce, Th, U, Nb, Sn,and Mo) in the parental L were established by analyzing MI in quartz.

The MI from both rhyolites are variably enriched in Li and the volatile constituents F and Cl, and some are extremely enriched in Li, although whole rocks are not correspondingly enriched. Compositional variations in the MI from both rhyolites also constrain magmatic differentiation. M evolution was dominated by crystal fractionation, modified by mass transport in a Cl- and H_2O-rich magmatic-hydrothermal F, and resulted in increasing abundances of U, Nb, and Cs (±Li, F, Cl, B, Y, Ce, Be, Rb, Mo, and Sn) in both L. The rhyolite L apparently were heterogeneous prior to eruption. The Cerro el Lobo L contained gradients in volatiles and trace elements: comparatively less Cl, Be, B, Al_2O_3, and CaO (±Li, F, U, and Th) were present in the early-erupted, H_2O-rich fractions of L.

Comparing compositions of whole rocks with the mean compositions of MI constrains relative mobilities of magmatic constituents during and after eruption. Sodium, fluorine, lithium, uranium, and yttrium ($\pm H_2O$, Cl, Sn) were lost from both magmas and the Cerro el Pajaro magma apparently also lost Nb and Al as a result of eruptive and posteruptive degassing.

These geochemical relationships and constraints on preeruptive abundances and distributions of volatiles in tin rhyolite magmas probably apply to other tin rhyolites and, moreover, the high levels of Cl and Li enrichment may be representative of other highly-evolved granitic magmas genetically associated with lithophile mineralization. (Authors' abstract)

WEBSTER, J.D., THOMAS, Rainer, RHEDE, Dieter, FÖRSTER, H.-J. and **SELTMANN, Reimar,** 1996, Extreme tin and volatile enrichments in strongly peraluminous granite magma of the Erzgebirge, Germany: Evidence in melt inclusions for cassiterite saturation in granite liquid (abst.): Geol. Soc. Canada/ Mineral Assoc. Canada Joint Annual meeting, 27-29 May, 1996, Abstract volume, v. 21, p. A101. First author at Dept. of Earth and Planetary Sci., AMNH, Central Park West at 79th St., NY, NY 100024-5192.

We have found that the highly evolved granitic and pegmatitic M of the Sn and W deposit at Ehrenfriedersdorf in the Central Erzgebirge (SE Germany) are characterized by extreme enrichments in F, P, and up to 1200 ppm Sn. These high levels of Sn abundance are consistent with experimentally-determined Sn solubilities in cassiterite-saturated granitic L. To the best of our knowledge, this is the most unequivocal geologic evidence indicating that cassiterite may crystallize directly from some granite magmas.

The MI are contained in pegmatitic and granitic quartz, topaz, and also in triplite collected from the granite cupola that overlies the source granite and underlies granite-derived vein greisens with quartz, cassiterite, and wolframite. The MI (up to 50 microns in diameter) are crystallized and comprised of silicate and other minerals and shrinkage/V bubbles. Frequently, we have found dxl of cassiterite and topaz. The I were remelted in the host quartz at 600 to 1000°C for 20 hours before analysis; some I still contain small crystals of cassiterite and topaz after remelting and quenching.

The compositions of the glass I were determined by electron and ion microprobe analysis, and the results imply that some fractions of the parent L reached exteme levels of chemical differentiation relative to whole-rock compositions. Some I show evidence for L immiscibility (coexisting silicate and F- and P-rich L). The evolved silicate L contained abnormally low concentrations of Ca, Sr, and LREE but exceedingly high abundances of Sn, F, P, Li, Rb, Cs, and Be. The Sn concentrations determined by ion microprobe range from 80 to 1200 ppm-elemental (electron microprobe analyses show similar results). This implies that cassiterite may well have precipitated directly from the evolved L and also is consistent with the presence of cassiterite crystals within the MI and with Th (up to 600°C) of FI in quartz, cassiterite, topaz, and triplite. (Authors' abstract)

WEDEKIND, M.R., 1990, Geology and geochemistry of the Warrego Au-Cu-Bi mine, Tennant Creek, Northern Territory, Australia: Doctor of Philosophy thesis, Univ. of Tasmania, 379 pp.

FI evidence in mineralised ironstone lodes consistently indicates phase separation occurred with economic mineralisation, and a model whereby P release associated with fracturing of the ironstone lode has resulted in destabilisation of metal complexes in solution to promote their rapid deposition is preferred. (From author's abstract by E.R.)

WEEDMAN, S.D., BRANTLEY, S.L., SHIRAKI, Ryoji and **POULSON, S.R.,** 1996, Diagenesis, compaction, and fluid chemistry modeling of a sandstone near a pressure seal: Lower Tuscaloosa formation, Gulf Coast: AAPG Bull., v. 80, no. 7, p. 1045-1064. First author at Dept. of Geosci., Pennsylvania State Univ., University Park, Pennsylvania 16802.

Petrographic, isotopic, and FI evidence from normally and overpressured sandstones of the lower Tuscaloosa Formation (Upper Cretaceous) in the Gulf Coast documents quartz-overgrowth precipitation at 90°C or less, calcite cement precipitation at approximately 100°C and 135°C, and prismatic quartz cement precipitation at about 125°C. Textural evidence suggests that carbonate cement dissolution occurred before the second phases of calcite and quartz precipitation, and was followed by precipitation of grain-rimming chlorite and pore-filling kaolinite. Geochemical calculations demonstrate that present-day lower Tuscaloosa Formation water from 5500 m depth could either dissolve or precipitate calcite cements in model simulations of upward water flow. Calcite dissolution or precipitation depends on P_{CO_2} variability with depth (i.e., whether there is one or two-phase flow) or on the rate of generation of CO_2 with depth. Calculations suggest that 10^5-10^6 rock volumes of water are required to flow through the section to precipitate 1-10% calcite cement.

Compaction analysis suggests that late-stage compaction occurred in normally pressured sandstones after dissolution of carbonate cements, but was hindered in overpressured sandstones despite the presence of high porosity. These results document the inhibition of compaction by overpressured F and constrain the timing of P seal formation. Modeling results demonstrate that the proposed paragenesis used to constrain timing of P seal formation is feasible, and that most of the cement diagenesis occurred before the P seal became effective as a permeability barrier. (Authors' abstract)

WEI, Changshan and **ZHAI, Yusheng,** 1996, Fluid inclusion plane method--a method for time/space reconstruction of palaeostructural stress field and palaeofluid migration field: Geological Sci. and Tech. Information (Dizhi Keji Qingbao), v. 15, no. 3, p. 81-85 (in Chinese; Engl. abst.). Authors at China Univ. of Geosci., Beijing, 100083.

This paper presents a new method (FIP--FI plane method) for quantitative time/space reconstruction on palaeostructural stress field and palaeofluid migration field, and describes the research contents and the steps of this method. It is shown that the study of FIP has been applied successfully to many research fields of geoscience such as tectonics, magmatites, ore deposits, sedimentary basins and geothermal system, etc., in which quartz is investigated. (Authors' abstract)

WEI, Jiaxiu, 1996, Study of compositions of single-inclusions by Laser Raman microprobe and geochemistry of ore-forming fluid (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 487. Author at Inst. of Mineral Deposits, C.A.G.S., Beijing, China, 100037.

FI in quartz, fluorite, calcite and sphalerite of the Dachang tin-polymetallic ore-deposit in Guangxi, the antimony-ore deposit of Bameng in Guizhou, and the copper-gold ore-deposit of Zijinshan in Fujian were studied by geochemistry, microthermometry and Raman spectroscopy.

The ore-forming of Bameng antimony-ore deposit [started in the] $NaCl-H_2O$ system, but evolved into the $NaCl-CO_2-H_2O$ system with larger amount of CO_2, along with decreasing T.

Fluid inclusions of Zijinshan copper-gold deposit contain a lot of S, plus K^+, Na^+, Cl^-, HS^-, H_2S and $SO_4{}^{2-}$. The early ore-forming fluid evolved to $CO_2-NaCl-H_2O-SO_4{}^{2-}$ system with increasing H_2O, CO_2 and $SO_4{}^{2-}$. As a result, acidity (pH values from 5.47 to 3.64), and oxygen fugacity increase, the forming T decrease from 300°C to 100°C, resulting in the formation of copper-gold deposit. (From author's abstract, by E.R.)

WEI, Jiaxiu and CHEN, Keqiao, 1996, Study on the fluid inclusion and genesis of Zijinshan copper-gold deposit (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 487. Authors at Inst. of Mineral Deposits, C.A.G.S. Beijing, 100037.

Zijinshan copper-gold epithermal deposit is closely related temporally and spatially to volcanic-intrusive activity. The sal and densities of the ore-forming F and metallogenic P have been obtained through measurements of the T, P and sal of the FI in mineral. The T of silicification are determined to be 420-100°C. The forming T range in 300-100°C; sal from 28.3 wt.% NaCl, through 7.6 wt.% NaCl and 3.3 wt.% NaCl to 0.1 wt.% NaCl, densities from 0.52-0.79 g/cm^3 to 0.97-1.10 g/cm^3; pH values are approximately 5.47-4.13-3.64.

By Laser-Raman microprobe analysis, the single inclusions contain K^+, Na^+, Cl^-, HS^-, HCO^{-3}, H_2O, CO_2, CH_2, H_2S and $SO_4{}^{2-}$ etc. The ore-forming F at early stage is $KCl-NaCl-H_2O-H_2S$ system enriched in K^+, Na^+, Cl^-, and H_2S, it evolved to $CO_2-NaCl-H_2O-SO_4{}^{2-}$ system at late stage with increasing H_2O, CO_2, $SO_4{}^{2-}$ with more acidity and higher, oxygen fugacity resulting in the formation of copper-gold deposit of Zijinshan.

Compared with other similar deposits, it belongs to quartz-alunite-dickite [type]. (From authors' abstract, by E.R.)

WEI, Jiaxiu and **HU, Xiaodie,** 1996, Study of compositions of single-inclusion analysed by laser Raman microprobe and evolution of ore-forming fluid in Zijinshan copper-gold deposit, China (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 62-63. First author at Inst. of Mineral Deposits, C.A.G.S., Tianjin, CHINA, 100037

The Zijinsham copper-gold deposit is hosted by the Yanshanian granite near a caldera. The country rocks have suffered sericitization, dickitization, alunitization, silification and pyritization.

The sal, densities and P of the ore-forming F have been obtained from FI. The T of silification are determined to be 420-100°C. The ore-forming T range in 300-100°C; sal from 28.3 through 7.6 eq. wt.% NaCl and 3.3 to 0.1 eq. wt.% NaCl, densities range from 0.52-0.79 g/cc to 0.97-1.10 g/cc; pH values are approximately 5.47-4.13-3.64.

Zijinshan FI contain much sulfur. The single-inclusions have K, Na, Cl, HS, H_2O, H_2S and $SO^{2-}{}_4$. The ore-forming F at the early stage is in the $KCl-NaCl-H_2O-H_2S$ system being enriched in K, Na, Cl and H_2S, and along with the decreasing ore-forming T, evolves to the $CO_2-NaCl-H_2O-SO^{2-}{}_4$ system at the late stage with increasing H_2O, CO_2 and $SO^{2-}{}_4$. As a result, acidity (pH values from 5.47 to 3.64), and oxygen fugacity increase, the forming T decrease from 300 to 100°C, resulting in the formation of copper-gold deposit. The data indicate that the Zijinshan copper-gold deposit is an epithermal deposit belonging to the quartz-alunite-dickite type. (From authors' abstract by E.R.)

WEI, Junhao and **LI, Jianwei,** 1996, The metallogenetic mechanism of Shuijinton gold deposit in Chongli, Hebei, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 779. Authors at China Univ. of Geosci., Wuhan, China.

Shuijintun gold deposit is located in high-grade amphibolite and granulite facies. The alterations related to mineralization concern K-feldsparization, silicification, pyritization, chloritization, sericitization and carbonatization. Component analysis of FI shows that H_2O possesses the highest content and the value of CO_2/H_2O is relatively low (0.1~0.12), which imply that ore-F was related mainly to metallogenic environment of reduction. Based on G and L components of FI and thermodynamic theories, some important parameters related to mineralizing process were calculated (T = 255-310°C, P = 340-520 bar, pH = 6.40-8.82, Eh=60.77--67.18 mv). It is thus evident that the mineralization occurred under neutral-partially alkalic condition. (From authors' abstract by E.R.)

WEN, Chunqi, QIN, Gongjiong, LIU, Wenzhou and **CAI, Jiaming,** 1996, Fluid inclusion in the Jinding superlarge lead-zinc deposit, Yunan, China (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 50-52. First author at Chendu Inst. of Tech., Chendu 610059, China.

The Jinding superlarge lead-zinc deposit occurs in clastic rocks.

FI in sphalerite, quartz, calcite, celestine and gypsum are mainly very small; they are mainly L, and secondly L-V with about 2-3% V.

Mineralization T based on Th range from 123 to 204°C, and Td from 155 to 342°C. P 230-330 × 0.1 MPa; sal 6.7-11.4%; and density 0.97 g/cm^3. Fugacity of CO_2, O_2 and S are estimated, also Eh and pH.

CO_2/H_2O ratios generally range from 0.024 to 0.160; Na/K ratios range from 2.06 to 13.247; F/Cl ratios are less than 1, average 0.355. (From authors' abstract by E.R.)

WEN, Ni, BOYCE, A.J., FALLICK, A.E., ASHWORTH, J.R. and **IXER, R.A.,** 1996, The genesis of Cu-bearing quartz veins by metamorphic remobilization from stratiform red bed deposits, SW County Cork, Ireland: Mineral. and Petrol., v. 57, p. 73-89. First author at School of Earth Sci., Univ. of Birmingham, East Kilbride, UK.

Polymetallic major veins of the West Carbery district (County Cork) are compared with the nearby stratiform-disseminated copper mineralization in metasedimentary rocks, containing minor veins (metamorphic quartz veins and veinlets). These stratiform deposits are hosted by non-marine Devonian sediments (Old Red Sandstone), metamorphosed in the Hercynian orogeny. In sulphides from the stratiform deposits and minor veins, isotopic compositions of sulphur ($\delta^{34}S$) range from -21.00 to +5.14‰, consistent with the vein sulphide being remobilized stratiform-disseminated sulphide, and the latter being of diagenetic bacteriogenic origin. Sulphate (barite), found in veins separate from the sulphides, has $\delta^{34}S$ +12.3 to +15.7‰ consistent with groundwater origin. In minor-vein quartz, FI have Th consistent with trapping under the estimated peak-metamorphic conditions (300-400°C, 1-3 kbar).

In the major veins, sulphide $\delta^{34}S$ (-15.8 to -4.2‰) suggest remobilization of diagenetic sulphide. Oxygen and hydrogen isotopes suggest deposition from metamorphic F (calculated $\delta^{18}O_{H_2O}$ approximately +8 to +13‰, measured range of δD -55.2 to -27.3‰. Immiscible CO_2-bearing F were trapped in the T range 280-350°C with F pressure <ca. 600 bar. The inferred P-T history is attributed to late-metamorphic uplift, with F P falling below lithostatic. The sulphide-bearing veins are interpreted as a small-scale example of redistribution of mineral deposits by metamorphic F. (Authors' abstract)

WENDT, A.S., 1993, The phyllite-quartzite unit (PQ): Structural evolution and fluid inclusion trails-constraints on the metamorphic history: 6th Congress of the Geol. Soc. of Greece with emphasis on the Geology of the Aegean, May 25-27, 1992, Athens, published in Bull. of the Geol. Soc. of Greece, v. 28, no. 3, p. 463-472. Author at Laboratoire de Geologie, E.N.S., 24, rue Lhomond, 75005 Paris, France.

In the Tertiary the Phyllite-Quartzite (PQ) Unit on Crete experienced high P/low T metamorphism. During uplift and cooling of rocks, progressive deformation caused formation of various structural elements. The oldest episode of the progressive deformation is characterized by plastic deformation mechanisms of HP-minerals such as carpholite and chloritoid. This deformation produced a flat dipping foliation, striking E-W, N-S trending intrafolial fold axes and N-S and E-W stretching lineations. Continuing deformation caused N-S and E-W trending fold axes, often with an axial plane cleavage. Related to the continuing uplift, at higher crustal levels the deformation generated a flat dipping fracture cleavage, striking roughly N-S, kinkbands, deformation lamellae and transgranular F trails, decorated by FI in quartz aggregates. The transgranular F trails and the deformation lamellae strike in N-S direction. The investigated FI along the deformation lamellae and along the transgranular trails contain a brine, whose composition corresponds approximately to the systems H_2O-$NaCl$-$CaCl_2$ and H_2O-$NaCl$-$MgCl_2/FeCl_2$ (density = 0.8 $g{\bullet}cm^{-3}$, based on microthermometric analysis). The Tt of these I is between 130°C and 250°C. During the development of these deformational processes the dominant deformation mechanism was P solution of quartz.

All features were mainly caused by E-W extensional tectonics. Deformation took place in the flattening field with an elongation between 40% to 60%. The latest, Quarternary deformation took place at a shallow crustal level and caused normal faults and joints, striking N-S and E-W. (Author's abstract)

WESTRA, Gerhard and **RIEDELL, K.B.,** 1995, Geology of the Mount Hope stockwork molybdenum deposit, Eureka County, Nevada (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A78-A79. First author at Exxon Exploration Co., Houston, TX.

Early barren veins and the main quartz-molybdenite vein stage are characterized by highly saline NaCl-KCl-brine I that homogenize at 174-483°C and show evidence for boiling. Minimum depth of formation is estimated at 500-1,000 m. Later, relatively molybdenum-poor "blue quartz" veins contain only L-rich I. Late veins are comprised of quartz, sericite, chlorite, and pyrite, with magnetite and biotite present at greater depth. L-rich low sal FI are the only I present. The hydrothermal event ended with the formation of barren pyrite, clay, or carbonate seams and fracture coatings.

Mineralization is spatially and temporally associated with three of the six intrusive quartz porphyry phases of the complex. The geometry of known molybdenum zones is best explained by assuming two partially overlapping, molybdenum-bearing hydrothermal systems lying side by side. Each system consists of two stacked shells with the shallower shells of higher grade. The shallower molybdenum shells lie 150 to 500 m symmetrically above the upper contact of aplitic quartz porphyry. Deeper zones of molybdenum mineralization cap granite porphyry 0 to 200 m above its upper contact. The Mount Hope molybdenum deposit shows many similarities with known Climax-type molybdenum deposits. (From authors' abstract by H.E.B.)

WESTRA, Gerhard and **RIEDELL, K.B.,** 1996, Geology of the Mount Hope stockwork molybdenum deposit, Eureka County, Nevada, *in* Coyner, A.R., and Fahey, P.L., eds., Geology and Ore Deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 1639-1666. First author at Exxon Coal and Minerals Co., 2401 S. Gessner, Houston, TX 77063.

Mineralization is spatially and temporally related to the ~38-Ma Mount Hope igneous complex, a small center of high-silica rhyolite composition.

The hydrothermal system shows well-defined alteration and metal zoning patterns with, from periphery to core, weak argillic-propylitic, argillic, potassic-phyllic, potassic, high-silica, and biotite alteration zones. Molybdenum and fluorine contents rapidly increase toward the potassic zone.

Early barren veins and the main quartz-molybdenite vein stage are characterized by highly saline NaCl-KCl brine I that homogenize at 174-483°C and show evidence for boiling. Minimum depth of formation is estimated at 500-100 m. Later, relatively molybdenum-poor "blue quartz" veins contain only L-rich I. Late veins are comprised of quartz, sericite, chlorite, and pyrite, with magnetite and biotite present at greater depth. L-rich low sal FI are the only I present. The hydrothermal event ended with deposition of pyrite, clay, or carbonate in seams and fracture coatings. The deposit shows many similarities with known Climax-type molybdenum deposits. (From authors' abstract by E.R.)

WHITNEY, D.L., 1996, Garnets as open systems during regional metamorphism: Geology (Boulder), v. 24, no. 2, p. 147-150. Author at Univ. of North Carolina, Dept. of Geol., Chapel Hill, NC, U.S.

If a garnet fractures during metamorphism, its interior will be in chemical communication with matrix phases (solids and F) and may participate in late prograde or retrograde metamorphic reactions. The results of petrologic techniques such as thermobarometry, P-T path calculations, and geochronometry may be misinterpreted if sites of garnet and mineral-I compositional modification are not identified. (From author's abstract by E.R.)

WHITNEY, D.L., MECHUM, T.A., DILEK, Yildirim and **KUEHNER, S.M.,** 1996, Modification of garnet by fluid infiltration during regional metamorphism in garnet through sillimanite-zone rocks, Dutchess County, New York: American Mineralogist, v. 81, p. 696-705. First author at Dept. of Geol., Univ. of North Carolina, Chapel Hill, NC 27599, USA.

Metapelitic rocks from a progressive metamorphic sequence in Dutchess County, New York, record evidence for reaction between garnet and F associated with quartz (±plagioclase) veins and for net transfer among garnet interiors, mineral I, and F. Garnet-F reaction resulted in modification of preexisting garnet textures, compositions, and growth-zoning patterns.

The textural and compositional record of garnet-F interaction varies with grade and with proximity of garnet to quartz veins. Garnet-zone rocks do not contain evidence for extensive reaction with vein-forming F. In upper staurolite- and kyanite-zone rocks, garnet that is crosscut by quartz veins contains a FI-filled region near the garnet-vein interface. This region truncates growth-zoning patterns and quartz I. FI in garnet decrease in abundance away from quartz veins. In some rocks lacking quartz veins, FI are concentrated in garnet interiors, and in particular near fractures, and are notably lacking around mineral I in garnet.

Inferences from textural and compositional features combined with a thermobarometric results indicate that preexisting garnet grains were modified at T ≈ 525-550°C and >4 kbar by one or more reactions involving F. The F pathways included foliation-parallel channels in the rock as well as microcracks in mineral grains. (Authors' abstract)

WHITNEY, D.L., MECHUM, T.A., KUEHNER, S.M. and **DILEK, Y.R.,** 1996, Progressive metamorphism of pelitic rocks from protolith to granulite facies, Dutchess County, New York, USA; constraints on the timing of fluid infiltration during regional metamorphism: J. of Metamorphic Geol., v. 14, no. 2, p. 163-181.

Indexed under FI. (E.R.)

WILHELMS, A., HORSTAD, I. and **KARLSEN, D.,** 1996, Sequential extraction; a useful tool for reservoir geochemistry?: Organic Geochem., v. 24, no. 12, p. 1157-1172.

Indexed under FI (E.R.)

WILKINSON, J.J., 1996, Faulting, fluid pressure fluctuations and gold mineralization at the Croagh Patrick quartz-gold vein deposit, County Mayo, Ireland (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A152. Author at Dept. of Geol., Imperial College of Sci., Tech, and Medicine, Prince Consort Rd., London SW7 2BP, U.K.; (e-mail j.wilkinson@ic.ac.uk)

The mesothermal quartz-gold vein system at Croagh Patrick, County Mayo, western Ireland, is hosted by greenschist facies Silurian quartzites which uncomfortably overly imbricated ultramafic rocks and slates. The deposit was developed during late Caledonian (Lower Devonian) sinistral transpression across a major crustal transcurrent fault, the Clew Bay-Fair Head line, an extension of the Highland Boundary Fault in Scotland. Mineralized veins show variations in gold grade of 5 orders of magnitude (0.01-1000 pm) over several hundred metres of exposure. Detailed CL textural analysis and FI studies have shown that gold deposition was primarily due to phase separation of a typical H_2O - CO_2-low sal F at 320-240°C and 160-50 MPa at an estimated palaeodepth of 5 km. The variability in gold grade is intimately linked to temporal and spatial variations in the phase separation process which was controlled by F P fluctuations during fault-fracture propagation. Initially, during growth of small en echelon vein arrays, F P did not decrease sufficiently for phase separation to occur. Subsequently, during linking of the en-echelon arrays to form large oblique-tensile veins, P drops during vein growth were large enough for unmixing to occur resulting in the deposition of significant quantities of gold. A minimum'critical' vein length of 50 m is estimated to be necessary for high gold grades (in excess of 10 ppm) to be developed. Bonanza grades are located close to intersections of the large linking veins which represent zones of maximum dilation. This study confirms that significant F P fluctuations can occur during fault-vein growth and that these have a fundamental control on the localization of gold mineralization. (Author's abstract)

WILKINSON, J.J. and **JOHNSTON, J.D.,** 1996, Pressure fluctuations, phase separation, and gold precipitation during seismic fracture propagation: Geology (Boulder), v. 24, no. 5, p. 395-398. First author at Imperial College of Sci., Tech. and Medicine, Fluid Processes Research Group, London, UK.

Gold mineralization at Croagh Patrick, western Ireland, occurs in quartz veins associated with three synchronous oblique tensile shear systems. The veins evolved by progressive thickening of isolated, en echelon, lensoid tensile fractures that show a power-law relation between their length and thickness. A change in power-law exponent marks the linking of the en echelon arrays by large, oblique-tensile veins. FI data show that gold was deposited due to unmixing of an H_2O-CO_2-NaCl F at 320-240°C and 160-30 MPa primarily due to decreases in F P. Evidence for phase separation is only observed in the large linking veins and is abundant close to intersections of the vein arrays. These sites are where high gold grades occur. The distribution of gold is believed to reflect both spatial and temporal variations in F pressure fluctuation during seismic fracture propagation, controlled by the vein growth mechanism and zones of maximum dilation. (Authors' abstract)

WILKINSON, J.J., NOLAN, J. and **RANKIN. A.H.,** 1996, Silicothermal fluid: a novel medium for mass transport in the lithosphere: Geology, v. 24, no. 12, p. 1059-1062. First author at Fluid Processes Research Group, Dept. of Geol., Imperial College of Sci., Tech. and Medicine, London SW7 2BP, UK.

New experimental data from synthetic FI studies in the system K_2O-CO_2-SiO_2-H_2O (KCSH) show that a potassic, silica-rich (≈90 wt% SiO_2) F can coexist immiscibly with a supercritical, alkaline, aqueo-carbonic F and quartz from T as low as 300°C to more than 750°C at relatively low geologic P (<200 MPa). This type of F phase may form in a range of geologic environments, including carbonatite complexes, alkaline subvolcanic-plutonic systems, and subduction zones. With a probable polymerized (silica-rich, M-like) structure, such SiO_2-rich F, if they form in the lithosphere, are likely to be important in the mobilization and transport of silica and large ion lithophile elements (e.g., K, Cs, Ba) and metals of economic significant (e.g., Au, Ag, U). (Authors' abstract)

WILLIAMS, A.E., 1996, Mass spectrometric analysis of volatiles in fluid inclusions: aliquot calibration valve to simulate inclusion rupture: Chemical Geol., v. 131, p. 155-165. Author at Dept. of Geol. Sci. and Inst. of Geophys. and Planetary Physics, Univ. of California, Riverside, CA 92521, USA.

Analysis of nano- to picomole quantities of G released from microscopic FI in minerals can be critical in determining details of the physical and chemical conditions under which mineral deposits formed. Such analyses can routinely be performed using quadrupole mass spectrometry of volatiles released by I decrepitation as minerals are heated or crushed. However, steady-state calibration of mass spectrometric factors has proved inadequate to accurately quantify small amounts of I G mixtures analyzed under dynamic conditions. An on-line G aliquot valve mass spectrometer calibrating system has been developed, using adaptation of an high-P L chromatography valve. By rapidly discharging controlled aliquots of standard G or G mixtures, dynamic calibrations simulate nearly all analytical parameters that affect volatiles released during mechanical rupture of FI. Analytical sensitivity of the mass spectrometry system is non-linear in its dependence on partial pressure, an effect which could not be deduced using steady-state calibrations. After applying this additional correction, microsample measurements previously wildly in contrast with presumed trapping conditions now accurately reproduce F compositions known from geothermal well flow tests or bulk I analyses. (Author's abstract)

WILLIAMS, A.E. and **TAYLOR, M.C.**, 1996, Mass spectrometric identification of boric acid in fluid inclusions in pegmatite minerals: Geoch. Cosmo. Acta, v. 60, no. 18, p. 3435-3443. Authors at Dept. of Earth Sci. and Inst. of Geophys. and Planetary Physics, Univ. of California, Riverside, CA 92521, USA.

Direct, on-line mass spectrometric analyses were performed on volatiles released from microscopic FI in quartz, feldspar, and tourmaline from the miarolitic Belo Horizonte #1 pegmatite in the San Jacinto district, and Himalaya pegmatite dike system in the Mesa Grande district of southern California. These analyses are the first I volatile studies to indicate the presence of significant and variable concentrations of B compounds in pegmatite formation F. Boron appears as boric acid $B(OH)_3$, which is found at levels ranging from less than detection limit ($<10^{-7}$ mole fraction) to as high as 10^{-4} mole fraction. High B concentrations are seen in IF from miarolite filling quartz, cleavelandite variety albite feldspar, and schorl tourmaline from the Belo Horizonte #1, while negligible amounts appear in late-stage green/pink-zoned gem elbaite tourmalines from that mine. FI in quartz, as well as grey and pink tourmaline from the miarolites in the Himalaya mine, have undetectable levels of B compounds. In addition to confirming the presence of very high boric acid concentrations in some pegmatite forming solutions, observations of large variations in abundance may provide new constraints on F chemical evolution trends during the genesis of these regionally and paragenetically complex gem deposits. (Authors' abstract)

WILLIAMS, L.B., HERVIG, R.L. and **BJØRLYKKE, K.**, 1996, The origin of quartz cements in hydrocarbon reservoirs, offshore Norway: Evidence from O-isotope microanalyses (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A340. First author at Dept. Geol., Center for Solid State Sci., Arizona State Univ., Tempe, AZ 85287, USA; e-mail (Lynda.Williams@asu.edu)

Oxygen isotope ratios were measured by S ion mass spectrometry on a Cameca IMS 3f. Analytical spots average 10 µm and allowed 20 microanalyses in a large quartz overgrowth. FI in the quartz cement record T of cementation, therefore the isotopic data can be interpreted to identify the isotopic composition of the paleofluid present during quartz precipitation. Textural and petrographic relationships among minerals, together with the isotopic constraints, help to limit variables in diagenetic reaction progress and deduce silica sources. The results indicate that quartz first precipitated from meteoric waters (–10 to –5‰ $\delta^{18}O$) at $T < 80°C$. FI data suggests that most quartz precipitated at T between 100-130°C, which is consistent with precipitation of 13-19‰ quartz from meteoric waters that gradually increased in $\delta^{18}O$ from –5 to 0‰. The latest quartz (23‰) comprises < 5% of the total quartz cement and precipitated in the last 5 Ma at T up to 150°C from +2 to +5‰ water. There is no evidence for episodic cementation from upwelling, hot basinal F. Quartz cements precipitated gradually over a long period of burial from diagenetically buffered waters. (From authors' abstract by E.R.)

WILSON, M.R., KYSER, T.K. and **FAGAN, Roxane**, 1996, Sulfur isotope systematics and platinum group element behavior in REE-enriched metasomatic fluids: a study of mantle xenoliths from Dish Hill, California, USA: Geoch. Cosmo. Acta, V. 60, no. 11, p. 1933-1942. First author at Dept. of Earth Sci., Memorial Univ., St.John's, Newfoundland A1B 3X5, Canada.

The sulfur isotopic compositions, trace and rare earth element (REE), and platinum group element (PGE) contents were determined for a suite of anhydrous spinel lherzolite xenoliths and their metasomatized equivalents from Dish Hill, California, USA, to evaluate the mobility of these elements in metasomatic F. Anhydrous xenoliths have REE patterns that vary from being slightly LREE-depleted to flat, as well as variable enrichments of LILE (Ba and Sr) and HFSE (Th and Nb) that indicate they were affected by cryptic metasomatism. The formation of amphibole in xenoliths (modal metasomatism) is accompanied by pronounced enrichments in HFSEs and REEs, particularly LREEs. With the exception of a single xenolith with slightly elevated PGE contents, the metasomatic F did not produce any appreciable changes in the platinum group element (PGE) contents, suggesting these elements are relatively immobile under these mantle conditions. Typical concentrations of PGEs in xenoliths from Dish Hill are 0.8 ppb Os, 1 ppb Ir, 0.6 ppb Rh, 2.5 ppb Pt, 1.8 ppb Pd, and 1.7 ppb Au.

Modal metasomatism has resulted in a variable increase in sulfur content of the xenoliths, from a value of <10 ppm for anhydrous xenoliths, to between 25 and 120 ppm for amphibole-rich xenoliths. The $\delta^{34}S$ values of sulfides in anhydrous xenoliths from Dish Hill are near +7, which are unusually high for the mantle and indicate that the lithospheric mantle under California was most likely affected by subduction of crustal sulfur. Sulfides in amphibole-bearing xenoliths have variable but generally lower $\delta^{34}S$ values of 3 to 8.7, suggesting that some portion of the metasomatic sulfur was derived from an asthenospheric mantle source with a more primordial sulfur isotopic composition. (Authors' abstract)

WIRTH, Richard, 1996, Thin amorphous films (1-2 nm) at olivine grain boundaries in mantle xenoliths from San Carlos, Arizona: Contrib. Mineral. Petrol., v. 124, p. 44-54. Author at GeoForschungsZentrum Potsdam, D-14473 Potsdam, Germany.

Olivine grain boundaries and phase boundaries in xenoliths from San Carlos have been investigated by high-resolution transmission electron microscopy (HREM) and analytical electron microscopy (AEM). Thin amorphous intergranular layers with variable width (1-2 nm) were detected along olivine grain boundaries. It is concluded that grain boundary melting occurred at the interfaces due to decompression during uplift. The M wetted olivine grain boundaries as well as olivine-opx phase boundaries. The thin amorphous layers formed M microsystems. Mixing of M from different microsystems is suggested to occur in wider M films, M veins or M pockets thus creating a magmatic M that could be extracted from its source. (From author's abstract by E.R.)

WOLFE, R.C., 1994, The geology, paragenesis and alteration geochemistry of the Endeavour 48 Cu-Au porphyry, Goonumbla N.S.W.: Bachelor of Science thesis, Univ. of Tasmania, 102 pp and appendices.

The Endeavour 48 Cu-Au deposit is hosted by volcanics which are intruded by a weakly mineralised biotite - quartz monzonite (BQM) at depth. Four major stages of hydrothermal alteration and related veins are recognised. Extensive pre-mineralisation selectively [yielded?] pervasive biotite and magnetite alteration and associated magnetite veinlets (stage 1A veinlets) as the first major hydrothermal event. This was followed by orthoclase alteration and related quartz-bornite-anhydrite stockwork veins (stage 2A & B). Intrusion of the major QMP body was closely associated with quartz-sulphide-carbonate mineralisation (stage 3) and related sericite alteration. Vein mineralisation was terminated at the end of stage 3 by pervasive sericite alteration of the QMP stock, which resulted in the formation of the disseminated chalcocite-bornite mineralisation. Based on timing relationships and stable isotope data, Endeavour 48 is a magmatic-hydrothermal dominated porphyry deposit, with little meteoric F input. Calculated $\delta^{18}O$ - δD values of the pervasive sericite alteration (average $\delta^{18}O_{300 \text{ and } 500^{\circ}C} = 9.83$ and 11.97‰; average $\delta D_{300 \text{ and } 500^{\circ}C} = -52$ and -71‰) and late stage fault zone sericite (average $\delta^{18}O_{300 \text{ and } 500^{\circ}C} = 7.81$ to 9.95‰; average $\delta D_{300 \text{ and } 500^{\circ}C} = -65$‰ and -84‰) are typical of P magmatic water. The $\delta^{18}O$ - δD values indicate that late-stage magmatic-hydrothermal F from the crystallising BQM stock are responsible for sericitic alteration, in contrast to conventional meteoric water models for sericitic alteration in porphyry systems. (From author's abstract by E.R.)

WOOD, B.J., PAWLEY, A. and FROST, D.R., 1996, Water and carbon in the Earth's mantle: Philosophical Transactions–Royal Soc. of London, A, 354/1711, p. 1495-1511.

WORDEN, R.H., SMALLEY, P.C. and OXTOBY, N.H., 1996, The effects of thermochemical sulfate reduction upon formation water salinity and oxygen isotopes in carbonate gas reservoirs: Geoch. et Cosmo. Acta, v. 60, no. 20, p. 3925-3931.

Indexed under FI. (E.R.)

WU, Houze and LIU, Yuexing, 1996, Synthesis of standard example of mineral inclusions and its application in evolution of magmatic solution: *in* Collection of the papers dedicated to the 30th Int'l. Geol. Cong., compiled by Research Inst. of Geol. for Mineral Resources, Guilin, 1996, p. 98-104.

WU, Kaihua and CHEN, Changrong, 1996, Application study of inclusion characters of gems in identification: Mineral Resources and Geol. (Kuangchan Yu Dizhi), v. 10, no. 1, p. 50-54 (in Chinese).

WULFF-PEDERSEN, E., NEUMANN, E-R., VANNUCCI, R., BOTTAZZI, P. and OTTOLINI, L., 1996, Origin of silicic glass inclusions in refractory mantle xenoliths from the Canary Islands (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 481. First author at Min.-Geol. Museum, Univ. Oslo, Norway.

Refractory spinel harzburgite, spinel lherzolite, and Mg-rich spinel dunite xenoliths from the Canary Islands contain highly silicic glass as mineral I and interstitial M. Within each island glass compositions show a systematic relation to type of host rock. Glass I in spinel harzburgite generally have higher silica contents than I in spinel dunite (60-70% versus 44-60%). The silicic glass is enriched in strongly- and depleted in moderately-incompatible trace elements relative to primordial mantle (e.g. 131 ppm Rb, 420 ppm Ba, 5 ppm La). High potassium content appears not to be related to the rock type, but rather to the presence of hydrous minerals like phlogopite and amphibole in the host rock (e.g. La Palma and Tenerife xenoliths). Glass compositions also vary with mode of occurrence. Glass I in orthopyroxene and olivine are generally richer in SiO_2 and poorer in TiO_2 than interstitial glass (<1% and ≤4%, respectively). The presence of small, euhedral Cr-diopside and olivine (Fo_{90-92}) crystals coexisting with highly silicic glass in polyphase I with similar compositions to Cr-di and ol in the peridotitic wall rock testifies to equilibrium between highly silicic M and refractory peridotite. The less silicic, more Ti-rich interstitial M, in contrast, may contain augite and Fe-rich olivines (Fo_{80-85}). The most striking variation in glass composition is seen in veined spinel xenoliths from La Palma. These show a gradual transition in phase assemblage and glass composition. In broad veins basaltic glass (45 wt.% SiO_2) relatively rich in incompatible elements (e.g. 993 ppm Ba, 180 ppm La, 3.4% TiO_2) coexist with amph + aug + ap + ox ± phl ± ol. As the veins grow narrower, the glass becomes gradually richer in silica and alkalies, and poorer in Ti, Fe, Ca and REE; the typical phase assemblage is glass + phl + di + sp. The narrowest veinlets contain a silicic, alkaline glass ($SiO_2 > 60\%$, $K_2O > 7\%$, $Na_2O > 6\%$) and phlogopite. This highly silicic glass has similar concentrations of highly incompatible elements as the basaltic glass in the broad veins (e.g. 973 ppm Ba), but is relatively depleted in moderately incompatible elements, such as the REE (e.g. 64 ppm La, 0.8% TiO_2). We interpret the observed change in M composition to be the result of a combination of fractional crystallization and reaction with peridotite wall-rock.

These data strongly suggest that the most highly silicic glass found as I in orthopyroxene and olivine and refractory spinel harzburgite, lherzolite and dunite represent M in equilibrium with the host rock. Such M may form by *in situ* partial melting involving incongruent melting of orthpyroxene or crystallization/reactions between basaltic initial M and peridotite wall-rock. The less silicic and more Ti-rich interstitial glass, most likely represent infiltrated M that have not reached equilibrium with the wall-rock. (Authors' abstract)

XAVIER, R.P., PIRES, P.F.R. and BATISTA, J. De J., 1996, CO_2-dominated fluids in greenschist and amphibolite facies mesothermal lode - gold deposits in Brazil (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 146-148. Authors at Instituto de Geociências - UNICAMP, Caixa Postal 6152, 13.081-970 - Campinas-SP, Brasil.

Introduction. It has been well established that low sal (<6 wt % eq. NaCl) H_2O-(10 - 30 mol%) CO_2 solutions are generally involved in the formation of Precambrian mesothermal lode-gold deposits hosted by greenschist facies metamorphosed volcano-sedimentary units.

The Fazenda Maria Preta (FMP) and Ambrósio (AMB) gold deposits are confined to N-S regional scale, left-lateral strike-slip brittle-ductile to ductile shear zones, respectively. At the FMP deposit, the orebodies include meter-wide quartz veins, sub-parallel to the foliation and hosted by carbonaceous phyllonites, and quartz-ankerite breccia and stockworks in rhyodacitic and dioritic sub-volcanic bodies. Hydrothermal alteration is pervasive throughout the shear zone domains and is chiefly represented by syntectonic carbonatization and sericitization, compatible with greenschist facies P-T conditions.

The AMB deposit is located in a narrow sequence of highly deformed sequence of mafic metavolcanics and clastic-chemical metasediments, tightly squeezed between two syntectonic granitic batholiths, and metamorphosed to amphibolite facies.

CO_2-rich I, mostly monophase at room T, are the dominant, or virtually the only FI type, in the auriferous quartz veins of the greenschist facies FMP and amphibolite facies AMB deposits. In the FMP deposit, vein quartz commonly exhibits incipient recovery and these inclusions form large and pervasive intragranular swarms or planar arrays. In the AMB deposit, quartz veins have undergone intense recovery with quartz recrystallization, in which the CO_2-rich I appear restricted to clusters, intergranular trails, or along subgrain boundaries. In both cases, the $TmCO_2$ values for the CO_2-rich I vary from –56.8 to –58.6°C and, combined with laser micro-Raman (LRM) analysis, demonstrate that the carbonic phase is composed of pure CO_2 to a mixture of CO_2 and ≤ 10 mol% of $CH_4 + N_2$.

In the case of the FMP deposit, within-grain swarms of CO_2-rich I show $ThCO_2$ ($l+V \rightarrow l$) values ranging from –25 up to +30°C, indicating a large variation in the density of the carbonic phase (1.05 to 0.63 g/cm^3 for pure CO_2). Single swarms or planar arrays of monophase carbonic I also display a similar broad range of the $ThCO_2$, and yield multiple peak histograms.

The clusters and intergranular trails of CO_2-rich I in the quartz veins of the AMB deposit homogenize to the critical state, within the range of –8 to +28°C, with a well-defined maxima between 23 and 30°C, equivalent to a variation of 0.85 to 0.57 g/cm^3 for the CO_2 density.

Low-sal (0 up to 6 wt % eq. NaCl) H_2O-CO_2 I were observed only in some gold-bearing veins of the FMP deposit, but seem to be completely absent in the mineralized veins of the AMB deposit. These I occur as large swarms throughout the quartz grains and show considerable scattering of the degree of fill (DF = 0.1 - 0.8), suggesting that trapping may have occurred when the H_2O-CO_2 F were immiscible. Locally, however, the aq-carbonic F of these I were trapped from an homogenous F, inasmuch as the DF of the H_2O-CO_2 I for some swarms is less variable (DF= 0.45 - 0.70). The composition of their carbonic phase, as indicated by $TmCO_2$ and LRM data, are broadly similar to the CO_2-rich I, but their $ThCO_2$ ($l+V \rightarrow l$) values are much less variable and tightly constrained between +16°C to +28°C (0.76 - 0.73 g/cm^3 for pure CO_2).

The evolution of the ore-bearing H_2O-CO_2 F towards the $CO_2(\pm CH_4 \pm N_2)$ saturation and gold deposition, can be envisaged by the following scenario:

(1) Phase separation of the ore-bearing H_2O-CO_2 F during the formation of quartz veins in dilatant zones within the shear zone domains would form H_2O-rich and CO_2-rich F phases.

(2) Due to contrasting differences in their wetting properties, the H_2O-rich phase would be lost through the migration along quartz grain boundary, leaving behind the non-wetting CO_2-rich phase, which would then be trapped as CO_2-dominated F in I.

(3) Deformation acting upon the gold-bearing quartz veins during uplift may have induced CO_2 density re-equilibration of these CO_2-dominated I, which would explain the large scattering of the $ThCO_2$ values observed in both deposits. (From authors' abstract by E.R.)

XIA, Xuehui, 1996, Microbial mats in the Gaobanhe zinc-pyrite deposit, eastern Hebei, and the genesis of the deposit (in Chinese, Engl. abst.): Mineral Deposits (Kuangchuang Dizhi), v.15, no.2, p. 165-170. Author at Geological Inst. for Chemical Mineral, Ministry of Chemical Industry, Zhuozhou 072754.

The Gaobanhe ore deposit is a well-known zinc-pyrite deposit on the northern margin of the North China platform and within the Yanliao metallogenic belt, and the host rocks are sedimentary rocks of Proterozoic Gaoyuzhuang Formation, consisting of manganiferous dolomite, carbonaceous dolomite, siliceous dolomite, siliceous mudtone, manganiferous carbonaceous shale and siliceous banded dolomite. Orebodies layered in form occur along the strata and exhibit gradual relationship with wall rocks.

Detailed chemical analyses show that host rocks are characterized by Fe/Ti and (Fe + Mn)/Ti>20, Al(Al + Fe + Mn)<0.35, and high content of organic carbon, thus exhibiting chemical properties of hot-water sedimentary rocks. Main host rocks are analogous to ores in such REE geochemical features as low ΣREE, high LREE/HREE, positive Eu anomalies and negative Ce anomalies, also quite similar to characteristics of hot water sedimentary rocks. As for pyrite, Co/Ni ratios are mostly lower than 1, S/Se ratios are in the range of 17448~306476, and decrepitation Ts are 296~330°C. Na^+/K^+ of FI in sphalerite is as high as 13.75. F sal calculated from FI composition is 29 wt% NaCl. These data demonstrate that the ore deposit is of hot brine sedimentation origin.

Quite a lot of microbial textures were found in ores of stratiform orebodies. Pyrite cocci in the form of mats are distributed in the inercalations of ore beds--carbonaceous shale. These pyrite microspherolites might be grouped into four types: Pyrite cocci with wrapped saccate bodies; micelles of pyrite bacteria; pyrite bacilli; pyrite strawberries. It is concluded that the Gaobanhe ore deposit is characterized by dual origin of seawater spouting and biogenic mineralization. (Authors' abstract.)

XIA, Xuehui, YAN, Fei, LIU, Changtao, and **HUANG, Furong,** 1996, Genesis of the Guantian cupriferous and Te-bearing pyrite deposit in Guangdong with reference to other sulfate minerals (abst.): Acta Petrologica et Mineralogica, v. 15, no.4, p. 355-364. (in Chinese; Engl. abst.) Authors at Geological Inst. for Chemical Minerals, MCI, Zhuozhou 072754.

Research on the Guantian pyrite deposit in Guangdong led to the discovery of many sulfate [sulfide] minerals besides pyrite, such as emplectite, aikinite, ourayite, and enargite, in excess of ten species. Further studies were focused on the genesis of the deposit based on S, H and O isotopes, I Th and other features. It is concluded that the Guantian deposit owes its formation to the metasomatism at low to intermediate T by the postmagmatic hydrothermal solution along with less meteoric water, suggesting the deposit is a hydrothermal metasomatic vein type one. (From authors' abstract by E.R.)

XIAO, Xianming, LIU, Dehan and **FU, Jiamo,** 1996, Multiple phases of hydrocarbon generation and migration in the Tazhong petroleum system of of the Tarim Basin, People's Republic of China: Organic Geochem., v. 25, no. 3-4, p. 191-197.

Indexed under FI (E.R.)

XIAO, Z.M. and **YE, S.Q.**, 1996, Metallogenic geology and exploration model of Qixiashan lead-zinc-silver deposit, Nanjing, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 655. Authors at East China Exploration Bureau, China.

Qixiashan lead-zinc-silver deposit is one of the largest in Southeast China. The orebodies are mainly localized in the middle Carboniferous carbonate formation, especially in a reactivated fault.

The mineralization and ore types in the orefield are characteristic of their zonation in three dimensions, with horizontally a primary element zonation as Cu, Pb, Zn, Ag, Mn, Au from west to east, vertically from oxidized manganese cap to Au, Ag superenrichment zone to primary sulfide zone and laterally showing an ore-type zonation of strata-bounded nature.

Isotope composition determination including S, Pb, O, H, C and I research including phase analyses, sal, homogeneous T and composition have been carried out in detail with interesting results. Normal lead and model age of 577-816 Ma. suggest that lead derived from Sinian basement which is coincident with its high Pb-Zn abundance in this sequence. Wide range of δS_{34} - 29.4 - +14.1‰ with mostly present value -8 - +7‰ indicate that sulfur mostly derived from ore-hosting sequence and other minor source. In terms of δD-δO_{18} results, it is suggested that ore-forming F was formed from a mixture source of P water with meteoric water. Based on these research results, a two-circulation metallogenic model, or epigenetic strata-bounded deposit of thermal F (brine) two-circulation system, is proposed and discussed. (From authors' abstract by E.R.)

XIE, Qinglin, MA, Dongsheng and **LIU, Yingjun,** 1996, Geochemical characteristics of calcite in the Xikuangshan antimony deposit, Hunan: Mineral Resources and Geol. (Kuangchan Yu Dizhi), v. 10, no. 2, p. 94-99 (in Chinese; Engl. abst.).. Authors at Dept. of Geosci., Nanjing Univ., Nanjing, 210008).

Antimony in the ore-bearing calcite vein is highest in content, among the various calcite in the Xikuangshan antimony deposit, and gradually decreases from early to late stage. The studies on stable isotopes, FI and REE elements of calcites indicate that the mineralization solution is characterized by low sal. and moderate to low T. It was formed by the deep circulation of meteoric water through the Pre-Devonian systems. The mixing of down-seeping meteoric water and ore-bearing F is probably one of the factors resulting in precipitation of ores. (Authors' abstract)

XIE, Shucheng, YIN, Hongfu, WANG, Hongmei, ZHOU, Xiugao, FU, Jiamo, SHENG, Guoying and **ZHANG, Huizhi,** 1996, Biomarkers in fluid inclusions of polymetallic deposit of Qixiashan, Nanjing: Chinese Sci. Bull., v. 41, p. 4-9 (in Engl.). Authors at Inst. of Geoch., Acad. Sinica, Guangzhou 510640.

Most previous detailed studies of organic geochemistry in ore deposits focus on the bitumen and kerogen associated with ores and host rocks, not that in FI. Generally, organic matter in ore-forming F in situ [is?] involved in metallogenesis. The metallogenic organic F can be traced over [by?] hydrocarbon I. In the paper, a series of biomarkers are identified through such destructive technique on the hydrocarbon I as G chromatography-mass spectrometry (GC-MS). Comparison and contrast [with] extractable organic matter (EOM) is made among I, ores and host rocks. Metallogenesis related to EOM is discussed.

Samples and methods: Samples are quartz and calcite individual minerals formed in the main stage in Pb-Zn-Ag-Mn polymetallic deposit of Qixiashan of [in] Nanjing.

The samples used for GC-MS analysis must be pretreated. As much as 400-500 g quartz individual minerals formed in the main stage of Pb-Zn metallogenesis are crushed to 20 mesh, and treated with 1% hydrochloric acid, washed with distilled water and dried, then washed 5 times with chloroform, dried at low T, and then crushed to 200 mesh to liberate the organic I. Extract with chloroform for a week in Soxhlet apparatus. EOM is separated into paraffin alkanes, aromatics, non-hydrocarbons and asphaltenes. The latter two are analysed with PE 1725X FTIR microspectroscopy. Biomarkers in paraffin alkanes are identified with HP 5890 GC and Finnigan Mt 4515 GC-MS. All the utensils in the pretreating of the samples are washed with chloroform.

Most P hydrocarbon I formed in the main stages of Pb-Zn mineralizing are 2-phase with V and L hydrocarbons; a few are 3-phase, with additional water. The Tt of the hydrocarbon I ranges from 130-230°C, estimatedly measured by the adjacent aq FI. IR microspectroscopy analyses reveal that organic matter in individual I mainly contains benzene ring, long chain CH_2, $-CH_3$ and heteroatoms of oxygen and sulfur. Ultraviolet fluorescence spectrum shows the Q value and λ max are 2.25-5.56, 600-700 nm respectively.

EOM in hydrocarbon I was abundant in non-hydrocarbons and asphaltenes and no aromatics detectable. IR spectrum shows that both non-hydrocarbons and asphaltenes contain heteroatoms of sulfur (2619-2252 cm^{-1}), nitrogen (3400 cm^{-1}), oxygen (1720-1730 cm^{-1}, 1300-1000 cm^{-1}). The special organic component in hydrocarbon I of Qixiashan deposit is 26.9 x 10^{-6}, with a maximum of 200.4 x 10^{-6} [units?].

N-alkanes in hydrocarbon I range from C_{15} to C_{25} with carbon number maximum at C_{17} and no carbon number predominance (Fig. 1), showing bacterial and algae sources. Isoprenoid alkanes identified are norpristane, pristane (Pr), phytane (Ph) and tetramethyl heptadecane. The ratio of Pr/Ph is 0.72. Extended tricyclic terpanes identified (Fig. 1) range from C_{19} to C_{29} with a dominance of C_{21} and C_{23}. The total amount of C_{21} and C_{22} is equal to that of C_{23} and C_{24}. Hopanes (Fig. 1) detected are norhopanes of Tm, Ts and C_{29}, C_{30} $\alpha\beta$ hopane and morteane, and homohopanes of C_{31} to C_{33}. The ratios of C_{32} $\alpha\beta$22s/(22S+22R) and Tm/T are 57% and 1.0 respectively, showing high maturity of organic matter. Steranes are mainly the common 12 cholestanes of C_{27}, C_{28} and C_{29}.

The results indicate that hydrocarbon I in ores and host rocks are similar on many biomarker parameters, as well as the proportion of paraffin alkanes. Except for biomarkers, EOM in ores are quite different from that in I. The components of EOM in ores are rich in aromatics and short of non-hydrocarbons and asphaltenes. The difference might be caused by the complicated organic interactions in F coinciding with the precipitation of Pb and Zn. There in ores exists positive correlation between organic carbon and sulfur, and close relationship between total amount of Pb and Zn and the value of S/C. It reveals that organic matter in F affects metallogenesis of Pb and Zn by controlling sulphur.

It is concluded that organic F involved in Pb-Zn mineralizing in the polymetallic deposit of Qixiashan probably derives from bacteria and algae, and is similar to crude oil of high maturity. Part of lead and zinc in F can be transported by organic complexes, while precipitating of metals is caused by organic F providing with S^{2-}. Biomarkers in ores similar to that in I can indicate the source of organic matter in F. Organic matter in I must be studied to ascertain organic metallogenesis because of the EOM difference between ores and I. (From authors' abstract by E.R.)

XIE, Xinong and **LI, Sitian,** 1996, Fluid flow and dynamic model in fault zones: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 145-151. Authors at China Univ. of Geosci., Wuhan, 430074.

More and more evidences show a close relationship between the F flow and the faulting activity. F flow in fault zones not only affects the formation, development and decay of faulting and fault strength, but also controls the formation of mineral deposits adjacent to the fault zones. F flow leads to the recirculation of F and water-rock interaction in a fault zone. Redistribution of F makes a quick response to the accumulation and expulsion. Coupling fluctuation in FP and shear stress influence the fault shear strength during frictional reactivation and control over the relative timing of fault opening and sealing. Hence, episodic variation of F flow indicates the cyclic fluctuation of faulting or seismic activity. (Authors' abstract)

XIE, Yihan, FAN, Hongrui and **WANG, Yinglan,** 1996b, REE daughter minerals in fluid inclusions in the giant Bayan Obo REE-Fe-Nb ore deposit: discovery and implication (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 26-27. Authors at Inst. of Geol., Chinese Acad. of Sci., Beijing 100029.

The giant polymetallic Bayan Obo REE-Fe-Nb ore deposit is located in the center of Inner Mongolia, P.R.C., and near the contact between North China Platform and Inner Mongolia Hercynia [Hercynia?]Geosyncline. The orebodies occur in unit H8 dolostone of the Middle Proterozoic Bayan Obo group.

Hydrothermal metasomatic origin of this ore deposit has been proposed. But composition, property and origin for hydrothermal F are still controversial. Recently, on the basis of the observation from FI in the Bayan Obo ore deposit under optical microscope and scanning electron microscope (SEM), we have identified multiple dm from FI in either quartz ± fluorite ± barite ± REE veins or dolomite of H8 dolostone marble. The dm are complex, including barite, calcite, REE minerals and some uncertainty minerals besides common halite and sylvine. The REE dm-bearing I normally range from 5-8 µm, and occur as negative crystal of host mineral.

The I contain either three or four phase at room T: solid dm, aq F, CO_2 L and/or CO_2 V. The average Tm of CO_2 (Tm = -57.0±°C), indicates that the carbonic phase within the I is essentially pure CO_2. The partial Th of CO_2 range from 25.6 to 27.8°C. During heating runs, disappear T of V range from 246 to 285°C, halite M from 280 to 302°C, corresponding to sal from 35.6 to 37.9 wt% NaCl. All dm including REE minerals are observed to dissolve between 407 and 428°C. It is interesting that REE minerals and other dm recrystallize after cooling. REE dm are hexagonal, their compositions contain La, Ce, Nd using energy spectrum lines of SEM.

Microthermometric analyses reveal that REE minerals were not trapped as solid phases, but were precipitated from the F after trapping of the I. Therefore, they are real dm. Ore-forming F should be high sal, rich CO_2 and rich REE solution. This result supports host-rock controlled epigenetic, hydrothermal metasomatic origin of the giant Bayan Obo REE-Fe-Nb ore deposit (Authors' abstract)

See also adjacent items (E.R.)

XIE, Yihan, WANG, Yinglan and **ZHANG, Rufan,** 1996, A discovery of REE minerals in fluid inclusions in the Bayan Obo REE-Fe-Nb ore deposit: Chinese Sci. Bulletin, v. 41, no. 5, p. 401-404 (in Engl.). First author at Inst. of Geol., Chinese Acad. of Sci., Beijing 100029, China)

Recently, on the basis of the observation of FI in the Bayan Obo ore deposit under optical microscope, the authors have identified with scanning electron microscope (SEM) that the dm contained in FI include calcite, barite and many REE minerals besides common halite and sylvine.

The REE-bearing FI are fairly abundant in vein fluorite-quartz, and can also be found in dolomite of H8 dolostone. Barite veins contain many dm-bearing FI. The I range from 5 to 8 µm in size, and occur at random as negative crystal shapes. Some other spherical minerals less than 1 µm besides square halite can be seen among the dm.

On microscopic heating-freezing stage, L CO_2 can be seen around bubble at the room T (20°C±) between aq solution and bubble. Th of CO_2 range from 25.6 to 27.8°C. The FI homogenize by dissolution of all dm at T from 407 to 428°C. The disappearance T of halite range from 280 to 302°C, corresponding to sal from 35.6% to 37.9% NaCl. (From the authors' paper by H.E.B.)

See previous items (E.R.)

XIE, Shucheng, YIN, Hongfu, ZHOU, Xiugao and **WU, Shunbao,** 1996a, Biometallogenesis of Pb-Zn-Ag-Mn polymetallic deposit of Qixiashan, Nanjing, China (abst): 30th Int'l Geog. Cong., Abstracts, v. 1, p. 404. Authors at Palaeontology Laboratory, China Univ. of Geosci., Wuhan.

The Qixiashan polymetallic deposit of Pb-Zn-Ag-Mn is a sedimento-hydrothermal genetic deposit. Organic geochemistry studies show that organic matter in ores has a complicated origin, and at some extent differs from that in the host rocks. Carbonate often abounds in organic FI. This kind of mineralizing phenomenon demonstrates that organic matter has ever reduced SO_4^{2-} to S^{2-} and formed sulfides and carbonate.

The abundance of organic I in various ores also strengthens the reliability of the conclusion of organic matter positively involving in forming ores. Analyses of the individual organic I with FTIR and Laser Raman Microspectroscopy show that organic functional groups relate to the ore types. The result reveals that some organic matter may play roles in transporting metallogenic elements while some in precipitating. Studies on organic geochemistry and tectonic background testify that these organic F may originate from the oil-bearing strata in the mountain range, and in the surrounding oil-bearing basins. The F components further prove the close connection between the metallogenic F and the oil pools. (From authors' abstract by E.R.)

XIE, Shucheng, YIN, Hongfu, ZHOU, Xiugao and **WU, Shunbao,** 1996b, Biometallogenesis of Pb-Zn-Ag-Mn polymetallic deposit of Qixiashan, Nanjing, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 712. Authors at Palaeontology Laboratory, China Univ. of Geosci., Wuhan, China.

The Qixiashan polymetallic deposit of Pb-Zn-Ag-Mn is located in Nanjing-Zhenjiang mountain range. It is a sedimento-hydrothermal genetic deposit. The ore bodies are hosted in the oil-bearing carbonate rocks of Upper Carboniferous and Lower Permian. Organisms, organic matter and organic F play important roles in forming ores. The $\delta^{34}S$ values of sulfides range from -27.4‰ to 14.1‰, indicating the organisms activities in forming sulfides.

Organic geochemistry studies show that organic matter in ores has a complicated origin, and to some extent differs from that in the host rocks in the parameters of A/C, Ro, H/C, O/C, OEP, Pr/Ph and the characters of biomarkers. Many ore-forming elements such as Ag, Cd, Pb, Zn and Y are enriched in organic matter. Carbonate often abounds in organic FI. This kind of mineralizing phenomenon demonstrates that organic matter has ever reduced SO_4^{2-} to S^{2-} and formed sulfides and carbonate.

The abundance of organic I in various ores also strengthens the reliability of the conclusion of organic matter positively involving in forming ores. Analyses of the individual organic I with FTIR and Laser Raman Microspectroscopy show that organic functional groups relate to the ore types. The result reveals that some organic matter may play roles in transporting metallogenic elements while some in precipitating. (From authors' abstract by E.R.)

XIE, Yihan, FAN, Hongrui and **WANG, Yinglan**, 1996a, REE daughter minerals in fluid inclusions in the giant Bayan Obo REE-Fe-Nb ore deposit: discovery and implication (abst.): 30th Int'l Geol. Cong., Abstracts, v. , p. 485. Authors at Inst. of Geol., Chinese Acad. of Sci., Beijing 100029.

See next item. (E.R.)

XIONG, Qunyao and **LI, Yan**, 1993, A preliminary study of the formation mchanism of the Xiaseling tungsten deposit in Changhua, Zhejiang Province: Bull. of the Inst. of Mineral Deposits, Chinese Acad. of Geol. Sci., 1993, no. 1, serial no. 26, p. 153-162 (in Chinese; Engl. abst.). Authors at Inst. of Mineral Deposits, Chinese Acad. of Geol. Sci.

A rather detailed study has been made on FI in the Xiaseling tungsten deposit, Zhejiang Province. Using such means as I thermometry, hydrogen, oxygen and carbon isotopes of I and gaseous and L composition of I, the authors determined some physical-chemical parameters for mineralization such as T, P, sal, F density, pH, fO_2, f_{CO_2} and Eh and analysed some problems concerning ore-forming mechanism, holding that ore-forming hydrothermal F came from the fine-grained biotite granite stock in the east. Moreover, the relationship of $\delta^{18}O$ to the composition of the granite implies the probable existence of an associated gold deposit within the tungsten ore district. (Authors' abstract)

XIONG, Yongliang, 1996, Kinetic constraints on the formation of epithermal Au mineralization in a detachment fault context: an example from the Okanagan Falls area, southern B.C., Canada (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 741. Author at Dept. of Geol. and Geological Engineering, Univ. of Idaho, Moscow, Idaho.

A kinetic modeling has been conducted based on $\delta^{18}O$ values of [whole] rocks and F.I. data. (E.R.)

XU, Guojian, 1996, Fluid inclusions in crack - seal veins at Dugald River, Mount Isa Inlier: Implications for palaeostress states and deformation conditions during orogenesis (abst.): Geological Soc. of Australia Abstracts Number 42, Evolution of Metamorphic Belts, LaTrobe Univ., December, 1996, p. 77. Author at Earth Sci., James Cook Univ., Townsville 4811, Queensland.

An integrated geometrical investigation of FI trails and microthermometric analysis were carred out for FI in fibrous crack - seal veins at Dugald River, Mount Isa Inlier. Two general types of FI were distinguished: one is $CO_2 \pm CH_4$ = rich and the other one is H_2O - rich, and at least three stages of F percolation are interpreted to have occurred during vein formation. (From author's abstract by E.R.)

XU, J.-H., XIE, Y.-L. and **SHEN, S.-L.**, 1996a, A comparison of fluid inclusion study on altered rocks in gold deposits of the Xiaoqinling Mt. and the Jiaodong Peninsula, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 749. Authors at Dept. of Geol., Univ. of Sci. and Tech., Beijing.

See adjacent item (E.R.)

XU, Jiuhua and **ZHANG Xifan**, 1996, Ore-forming fluids of the Hougou gold deposit related to alkaline complex, North Hebei, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 748. Authors at Dept. of Geol., Univ. of Sci. and Tech., Beijing.

The Hougou gold deposit occurs in an alkaline complex and ore bodies are controlled by potash altered rock zones and fractured faults. Hydrothermal alteration types are dominated by microclinization and pyritization, accompanying with silicification, sericitization and carbonatization. Three mineralization stages can be divided: (1) gold-pyrite-microcline; (2) gold-polymetallic sulfide-quartz; and (3) carbonite [carbonatitic].

The values of $\delta^{18}O$ and δD show that ore forming F were mixed by magmatic and meteoric water, not only because of a distinct oxygen-shift toward meteoric water line in Taylor's (1979) diagram, but of a close relationship between δD and latitude (Fig. 1 [deleted]) when compared with lode gold deposits in other districts.

The CO_2/H_2O (in weight) of fluid inclusions in veinlet quartz is from 0.073 to 0.65, and that in microclinite is from 0.057 to 0.35. The K^+/Na^+ and F^-/Cl^- of FI are mainly 0.40~3.05 and 0.03~0.41. (From authors' abstract by E.R.)

XU, Jiuhua, XIE, Yuling and **SHEN Shiliang**, 1996b, A comparison of fluid inclusion study on altered rocks in gold deposits of Xiaoqinling Mt. and Jiaodong Peninsula, China (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 46-47. Authors at Univ. of Sci. and Tech., Beijing, China 100083.

Gold deposits in both areas occur in Precambrian granitoid-greenstone terraces [terranes?], controlled by brittle-ductile shear zones. A comparison of wallrock alteration and FI in the two areas has been studied and significant conclusions have been deduced. Wallrock alteration in the Xiaoqinling can be identified as three zones, and four generations of hydrothermal quartz can be distinguished. Early quartz (Q_1) usually contains FI with high sal (Type A), while later quartz (Q_3) is rich in CO_2 FI (Type C). The Th of type A I ranges from 195°C to 380°C, with Tm of NaCl crystals ranging from 155°C to 345°C (when Tm<Th), or from 225°C to 465°C (when Tm>Th). The Th of type C are from 160°C to 325°C. Component analyses of FI indicate that altered rocks have higher K^+/Na^+ and F^-/Cl^- than vein quartz on the other hand. CO_2/H_2O of FI in altered rocks are lower than those in vein quartz. In gold deposits of the Jiaodong Peninsula, earlier quartz usually contains salt-aq (g+l) I (Type B), and Type A I are occasionally seen while in later quartz. CO_2 I are also commonly observed. They have similar Th ranges when compared with those in Xiaoqinling. However,they have higher K^+/Na^+, F^-/Cl^- and lower CO_2/H_2O than those in Xiaoqinling (Table 1). Moreover, the P of ore-forming F of Jiaodong area were lower than those in Xiao-qinling. The differences of K^+/Na^+ and F^-/Cl^- between two areas indi-

Table 1 Comprised Characteristics of Fluid Inclusions

deposits	Th, °C	Sal wt%	P, Mpa	K^+/Na^+	F^-/Cl^-	CO_2/H_2O
XQL AL	210-380	7.7	57-190	0.9-1.9	0.01-0.25	0.09-0.27
VQ	180-360	4.2-8.0	132-190	0.07-0.55	0.0-0.04	0.07-0.68
JD AL	250-350	7.5-11.5	80	0.21-5.0	0.1-0.70	0.01-0.12
VQ	205-370	2.4-6.5	21-86	0.2-2.6	0.03-0.35	0.03-0.35

XQL—Xiaoqinling, JD—Jiaodong, AL—Altered Rock(type), VQ—Vein Quartz(type). Source: 1)This work, 2)Hu et al 1989, 1992; 3)Xu, 1992; 4)Yang, 1984 Wang and Wang, 1991 cates that gold mineralization was related with host rocks, while CO_2/H_2O values show different FP during gold mineralization.

The $\delta^{18}O$ values of altered wall rocks in Xiaoqinling are from 9.8‰ to 11.0‰ and (δD from -59.0‰ to -69.0‰) which are similar to those of quartz veins ($\delta^{18}O$ ‰ = 9.6-12.76, δD ‰ = -48 ~ -.87.4). The $\delta^{18}O$ of both altered rocks and vein quartz from Xiaoqinling area are lower than those from Jiaodong which may imply continental effect of meteoric water. (From authors' abstract by E.R.)

XU, Qidong, 1996, Fluid inclusion study in metamorphic rocks: Several key points: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 216-221. Author at China Univ. of Geosci., Wuhan, 430074.

FI in metamorphic rocks carry information on the nature and composition of F present at the peak of metamorphism and during retrograde metamorphism. Because of some particularity and a long period of evolution of metamorphism, much knowledge of FI obtained from F-rich deposition environments may not fit for FI in metamorphic rocks. In order to directly clarify petrologic meaning of FI data in metamorphic rocks, [one must] judge the influence of post-trapping reformation on composition and volume of FI to constrain the FI data by various methods with the data of composition and nature of F obtained by other methods. (From author's abstract by E.R.)

XU, Peicang, LI, Rubi, WANG, Yongqiang, WANG, Zhihai and **LI, Yueqin,** 1996, A Raman microprobe study of Cl^- anionic concentration (mol/L) in aqueous solution of fluid inclusion (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 485. Authors at Xi'an Inst. of Geol. and Mineral Resources CAGS, Xia'n 710054, China.

In this paper, through study of Cl^- (mol/L) concentration for synthetic standard solutions that have certain Cl^- (mol/L) concentrations and natural FI in quartz at Swesland Alpers [Swiss alpine?] Mountains valley by means of Raman microprobe, we conclude:

1. The Cl- anionic in aq solution exists in the form of the Cl^- - (H^+ - OH^-)n anionic group. It's Raman shift is 2991 cm^{-1} and the Raman scattering intensity is weaker [by] about 100 times than that of (SO_4^{2-}) at 981 cm^{-1}.

2. We obtained a calibration curve of Cl^- concentration (mol/L) relative to Raman scattering intensity Ij/IH_2O. After using this curve the measurment values of sal (NaCl wt%) by Raman microprobe are identical with [those from] microthermometry.

3. The composition, sal and the miscibility of $H_2O(L)$ - $CO_2(L)$ in aq solution of F inclusions in quartz of migmatitic granite at Xiao Qinling Mountains of China have been determined by above method.

The above facts not only have proved that this method of measuring Cl^- concentration and the inference which Takenouchi put forward in 1965 are exact, but also have substantiated the rules of mixed solution in $H_2O(L)$-$CO_2(L)$-NaCl ternary systems. These have important significance for investigating FI and F geology.

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(1) M.J. Colles etc. Jour. Chem. Phys. v. 56, no. 7, p. 3384-3391. (1972)

(2) I-Ming Chou, J.D. Pasteris etc. Geochimica et Cosmochimica Acta v. 54, p. 535-543. (1990) (From authors' abstract by E.R.)

XU, Qidong, ZHONG, Zengqiu and **SUO, Shutian,** 1996, Genesis of the mesothermal gold deposits from Tongbai-Dabie area, central China: constraints from the nature of the ore-forming fluids (abst.): 30th Int'l. Geog. Cong., Abstracts, v. 1, p. 428. Authors at Faculty of Earth Resources, China Univ. of Geosci., Wuhan, China.

Mesothermal gold mineralization occurs widely in Tongbai-Dabie area. H, O, S, Pb isotope data provide the evidence that the F, sulfur and ore-forming elements in metallogenic F had different sources: F mainly came from meteoric waters moving through these rocks, while sulfur and ore-forming elements were extracted by the waters owing to interaction between F and rocks. Therefore, the metallogenic F mainly were evolved meteoric waters.

The FI studies of tens of mesothermal gold deposits show that the metallogenic F belong to $NaCl-CO_2-H_2O$ system with low sal (6 wt.% NaCl) and CO_2-rich (10 mol%). There are assemblages of three-phase CO_2-bearing I, two-phase salt water I and two-phase CO_2-rich I, with different modes of partial and total homogenization and so on, in the most deposits. These are interpreted to represent three stages of complex immiscible processes for the metallogenetic F, which include initial boiling on or nearby V-L phase surface —> unmixing in two phase field —> CO_2 effervescence of S F. That gold formed during the middle-late period of deposition of the F [and] implies gold mineralization to be associated closely with the two-three stages of the immiscible processes. Tt is 220~370°C, trapping P is 500~1600 × 10^5 Pa according to the studies of three FI T-P methods, and the depth of the mineralization is 4~10 km with the north belt (4~6 km) being shallower than the central and south belts (7~10 km). (From authors' abstract by E.R.)

XU, Wenxin, GUO, Xinsheng, JI, Shukai, LU, Jiuru and **LI, Shuping,** 1996, Geochemistry of the Tongkuangyu copper deposit, Shanxi: *in* Collection of the papers dedicated to the 30th Int'l. Geol. Cong., Research Inst. of Geol. for Mineral Resources, 1996, Guilin, p. 105-112 (in Chinese).

Indexed under FI (E.R.)

XU, Wenxin, GUO, Xinsheng, LI, Shuping and **JI, Shukai,** 1996, Geochemistry of the Henglinguan copper deposit: Mineral Resources and Geology (Kuangchan Yu Dizhi), v. 10, no. 1, p. 232-239 (in Chinese; Engl. abst.). Authors at Research Inst. of Geol., for Mineral Resources, CNNC, Guilin 541004.

Studies of geochemistry of REE, isotope and mineral I [FI] in the Henglinguan copper deposit indicate that its forming T is 350°C±30°C; pressure is 38 x 10^5 Pa~240 x 10^5 Pa; sal is 30 wt.%~42 wt.%; $\log f_{O_2}$ is -30.41~-31.47; $\log f_{S_2}$ is -5.4~-8; pH is 7.3; $\log f_{CO_2}$ is -2.49; solubility of copper ($\log m_{Cu}$) is -5.87~-2.21. The Pb-Pb isotope dating in the country rock is 1775 x 10^6a, and that is [of?] the ore is 1845 x 10^6a, sulfur isotope composition in the ore is -8.1‰~36.9‰, showing nonequilibrium sulfur isotope. The carbon isotope composition is -7.1‰~2.6‰, and the $\delta^{13}C_{\Sigma C}$ is -5.3‰ in carbonate rock. The hydrogen and oxygen isotope composition of the mineralization F is charactered by metamorphic hot brines; therefore, the metallogenesis of the deposit should be considered as metamorphic hot brine. (Authors' abstract by E.R.)

XU, Xuechun, 1996a, Advances in the study of metamorphic fluids: Earth Sci. Frontiers, v. 3, no. 3/4, p. 200-208–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.). Author at Changchun Univ. of Earth Sci., Changchun, 130026.

Metamorphic F is a major dynamic agent of metamorphic process. At present, the study of it focuses on lower crust and granulite facies metamorphic F, subduction zone and high-ultrahigh P metamorphic F and contact metamorphic F. The main problems are F flow and element transportation, F-rock interaction and the source of the F. CO_2 is a main component of lower crust and granulite facies metamorphic F which has low a_{H_2O}. The study of $\delta^{13}C$ indicates that 2/3rds of the CO_2 is derived from deep crust and mantle. CO_2-rich F flow is a major cause for thermal perturbation during the granulite facies metamorphism and charnockitization, and results in LILE depletion in granulite. Subduction zone is the most active site for high-ultrahigh P metamorphism and F flow rich in H_2O, CH_4, and CO_2. The F released during high P metamorphism play an important role in the evolution of subducted crustal rocks and may connect directly with igneous activity in island arcs. Mineral stability is close to [equilibrium] with the F under high P metamorphic conditions, [but] isotopic data indicate that F mobility was limited. The F-M interaction model provides an attractive explanation for the instantaneous and selective transport of elements between the downgoing slab and the overlying mantle wedge. Impure limestones with interstratified metachert layers are excellent for the study of contact metamorphic F. The F/rock ratio which is 40:1 in wollastonite zone shows that there [is much] F during contact metamorphism. F compositions vary in different contact metamorphic processes depending on the F source and the features of sedimentary rocks and intrusive rocks. The direction and mechanism of F flow are controlled by deformation,magmatism and dynamic conditions of contact metamorphism. (From author's abstract by E.R.)

XU, Xuechun, 1996b, Metamorphic processes and fluid evolution in the Early Proterozoic orogenic belt of the northern margin of the North China platform (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A-230. Author at Dept. of Geol., Changchun Univ. of Earth Sci., Changchun, Jilin 130026, People's Republic of China.

The Early Proterozoic orogenic belt of the northern margin of the North China platform is composed of two groups of metamorphic rock series, granulite-gneiss and khondalite. Both series have undergone granulite facies metamorphism during Early Proterozoic orogenesis.

A study of FI demonstrates that CO_2 is dominant and contains detectable amounts of CH_4, N_2, CO and H_2S. CO_2-rich FI have high density (0.78-0.906 g/cm^3) and lower H_2O activity. The components and nature of metamorphic F changed along with the evolution of metamorphism. The Th of CO_2-rich FI show four peak values, which represent the F components and nature of four metamorphic stages and indicate F evolution during Early Proterozoic orogenesis. F evolution has a clockwise P-T-t path. The three dynamic processes demonstrate mechanisms of subsidence, uplift, and stabilization of the orogenic belt. (From author's abstract by E.R.)

XU, Xuechun, LIU, Jianzhong, and LI, Tiesheng, 1996, Components and physiochemical nature of fluid in Archaean lower crust of northern margin in the North China Platform: J. of Changchun, Univ. of Earth Sci., v. 26, Special Issue 1996 (dedicated to the 30th International Geological Congress, but not in the IGC Abstracts volumes), p. 87-94 (in Engl.).

It is widely [known that] in northern margin of the North China Platform granulite facies metamorphic rocks were formed in Archaean lower crust. Studying of F components in granulite facies rocks indicates that CO_2 is a main F composition of lower crust, with detectable amounts of CH_4, CO, N_2 and H_2O. They were formed under the physiochemical conditions of low water activity, strong reduction, weak oxidization and low oxygen fugacity. (Authors' abstract.)

XU, Yigang, MERCIER, J-C. C., MENZIES, M.A., ROSS, J.V., HARTE, Ben, LIN, Chuanyong and SHI, Lanbin, 1996, K-rich glass-bearing wehrlite xenoliths from Yitong, northeastern China: petrological and chemical evidence for mantle metasomatism: Contrib. Mineral. Petrol., v. 125, p. 406-420. First author at Laboratoire de pétrologie physique, Univ. Paris 7 and I.P.G.P., 2 Place Jussieu, F-75252, Paris, France.

The glasses must have resulted from local penetration of mantle metasomatic M which may have been produced by partial melting of peridotites with involvement of deep-seated F. Such M may have been significantly modified by subsequent fractional crystallization of ol, cpx and sp, extensive reaction with the mantle conduit and the xenolith transport process. (From authors' abstract by E.R.)

XU, Yongchang, 1996, The mantle noble gas of natural gases: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 63-71. Author at State Key Laboratory of Gas Geoch., Lanzhous Inst. of Geol., Chinese Acad. of Sci., Lanzhou 730000.

Natural G is an important component of the interior earth F. The mantle noble gas of natural G originated from the volatile components of the mantle. $^3He/^4He$ is a key index of mantle materials; when if is higher than 1.4×10^{-6} in natural G, a considerable mantle [content is suggested] and indicates that tectonic activity was strong, allowing mantle volatiles to migrate into the sedimentary shell along the fracture system. In $^{40}Ar/^{36}Ar$ and $^{20}Ne/^{22}Ne$ natural G also could be used as indicators of the structure features. The $^3He/^4He$, $^{40}Ar/^{36}Ar$ and $^{20}Ne/^{22}Ne$ in natural G differ in various areas of China; they are much higher in eastern China and much lower in the midland, indicating that the oil-G basins in eastern China are the most active structural setting, the midland is stable, and the basins in western China are sub-stable. Under the active structural background in eastern China, migration of mantle volatiles into sedimentary G reservoirs, forming the first example of complex helium resources in the world. CO_2 resources related to the mantle volatiles were also discovered in the sediments. In addition, eastern China probably became an important area for mantle methane to accumulate as G reservoirs. (From author's abstract by E.R.)

XU, Zemin, SUN, Shixiong and LIU, Dan, 1996, The hydrogeochemical feature of the mineralizing solution and mineralization zoning pattern of the Zhenyuan gold deposit: J. Chengdu Inst. of Tech., v. 23, no. 1, p. 49-56.

YAGI, M., UCHIDA, T. and FUKASAWA, K., 1996, Estimation of subsurface temperatures using fluid inclusions and vitrinite reflectances in the Akan geothermal area, Hokkaido, Japan: Proceedings 18th NZ Geothermal Workshop 1996, S. F. Simmons et al., eds., Geothermal Inst., The Univ. of Auckland, p. 145-149. Authors at JAPEX Research Centre, Japan Petroleum Exploration Co. Ltd., Japan.

Five hundred microthermometric measurements were made on FI and approximately 700 measurements of vitrinite reflectance (Ro) were performed on core samples taken from wells in the Akan geothermal area, Hokkaido, Japan. The Th in samples from below 1000 m in the well AK-7 are in close agreement with the present subsurface T (up to 292°C). An abrupt increase of the Ro ratio with depth occurs in AK-7 and is attributed to the present thermal regime. (Authors' abstract)

Boiling has occurred; CO_2 content (from crushing studies) contributes only 0.1°C maximum to the depression of Tm. (E.R.)

YAN, Ming, LIU, Yingjun and MA, Dongsheng, 1996, Geological geochemistry and genesis of the gold deposits in northern Guangxi: J. of Guilin Inst. of Tech. (Guilin Gong Xueyuan Xuebao), v. 16, no. 2, p. 110-118 (in Chinese; Engl. abst.). First author at The Polar Research Inst. of China, Shanghai.

According to geochemical studies of I and hydrogen and oxygen isotopes, the ore-forming solution of Fenshuiao gold deposit in nothern Guangxi belongs to the Na-K-C-Cl-S system with low-middle T and middle pressure, shows weakly alkaline and reducing behaviors, is dominated by metamorphic water at the early stage and by formation water derived from meteoric water at the middle-late stage, showing obvious character of mixed genesis. Genetically, it is a stratabound gold deposit that has undergone alteration by groundwater or a so-called "Jiangnan" type gold deposit. (From authors' abstract by H.E.B.)

YANG, Fanglin, 1996, Mineralization background of large-scale epithermal hydrothermal gold deposits in West Tianshan (abst): 30th Int'l Geog. Cong., Abstracts, v. 1, p. 393. Author at Shenyang Inst. of Geol. and Mineral Resources, China.

The Axi epithermal hydrothermal gold deposit in West Tianshan in China is large-scale. Study of isotopes and I thermometry for the mineralization indicates that the gold deposits of this type are [related] to volcanic action. The ore materials are from the volcanic products and the basement rocks. The ore-forming T is 120-180°C and pressure is 100×10^5 pa. The ore-forming F is made mainly of meteoric water. The gold deposits are formed in a depth of about 400-500 m under the conditions of low sal, intermediate to alkaline (pH) and reduction (Eh). (From author's abstract by E.R.)

YANG, Kaihui and SCOTT, S.D., 1996, Magmatic fluid contributed to the hydrothermal system on the sea floor of the Manus Basin, Western Pacific (abst): 30th Int'l Geog. Cong., Abstracts, v. 1, p. 397. Authors at Marine Geol. Research Laboratory, Dept. of Geol., Univ. of Toronto, Canada.

"Black smokers" on the modern sea floor, an analog of ancient polymetallic massive sulfide deposits throughout geological history, are formed from the venting of high-T (up to 400°C) hydrothermal F. The conventional view is that these F originate from seawater-rock reactions in a convective hydrothermal system driven by a hot magma body.

Evidence for a magmatic contribution to an active, modern, submarine hydrothermal system has been found [by] means of a M I study of dredged volcanic rocks that host the PACMANUS Cu-Zn-Pb-Ag-Au polymetallic sulfide deposit in the eastern Manus Basin of Papua New Guinea. The major element composition of the silicate glass of the M I, trapped within phenocrysts of pyroxene and feldspar, is similar to the bulk analyses. However, compared with the matrix, the glass of the M I contains higher, relatively homogenous concentrations of water (6-9 wt%) and chlorine (0.1-0.3 wt%) indicating that the initial magma prior to degassing was enriched in these components. CO_2-rich bubbles, determined by Infra-red spectroscopy, in the M I within pyroxene phenocrysts represent an immiscible gaseous phase in the early phase of magma. Electron microscopy and microprobe analyses show that high concentrations of chlorides and sulfides of the ore-forming metals (Cu, Zn, Fe, Ni) and precious metals (Au, Ag, Pt, Pd) are precipitated on the walls of the CO_2-rich G bubbles. The concentrations of these ore metals are low in the volcanic rocks hosting the PACMANUS polymetallic massive sulfides (e.g., dacite with 5 ppm Ni, 57 ppm Cu and 79 ppm Zn), but they are highly enriched in the CO_2-rich magmatic F. This discovery demonstrates the existence of an ore metal-rich magmatic F, which was probably separated from a magma by depressurization and then transported to the hydrothermal systems that [are] forming the massive sulfide deposits on the sea floor. (From authors' abstract by E.R.)

YANG, Rongyong, XU, Zhaowen, REN, Qijiang, GUO, Jichun and LU, Xianchai, 1996, The type and metallogenic conditions of shuidongling zinc-copper deposit in Nanzhao, Henan Province: Acta Scientiarum Naturalium Universitatis Sunyatseni (Zhongshan Daxue Xubao), v. 35, no. 4, p. 95-100 (in Chinese; Engl. abst.). First author at Dept. of Earth Sci., Zhongshan Univ., Guangzhou, 510275.

Shuidongling zinc-copper ore deposit, which formed in Erlangping back arc basin in the early Palaeozoic Era, is situated in copper metallogenic prospect area and belongs to the typical Kurko [Kuroko?]type ore deposit. The metallogenic F is characterized by high K^+/Na^+ and F^-/Cl^- and low CO/CO_2 ratios. The T, f_{O_2}, pressure and pH value of metallogenic F [FI data] are 197~330°C, 3×10^{-31}~8.1×10^{-33} Pa, 77.97×10^5 Pa and 5.73~6.12 (t = 300°C) respectively. The isotopic features prove that metallogenic materials are derived from subjacent volcanics and the sulfur has a mixed source (magmatic water plus seawater). In addition, the magma played a role in the mineralization. (Authors' abstract)

YANG, Weiran and ZHANG, Wenhuai, 1996a, Tectonic fluids–a new research domain: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 124-130. Authors at China Univ. of Geosci., Wuhan 430074.

A review of the importance of tectonic F. (E.R.)

YANG, Weiran and ZHANG, Wenhuai, 1996b, Character of fault property and combination of fluid inclusions: Earth Sci. J. of China Univ. of Geosci, v. 21, no. 3, p. 285-290 (in Chinese).

YANG, Wenbo, KROUSE, H.R. and SPENCER, R.J., 1996, Improved techniques for stable isotope analyses of microlitre quantities of water from FI in halite and concentrated brines: Chemical Geol., v. 130, p. 139-145. First author from Dept. of Geol. and Geophys., Univ. of Calgary, Calgary, Alta, T2N 1N4, Canada.

A method has been developed to analyze both H- and O-isotope compositions of saline waters and FI brines without significant interference of salts. It involves high-T distillation under vacuum and reaction of the extracted water with zinc to produce H_2 for H-isotope analyses and with guanidine hydrochloride (GuHCl) to produce CO_2 for O-isotope analyses. Precisions of ±2‰ and ±0.3‰ for δD- and $\delta^{18}O$-values, respectively, can be realized with as little as 4 µl saline water for both elements. (Authors' abstract)

YANHE, Cui and SHAOMEI, Qi, 1996, The genesis of the Detiangou gold deposit, Beijing: Mineral Deposits, v

15, No. 2 (1996) p 156-164 [in Chinese; Engl. abst.]. Authors at Inst. of Mineral Deposits, Chinese Acad. of Geol. Sci., Beijing 100037.

The Detiangou ore deposit consists of gold-polymetallic quartz veins in Archean migmatized granulites, etc.; the hydrogen and oxygen isotope data of FI in quartz veins indicate that ore-forming F were mainly composed of magmatic water mixed with some meteoric water. The sulfur isotope composition ($\delta^{34} = -0.9‰\sim2.8‰$) of sulfides from the ore veins is close to that of meteoric sulfur, suggesting that the sulfur came from deep magma. The orelead isotopes are similar to lead isotopes of syenite dikes, indicating characteristics of mantle-derived materials. Ore-forming substances are also considered to have come from the mantle.

FI in quartz from the ore veins are composed of Na^+, K^+, Mg^{2+}, Cl^-, SO_{-4}^2, H_2O and CO_2, with an average sal of 5 wt% eq. NaCl.

The altered rock of ore veins has a K-Ar age of 147×10^5, a, suggesting that the Detiangou gold deposit was formed in Middle Yanshanian period. (From authors' abstract by E.R.)

YAO, Dexian, LI, Zhaolin, YE, Yinfa and **ZHANG, Shouji**, 1996, Geology and genesis of the Baoshan silver (antimony) deposit in eastern Guangdong (in Chinese; Engl. abst.): Mineral Deposits (Kuangchuang Dizhi), v. 15, no. 2, p. 123-132. First author at Dept. of Geol., Zhongshan Univ., Guangzhou 510275.

The Baoshan large-sized (antimony) deposit in eastern Guangdon has Early Jurassic volcanic-sedimentary rocks as host rocks. Silver and antimony contents of ore-bearing wall rocks are 3~2 orders of magnitude that of their abundances in identical rocks, and are 18~16 times their abundances in the same sort of rocks in eastern Guangdong, showing characteristics of source bed. The Yanshanian volcanic-subvolcanic rocks include quartz porphyry, diabase and basalt, which contain relatively high silver, with the concentration coefficient of silver being 33, 44 and 34 respectively. Volcanic acitivites brought such ore-forming materials as silver and antimony from the depth and caused activation and migration of ore-forming elements in wall rocks, which eventually entered hydrothermal solution.

Silver and antimony migrate mainly in the form of sulfur complex. The favorable conditions for the precipitation of silver and antimony are pH 6.5~7.0, Eh -0.54 eV, t 160~290°C, P $160 \times 10^5 \sim 175 \times 10^5$ Pam ore-forming depth 640~760 m, sal 2.23 wt%~19.04 wt% NaCl, and density 0.52~0.97 g/cm^3. Sulfur, lead, oxygen and hydrogen isotopic compositions and REE partitioning show that metallogenic substances and ore-forming F came mainly from magma at depth, with the addition of wall rock materials and meteoric water. The ore deposit is a shallow-seated medium-low T volcanic hydrothermal one, with filling as the major mineralization form.

FI data are given. (HEB) (From authors' abstract by HEB.)

YAO, Yong, MORTEANI, Giulio and **TRUMBULL, R.B.**, 1996, A geochemical study of the granite-hosted Niuxinshan gold deposit (Hebei province, NE China) (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 742.

The Niuxinshan gold deposit is a typical example of the numerous granite-hosted gold-bearing quartz vein deposits of eastern Hebei province, NE China. The gold mineralization is bound to intensely fractured and altered zones in the granite which contain quartz veinlets from one to 20 cm in thickness. The alteration is typically a sericitization and pyritization with Au contents up to 732 ppm. In the zones near quartz veins, where sometimes fluoritization is predominant, the Au contents are less than 35 ppb. FI studies show that the ore forming F consisted of CO_2-rich H_2O with a sal of 0.4-7.5 wt% NaCl eq., a minimum T of 217-368°C, and minimum P of 1.5-3 kbar. (From authors' abstract by E.R.)

YARDLEY, Bruce, 1996, Earthquakes with gold linings: Nature (London), v. 382, no. 6588, p. 210-211. Indexed under FI (E.R.)

YE, Xusun, YAN, Yunxiu and **HE, Haizhou**, 1996, A preliminary study on the metallogenetic factors of the world class tin-multimetal deposit in Dachang Guangxi (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 793. Authors at Inst. of Geol. for Nonferrous Metals, Nanning, China.

By the calculation of FI, the granite intruding depth of Daching is about 3-4 km, and the ore-forming depth may be 1-2.5 km. The age of ore is 101 ± 2.9 Ma, $^{87}Sr/^{86}Sr = 0.7174$ (determined from the FI of cassiterite and quartz in ore), both of them are similar to the granite's. (From authors' abstract by E.R.)

YESILYURT, Suleyman, 1995, Geology, geochemistry, and mineralization of the Liberty Bell gold mine area, Alaska (abst.): Symposium, Geology and Ore Deposits of the American Cordillera, April 10-13, 1995, Reno/Sparks, Nevada, sponsored by Geol. Soc. of Nevada, U.S. Geol. Survey, and Sociedad Geol. de Chile, published in Program with Abstracts, p. A79-A80. Author at Dept. of Geosci., Oregon State Univ., Corvallis, OR 97331.

The geology of the Liberty Bell Gold Mine Area is dominated by weakly metamorphosed volcaniclastic-sedimentary rocks of the California Creek Member of the Totalanika Schist of Devonian-Mississippian (?) age.

The principal ore minerals at Liberty Bell are arsenopyrite, pyrite, and pyrrhotite. Chalcopyrite, kobellite, ullmannite, bismuthinite, tennantite, and loelingite, amounts of enargite, covellite, bornite, sphalerite, galena, malachite, and native gold are also present. The ore minerals occur mostly as tabular-and stringer-replacement bodies disseminations, cross-cutting veins, and open space fillings.

Sulfides at Liberty Bell are slightly depleted in ^{34}S relative to the sulfur standard. The δS^{34} values range from +1.12 to -4.95 per mil, and an equilibrium T of 441°C was calculated froma pyrite-chalcopyrite pair. FI in hydrothermal quartz-tourmaline veins have sal ranging from 6.7 to 15.5% NaCl eq. Th of these I range from 170 to 470°C.

Evidence found in this study strongly suggests that the mineralization at Liberty Bell is epigenetic in origin. It is closely associated with proximity to the Late Cretaceous porphyry intrusions. Therefore, future exploration in the area should target these intrusions and their contact zones rather than emphasizing stratigraphic control as commonly dominated previous efforts. (From author's abstract by H.E.B.)

YONG, Lai, LUNAR, R., MORENO, T., HIGUERAS, P., and **MONTERRUBIO, S.**, 1996a, Inclusion studies and its interpretation – the P-T-t pathways of Cabo Ortegal Complex, northwest Spain (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11: 30th Int'l. Geol. Cong. Abstracts, v. 3, p. 550. First author at Dept. of Geol., Peking Univ., China.

The Cabo Ortegal Complex comprises peridotite associated with high-P granulite and eclogite, gneiss, and various mafic rocks, which are separated by mylonitic contacts. These units have specific lithologies and metamorphic histories. Although most of these units underwent retrograde events associated with ductile shear deformation and development of S amphibole and quartz, the P mineral I which formed in progressive metamorphism can still be found in some garnets. In the intense retrograde rocks, a kelyphyitic border around the early mineral is commonly observed under the CL microscope. These coronae display dark blue luminescence colour. This implies that the early minerals are not homogeneous, and the I which trapped in them still keep the progressive processes information. Base[d] on the elemental equilibrium between the host and I minerals, the garnets and S minerals, the outline of the P-T-t pathway about progressive and retrograde metamorphism could be obtained. The T from the I was around 800°C (at 15-20 kb), it is close to the conditions from the porphyroclasts. That shows the T did not distinctly change in the former stage. Additionally, the studies of FI in interstitial quartz provide the latest P-T circumstances. As a boundary, the WNW direction of the discontinuous silicified rocks, divide the complex into south and north parts. The south part underwent stronger deformation and higher T (North: Th 280-200°C, S 17-15.5%; South: Th 400-245°C, S 19-18%) during the retrograde event. The study of the silicified rocks (Th: 210-180°C, S: 4-1.5%) indicate that geothermal system activated along the WNW faults after the retrograde event. (Authors' abstract)

YONG, Lai, LUNAR, R., MORENO, T., HIGUERAS, P., and MONTERRUBIO, S., 1996b, Inclusion studies and their interpretation–the p-T-t pathways of Cabo Ortegal Complex, northwest Spain (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 34-35. First author at Dept. of Geol., Peking Univ., China.

See previous abstract (E.R.)

YONGFENG, Hua and YOUPING, Liu, 1996, A genetic model for the Wanshan super-large mercury deposit, Guizhou: Guizhou Geol., v. 13 (1996) p. 61-66 [in Engl.]. Authors at Guizhou Bureau of Geological Survey, Corporation of Nonferrous Metal Industry, China.

Based on the geologic study of the Wanshan super-large mercury deposit for over 30 years, the paper, beginning with deposition and ending on completion of the mineralization, analyzes in 4-dimension space-time the total process of origin, evolution and formation of the mercury deposit, and then, proposed the mineralization model for the mercury deposit.

Briefly discusses FI evidence. (HEB) (Authors' abstract)

YOU, C.-F., CASTILLO, P.R., GIESKES, J.M., CHAN, L.H. and SPIVACK, A.J., 1996, Trace element behavior in hydrothermal experiments: implications for fluid processes at shallow depths in subduction zones: Earth and Planetary Sci. Lett., v. 140, no. 1-4, p. 41-52. First author at Scripps Inst. of Oceanography, Univ. of California at San Diego, 9500 Gilman Drive, La Jolla, California 92093, USA.

Chemical evaluation of F affected during progressive water-sediment interactions provides critical information regarding the role of slab dehydration and/or crustal recycling in subduction, reactions between décollement sediments and synthetic NaCl-$CaCl_2$ solutions at 25-350°C and 800 bar were monitored in laboratory hydrothermal experiments using an autoclave apparatus. This is the first attempt in a single set of experiments to investigate the relative mobilities of many subduction zone volatiles and trace elements but, because of difficulties in conducting hydrothermal experiments on sediments at high P-T conditions, the experiments could only be designed for a shallow (~10 km) depth. The experimental results demonstrate mobilization of volatiles (B and NH_4) and incompatible elements (As, Be, Cs, Li, Pb, Rb) in hydrothermal F at relatively low T (~300°C). In addition, a limited fractionation of light from heavy rare earth elements (REEs) occurs under hydrothermal conditions. On the other hand, the high field strength elements (HFSEs) Cr, Hf, Nb, Ta, Ti, and Zr are not mobile in the reacted F. The observed behavior of volatiles and trace elements in hydrothermal F is similar to the observed enrichment in As, B, Cs, Li, Pb, Rb, and light REEs and depletion in HFSEs in arc magmas relative to magmas derived directly from the upper mantle. Thus, our work suggests a link between relative mobilities of trace elements in hydrothermal F and deep arc magma generation in subduction zones. The experimental results are highly consistent with the proposal that the addition of subduction zone hydrous F to the subarc mantle, which has been depleted by previous melting events, can produce the unique characteristics of arc magmas. Moreoever, the results suggest that deeply subducted sediments may no longer have the composition necessary to generate the other distinct characteristics, such as the B-δ^{11}B and B-^{10}Be systematics, of arc lavas. Finally, the mobilization of B, Cs, Pb, and light REEs relative to heavy REEs in the hydrothermal F fractionate the ratios of B/Be, B/Nb, Cs/Rb, Pb/Ce, La/Ba and LREE/HREE, which behave conservatively during normal magmatic processes. These results demonstrate that the composition of slab-derived F has great implications for the recycling of elements; not only in arc magmas but also in mantle plumes. (Authors' abstract)

YU, Xiaoying and SHI, Jixi, 1996, Infrared, ultraviolet and fluorescence analyses and their application in the study of organic inclusions: Acta, Mineralogica Sinica, v. 16, no. 2, p. 212-217 (in Chinese; Engl. abst.). Authors at Inst. of Geoch., Chinese Acad. of Sci., Guiyang, 550002.

Studies have been done on adsorbed organic matter and I organic matter in rocks by using the infrared, ultraviolet and fluorescence analytical methods. IR analytical results show that there are obvious oil peaks due to I organic matter in oil-generating rocks, which are significantly different in peak shape from those of adsorbed organic matter. Ultraviolet analytical results demonstrate that there are two types of organic matter which are characterized by different spectral characteristics in the oil-generating rocks, the opposite case is observed in non-generating rocks. Fluorescence spectral characteristics of the oil-generating rocks are: strong fluorescence intensity (>40), around 450 nm, and spectra being located in the blue-green light region, indicating a high-maturity oil stage. The infrared, ultraviolet and fluorescence analyses can be used as a combined method and index to evaluate the oil-generating potentiality and evolutionary extent of organic I. (Authors' abstract)

YU, Xuefeng, 1996, Geological characteristics and genesis of the Guilaizhuang gold deposit (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 769. Author at No.2 Geological Brigade of Shandong Bureau of Geol. and Mineral Resources, China.

Guilaizhuang deposit is a new type of large-sized gold deposit. Its wallrocks are mainly carbonates [associated with] a high-potassium alkaline subvolcanic multi-phase intrusion and late stage cryptoexplosive breccia to which the gold mineralization is closely related.

Three stages of mineralization are recognized as follows: (1) quartz-pyrite stage; (2) polymetallic sulphide stage; and (3) gold-telluride stage. Wallrock alterations include quartzification, fluoritization, sericitization, pyritization and argillization. The T for mineralization ranges from 120°C to 270°C, and the P and depth, no more than 36.0 Mpa and 1500 m, respectively. (From author's abstract by E.R.)

YUN, S.-T., CHOI, S.-H. and **SO, C.-S.**, 1996, Complex geochemical evolution of hydrothermal fluids related to polymetallic Cu-Zn-Pb mineralization of the Namseon mine, Gyeongsang Sedimentary Basin, Korea: N. Jb. Miner. Abh., v. 170, no. 2, p. 127-153.

The Namseon polymetalic Cu-Zn-Pb deposit has a complex ore mineralogy. Stage I is economically barren with abundant arsenopyrite. Stage II is further divided into three substages: IIa, quartz and minor base-metal sulfides with rare W–Mo-bearing minerals; IIb, carbonates and some quartz with base-metal sulfides; IIc, characterized by quartz with various sulfosalts.

FI data indicate a complex geochemical evolution of hydrothermal F. During stage I, high T (up to 550°C), high-sal (34.9 to 29.2 wt.% NaCl eq.) F were formed by condensation of a magmatic V phase at pressures between 750 and 500 bars. CO_2-rich (≈60 to 15 mole % CO_2) and H_2O-rich F trapped each as FI in substage IIa suggest the presence of a compositionally heterogeneous F formed by F boiling and associated CO_2 immiscibility, trapped at T of ≈400°C-300°C and F P below 900 bars. Fracturing due to high internal P prompted rapid decreases in pressure and T of residual F and retrograde F boiling (at 300-200 bars and 300°C-250°C) during substage IIb. This retrograde boiling resulted in CO_2 loss and drop in carbonate activity, causing deposition of abundant carbonates. Deposition of Ag, Sb, Bi and Te-bearing sulfides and sulfosalts within substage IIc occurred at T of ≈250°C to 150°C from a dominantly aq F with low sal (≤ 5.0 wt.% NaCl eq.). This substage IIc, aq F was formed by mixing with local meteoric groundwater. FI data and mineral paragenesis suggest that active deposition of economic Cu-Zn-Pb ores in the Namseon hydrothermal system have been triggered at T below about 350°C, probably as a combined result of progressive decreases of T (down to 250°C) and fugacity of sulfur. These variations of geochemical parameters were largely controlled by CO_2 effervescence and later retrograde boiling, and could result in destabilization and solubility decrease of chloride complexes of copper, zinc, and lead.

Stable isotope data accompanying with FI interpretation for stage I mineralization and/or main base metal mineralization of stage II (substage IIa and IIb) represent P magmatic water and/or water from any source whose isotopic composition was controlled by exchange with a large volume of igneous rocks at near magmatic T, respectively. I water from the substage IIc quartz have significantly lowered oxygen and hydrogen isotope values. This indicates that magmatic water was progressively replaced by meteoric water during the later substage IIc mineralization. (From authors' abstract by E.R.)

YUN, S.-T., SO, C.-S. and **YOUM, S.-J.**, 1996, Geochemical studies of W–Mo vein deposits in Susan area, Hwanggangri district,Korea: Metal zoning related to progressive meteoric water mixing in a granitic hydrothermal system: Trans. Instn Min. Metall. (Sect. B: Appl. Earth Sci.), v. 105, May-August, B101-B116, 1996.

Tungsten-molybdenum deposits in the Susan area of the Hwanggangri district, Korea, consist of greisen-bordered quartz veins that are spatially, temporally and genetically associated with a late Cretaceous (88-89 m.y.), I-type, potassic biotite granite that intrudes an early Palaeozoic limestone-rich formation. Paragenetic data indicate three stages of hydrothermal mineralization: greisen-molybdenite-wolframite (38.9-75.2 mole% hübnerite)-scheelite mineralization (stage I); base-metal sulphide mineralization (stage II); and fluorite-carbonate mineralization (stage III).

FI and stable isotope data indicate that hydrothermal veins formed over a T range of 120-395°C from low-sal (0.2-9.6 eq. wt% NaCl) F. Early tungsten (as wolframite) and molybdenum (as molybdenite) deposition in stage I occurred at T of 300-395°C from magma-derived ($\delta^{34}S_{\Sigma S}$ = 3-4‰, $\delta^{18}O$ water ≈ 7‰, δDwater ≈ -55‰), low-sal, CO_2-rich F, mainly as a result of F boiling and associated CO_2 effervescence (accompanying pH increase). Following the early W–Mo deposition, progressively larger volumes of local meteoric water (δD - 140‰) entered the hydrothermal system, resulting in the successive deposition of scheelite (in stage II vughs), stage II base-metal sulphides and stage III fluorite-carbonates. The significant depletion of CO_2 in the ore F marks the change from deposition of wolframite to later scheelite. Remobilization of tungsten and its later deposition as scheelite in the outer and shallower portions of the hydrothermal system occurred at T of 215-275°C from F with $\delta^{18}O_{water}$ ≈ 2-3.5‰ and δD_{water} ≈ -80 to -71‰. Later mineralization of stages II and III was from lower-T F that became progressively lighter in stable isotope compositions: for stage II T = 210-335°C, $\delta^{18}O_{water}$ ≈ -4 to +4‰ and δD_{water} ≈ -86 to -74‰; for stage III T = 120-255°C, $\delta^{18}O_{water}$ ≈ -6 to +1‰ and δD_{water} ≈ -86 to -84‰.

It is concluded that the influx of meteoric water into the hydrothermal system increased with distance from the centre of the cooling pluton and resulted in a sequence of W–Mo, base-metal sulphides and fluorite-carbonate mineralization. (From authors' abstract by E.R.)

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): Dok. Ross. Akad. Nauk, v. 336, no. 4, p. 518-520 (in Russian, translated in Trans. (Doklady) of Russian Acad. Sci., Earth Sci. Sect., v. 336, p. 96-100, 1996). Authors at Research, Production and Training Center, State Committee on Geol. and Mineral Resources of Uzbekistan, Tashkent.

YUZHAO, Hu, YINLIANG, Cui and **LIU, Weihua**, 1996, On the geological characteristics and genesis of the Chahe Cu deposit, Yuanjiang: in "Yunnan Geology", v. 15, no. 2 (1996) p. 154-163 (in Chinese with Engl. abst.) First author at Dian-Qiang-Gui Petroleum Inst.

The Chahe Cu deposit is a polygenetic mineral deposit in the Kang-Dianearth axis. In this paper, the original rock of the Chahe metamorphic rock series is recovered according to the macroscopic and microscopic characteristics, chemistry, trace elements and heavy minerals; the metamorphic rock is correlated in isotope dating, REE and stratigraphical characteristics with the related strata of the Kang-Dian area; 3 macroscopic and microscopic geological characteristics of this mineral deposit are described and the properties of metallogenetic F are discussed by using the test results of Th and composition of I. In the end, the relation between the metallogenesis and the evolution of Archaeozoic and Early Proterozoic earth crust is discussed basing upon the theory of the rift. (Authors' abstract)

ZAGORSKIY, V.Y., PROKOF'YEV, V.U. and **KUZ'MINA, T.M.**, 1992, Melt inclusions in spodumene and quartz from rare-metal pegmatites: Dokl. Akad. Nauk, v. 327, no. 8, p. 121-124 (in Russian)

ZÁK, Karel, DOBES, Petr and **SZTACHO, Petr,** 1996, Vein-type hydrothermal deposits of the Bohemian Massif: Evolution of hydrothermal fluid sources and relation to extension events in the crust: Global Tectonics and Metallogeny, v. 5, no. 3 & 4, p. 175-178. Authors at Czech Geol. Surv., Klarov 3, 11821 Prague, Czech Republic.

Geochemical tools (C, O, S, Sr, and Pb isotopes, FI) were used to estimate hydrothermal F sources and conditions of ore deposition of selected sulfide, uranium, fluorite and barite mineralization types. (From authors' abstract by H.E.B.)

ZANETTI, A., VANNUCCI, R., BOTTAZZI, P., OBERTI, R. and **OTTOLINI, L.**, 1996, Infiltration metasomatism at Lherz as monitored by systematic ion-microprobe investigations close to a hornblendite vein: Chemical Geol., v. 134, p. 113-133. First author at Dipartimento di Scienze della Terra, Univ. di Pavia, via Abbiategrasso 209, I-27100 Pavia, Italy.

ZAW, Khin, HUNNS, S.R., Ryan, C.G. and **MERNAGH, T.P.**, 1996, Chemical composition of fluid inclusions from the Mt. Chalmers VHMS deposit, Australia, bearing on source of ore-forming fluids (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special issue from Workshop at 30th I.G.C., p. 31-32. First author at CODES Key Center, Univ. of Tasmania, Hobart, Tasmania, Australia 7001.

See Khin Zaw et al., FIR 28, p. 72-73 (E.R.)

ZENG, Nanshi, IZAWA, Eiji, WATANABE, Takashi and **MATSUKI, Masayoshi,** 1996, Hydrothermal alteration zoning and micaceous minerals in the Otoge epithermal Au-Ag system, Yamagata Prefecture, Japan: Resource Geol., v. 46, no. 6, p. 355-368. First author at Dept. of Mining, Kyushu Univ., Hakozaki, Fukuoka 812-81, Japan.

The Otoge mine is located near the southern border of Yamagata Prefecture. Since the discovery of Au-Ag mineralization near the mine, the area has become an active target of exploration for gold. Pyroclastic rocks in the area, which are mostly dacitic to rhyolitic compositions, were subjected to intense hydrothermal alteration.

Based on mineral assemblages, six alteration zones: the propylitic, smectite, interstratified I/S, sericite, kaolin and pyrophyllite zones, were defined.

Chemical and mineralogical data suggest that the pyrophyllite and kaolin zones formed by acid hydrothermal F, and the sericite zone associated with Au-Ag bearing quartz veins resulted from a near neutral pH hydrothermal activity. The crosscutting relationship and age data indicate that the acid hydrothermal lateration was followed by the near neutral pH sericitization and Au-Ag mineralization. All these hydrothermal activities occurred during 4.7-4.0 Ma. (From authors' abstract by E.R.)

FI in quartz given an average Th of 296±°C for quartz veins from the deep pyrophyllite zone, 284±7°C for quartz veins from the deep sericite zone, and 250±13°C for quartz network from the shallow sericite zone with silicification (Zeng et al., in prep.).

If we assume the T of mineralizing solution at a given depth was close to the boiling point for the corresponding hydrostatic P, the depth of mineralization can be estimated from the above-mentioned T. Based on the data of Haas (1970), the depth from the paleosurface is >450 m at the zone of silicification in the clay pit (1000 m level) and >800 m at the deep part (650 m level) where quartz veins were formed. This indicates that, at least, the overburden of 450 m has been eroded at the Otoge clay deposit during the past 4 Ma. (From authors' text by E.R.)

ZENG, Yishan, 1996, Geochemistry of hydrothermal solutions: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 89-95. Author at Dept. of Geol., Peking Univ., Beijing, 100871.

The geochemical aspects and their recent progresses in experimental and theoretical studies of hydrothermal solutions are briefly described: the thermodynamic properties, equation of state, dielectric constant, conductivity and dissociation equilibrium of water at high P and T: the phase relations and equations of state for the $NaCl-CO_2-H_2O$ system and its component systems ($NaCl-H_2O$ and CO_2-H_2O), especially some new results obtained by synthetic FI techniques and molecular dynamics simulation; the electrical conductances of dilute electrolyte solutions at elevated T and P; the estimation of standard partial molal thermodynamic properties and relevant physicochemical parameters of various species in aq solutions at elevated T and P based on the HKF model; speciation in hydrothermal solutions (mineral solubility determination, potentiometric and spectroscopic study of hydrothermal F); infrared absorption and Raman spectroscopic studies of the structure of water and hydrothermal solutions; the transport properties (viscosity and heat conductivity) of hydrothermal solutions. (Author's abstract)

ZHAI, Jianping, HU, Kai, and **LU, Jianjun,** 1996a, Genesis and geological-geochemical characters of the Rushan gold deposit, Shandong, China: Chinese J. of Geochem. (Zhongguo Diqiu Huaxue Xuebao), v. 15, no. 3, p. 203-212 (in Engl.). First author at Nanjing Univ., Dept. of Earth Sci., Nanjing, China.

The Rushan gold deposit, explored in recent years in the Jiaodong area, Shandong Province, is a quartz vein-type gold deposit hosted in granite. The T of its major mineralization episode is between 220 and 280°C. The sal of the ore-forming F is 5% to 9% NaCl eq., with H_2O and CO_2 as the dominant G constituents. The F is rich in Na^+, Ca^{2+} and Cl^-, but relatively impoverished in K^+ and F^-. Rb-Sr isochron ages of the deposit and the host Kunyushan granite are 104.8+ or -1.5 Ma and 134.6 Ma. It is considered that the emplacement of the lamprophyre under a tensile environment had provided sufficient heat energy to facilitate deep circulation of meteoric water by which ore metals were extracted from the Kunyushan granite through long-term water-rock reaction. (Authors' abstract)

ZHAI, Jianping, HU, Kai and **LU, Jianjiong,** 1996b, Geneses of Lushan gold deposit–evidence of ore-forming and H, O, Sr isotopes: Chinese Sci. Bull. (Keue Tonghao), v. 41, no. 12, p. 1119-1121 (Engl.).

ZHAI, Jianping, HU, Kai and **LU, Jianjun,** 1996c, A study on geochemistry of ore-forming fluid of the Qixia gold deposit: Geochimica (Diqiu Huaxue), v. 25., no. 6, p.

568-574 (in Chinese; Engl. abst.). Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing 210093)

The Qixia gold deposit is one of the important quartz-vein types hosted in metamorphic rocks in the east of Shandong, China. The T (FI data) of its major mineralization episode is between 180°C and 310°C. The sal of the ore-forming F is 4.2% to 7.9%, with H_2O and CO_2 as dominant G constituents. The F is rich in Na^+, Ca^{2+} and Cl^-, but relatively impoverished in K^+ and F^-, characterized by either $Ca^{2+}>Na^+>K^+$ (in five samples) or $Na^+>Ca^{2+}>K^+$ (in two samples), and similar to that of the ore-forming F derived from meteoric water. Hydrogen and oxygen isotopes in the ore-forming F are highly variable with $\delta^{18}O_{H_2O}$ ranging between -3.6‰ and 4.5‰ and δD_{H_2O} between -56‰ and -92‰. These isotopic values had fully reflected the distributive features of meteoric water exchanging with metamorphic focks of Jiaodong Group in different T and W/R ratios. (Authors' abstract)

ZHAI, Jianping, HU, Kai and **LU, Jianjun,** 1996d, Lamprophyres ore-forming fluids and H, O, Sr isotope studies of the Rushan gold deposit: Mineral Deposits (Kuangchuang Dizhi), v. 15, no. 4, p. 358-364 (in Chinese; Engl. abst.). Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing 210093.

The Rushan gold deposit, one of the quartz-vein type deposits is located in biotite monzonitic granite of Kunyushan complex pluton in Jiaodong region of China. Analyses show that gold content of lamprophyres from the gold deposit is not higher than that of common igneous rocks, the average gold abundances of all types of lamprophyres do not show obvious differences and vary around 2.5×10^{-9}, suggesting that in Jiaodong region it was quite impossible for lamprophyres to provide gold mineralization with material. The main metallogenic stage of the Rushan gold deposit has a T of 220~280°C, and the wt.% NaCl eq. values of ore-forming F range between 5% and 9%, the gaseous phase in the FI are dominated by H_2O and CO_2, and the L phase are rich in Na^+, Ca^{2+}, Cl^-, poor in K^+, F^-, and characterized by $Ca^{2+}>Na^+>K^+$ (three samples) or $Na^+>Ca^{2+}>K^+$ (six samples), quite similar to the composition of the ore-forming F derived from meteoric water. Initial data on the hydrogen and oxygen isotopic compositions of ore-forming F fall within a wide range: δD_{H_2O}= -128‰~-71‰ per mil and $\delta^{18}O_{H_2O}$=7.7‰~6.0‰ per mil, relative to SMOW; nevertheless, meteoric water alone can evolve into the observed isotopic compositions of the gold deposit through isotopic exchange reaction with granitic rocks at T between 200°C and 350°C. The Rb-Sr isochron age of the Rushan gold deposit and its country rock Kunyushan biotite granite is $(104.8 \pm 1.5) \times 10^6$a and 134.3×10^6a, respectively, with $(^{87}Sr/^{86}Sr)$ being 0.71307 and 0.7096 respectively. The time interval between the crystallization of the granite and the formation of the deposit is very long ($\geq 30 \times 10^6$a), but the $^{87}Sr/^{86}Sr)_i$ ratio of the gold mineralization is close to that of the granite. A genetic model in which the meteoric water react with granitic rocks at different T and W/R ratios can be used to explain the metallogenic mechanism of the Rushan gold deposit. (Authors' abstract)

ZHAI, Jianping, HU, Kai and **LU, Jianjun,** 1996e, Discussions on the applications of hydrogen and oxygen isotopes to the problems of ore genesis: Scientia Geologica Sinica, v. 31, no. 3, p. 229-237.

ZHAI, Yusheng, 1996, Problems in the study of structure-fluid ore-forming processes: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 230-236. Author at China Univ. of Geosci., Beijing, 100083.

A review based on approaches at 4 scales, global to microscopic. (E.R.)

ZHANG, Bangtong, CHEN, Peirong, CHEN, Diyun and **NI, Qisheng,** 1996, On the metallogenic physicochemical condition and material sources of no. 570 U (Ag, Mo) deposit of cryptoexplosive clastic rock type in north Fujian: Geological J. of Univ., v. 2, no. 2, p. 187-197 (in Chinese; Engl. abst.). Authors at Dept. of Earth Sci., Nanjing Univ.)

The study of FI showed that the ore-forming T is 150-180°C, enriched in HCO_3^-, F^-, SO_4^{2-}, K^+, Na^+, but has comparative[ly[low sal (1.25-1.48% NaCl eq.): and uranium moved mainly as $UO_2(CO_3)_2^{2-}$, $UO_2(CO_3)_3^{4-}$, $UO_2F_4^{2-}$, $UO_2F_3^-$ in the ore-forming solution. According to hydrogen and oxygen isotope studies, volcanic hydrothermal solution and meteoric water mixed. The geochemistry of Pb, S, C isotopes and trace elements from country rocks indicates that the ore-forming material has multiple sources in close relationship with basement rocks. It is determined that uranium is contributed mainly by the Gaxi granite body and felsic volcanic rocks of the Nanyuan Formation, molybdenum is derived from volcanogenic hydrothermal solution, but silver is mainly from metamorphic rocks of the Mayuan Group. (From authors' abstract by E.R.)

ZHANG, Dequan, LI, Daxing, ZHAO, Yiming, WANG, Wengui, and **GU, Guangxian,** 1996, The Wuziqilong copper deposit – the reformed upper part of a porphyry copper deposit (in Chinese; Engl. abst.): Mineral Deposits (Kuangchuang Dizhi), v. 15, no. 2, p. 109-121. First author at Inst. of Mineral Deposits, Chinese Acad. of Geological Sci., Beijing 100037.

The Wuziqilong deposit adjacent to the Zhongliao copper deposit occur on the side of an Early Cretaceous volcanic pipe filled with dacite porphyry.

Detailed geochemical sampling reveals an element zonation of Au (Ag, Cu) -Cu (Pb, Zn) -Cu-Mo from the upper part of the Wuziqilong deposit to the depth of the Zhongliao depost. FI and O-H isotope studies indicate that three types of fluids exist in the deposits. The first is high T and high sal F which comes from magmatic water and results in potassic alteration. The second, characterized by moderate to high T and sal, is a mixture of magmatic water and meteoric water that leads to phyllic alteration and porphyry copper mineralization. The third F, characterized by acid and lower T and sal, is derived from water-rock exchange under higher water-rock ratio value. This F is superimposed on porphyry copper alteration and mineralization from lower part upward through transformation, forming acid-sulfate type alterations and mineralization of the Wuziqilong deposit.

Evidence mentioned above suggests that the Wuziqilong deposit represents the partly reformed upper part of the deep Zhongliao porphyry copper syste. Rb-Sr isochron and K-Ar dating yielded ages of 105 x 10^6 a, 103 x 10^6 a and 100 x 10^6 a for granodiorite porphyry, potassic alteration and alunitic alteration respectively. (From authors' abstract by HEB.)

ZHANG, Fuxing and **SHEN, Ping,** 1996, Study on metallogenic physicochemical conditions and metallogenic mechanism of the Qinling micro-disseminated gold deposit in Zhen'An County, Shaanxi Province: Geol. and Prospecting, v. 32, no. 5, p. 8-15 (Chinese)

ZHANG, Guoheng, 1996, Mineralization characteristics of the association of microgranular disseminated gold deposit and silver deposit in Changkeng (abst.): 30th Int'l Geol. Cong., Abstracts., v. 2, p. 767. Author at 757 Geological Party of BGMR of GD Prov., China.

Both orebodies are stratiform, containing relatively high As, Sb, Hg and Ba, but the gold body also contains relatively high Bi and the silver body, relatively high Au and relatively low Co and Se. Sulfur isotopic composition of both orebodies displays a dispersion type distribution, with $\delta^{13}C$ averaging 13.41% [sic], sample points falling near the meteoric water line in the δD vs $\delta^{18}O$ diagram [sic], and lead isotopic data showing the nature of both source region lead and marine radiogenic lead. Organic matter and pure L phase are common in FI, while the average decrepitation T is 238°C for the gold body and 254°C for the silver body. (From author's abstract by E.R.)

ZHANG, H.-L. and **HAN, S.-J.**, 1996, Viscosity and density of water + sodium chloride + potassium chloride solutions at 298.15 K: J. Chem. Eng. Data, v. 41, p. 516-520. Authors at Dept. of Chem., Zhejiang Univ., Hangzhou 310027, P.R. China.

ZHANG, Jiang and **ZHANG, Xiangzhou**, 1996, Geological amd geochemical characteristics of Yamansu iron deposit in Xinjiang, Hami area and discussion of deposit origin (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 646. Authors at NW Bureau of Geol. and Expl., China.

Yamansu iron mining district is located in basic pyroclastic rocks. The orebody was metasomated along the fracture in the mineralization epoch, infilling in basaltic crystal tuff, volcanic breccia, agglomerate and limestone. The ore mineral is mainly magnetite (35 - 95), and then hematite, martite; the metallic sulphide is mainly pyrite (4 - 35%) and then chalcopyrite, galena, sphalerite, pyrrhotite. The gangue mineral is mainly garnet and then chlorite, actinolite and epidote. After measurement, the average $\delta^{34}S$ content in pyrite in ore mineral 1.95‰. It is close to the sulphur isotope composition in the spherulite meteorite (in which $\delta^{34}S$ content is 1.30-1.20‰). The $\delta^{18}O$ content in ore mineral magnetite is 4.92-5.25‰, which is close to that in basalt and andesite (5.50-7.40‰). The content of $\delta^{18}O_{H_2O}$ in callite [sic] in the iron vein is 8.31‰, which is right in the range of $\delta^{18}O_{H_2O}$ in primary magmatic water. So it follows that ore-bearing G-L in mineralization period is mainly from P magmatic water. After measurement, the ore-forming T of ore mineral magnetite is 476°C. The gangue mineral garnet associated with magnetite, whose ore-forming T is 310-800°C. So it can be concluded that ore-bearing G-L is mainly high T G-L. The ore-bearing G-L belongs to the type of NaCl (whose content of NaCl is 2.72-12.88‰ [sic]). On the whole, this iron deposit is volcanic G-L replacement-filling deposit. (From authors' abstract by E.R.)

ZHANG, Ligang, LIU, Jingxiu, CHEN, Zhensheng, and **YU, Guixiang,** 1996, Hydrogen and oxygen evolution for water-rock system in super-huge Tongchang copper deposit, Jiangxi Province: Scientia Geologica Sinica, v. 31, no. 3, p. 250-263 (In Chinese, Engl. abstr.). Authors at Yichang Inst. of Geol. and Mineral Resource, CAGS, Yichang 443003).

The super-large Tongchang disseminated porphyry Cu deposit in Dexin, Jiangxi Province, occurs in the contact zone between granodiorite porphyry and the low grade metamorphic tuff. A fairly systematic oxygen (hydrogen) isotope study was made on different stages of ore-forming F and altered rocks in the deposit. It is known that for the main ore-forming stage of quartz veins, $\delta^{18}O$=1.9‰ to -2.5‰ and δD=-54‰ to -62‰, and that for hydrothermal solution of the late stage of quartz vein, $\delta^{18}O$=-3.4‰ and δD=-57‰. Systematic sampling and oxygen isotope analysis in the deposit open pit show that there are at least 5 water-rock interaction low ^{18}O centers, quite coincident with the localities of superhuge copper orebodies.

The δD of altered rocks (whole rock) and ore-forming F are about -85‰ and -60‰, respectively, showing an equilibrated fractionation between altered minerals and mineralization F. The water content in altered rock is higher than 2% in Tongchang Cu deposit but lower than 2% in the other deposits such as Yinshan. Lengshuikeng mine near by the Tongchang mine in which appear H isotope kinetic fractionation in water-rock interaction system. Studies show that the higher H_2O content in Tongchang is related to the superimposed water-rock interactions.

The effective W/R ratio and T for the Tongchang porphyry type Cu (Mo) deposits at the hydrothermal F reservoir forming period is 0.5 to 1.0 and 300°C, but it is higher than 10.0 and lower than 250 during the water-rock interactions mineralization deposition. In addition, the minimum effective H_2O weight in water-rock system in super-giant copper district is about 1.9×10^{10} tons. (From authors' abstract by E.R.)

ZHANG, Ligang, LIU, Jingxiu, YU, Guixiang and **CHEN, Zhensheng,** 1996, Hydrogen and oxygen isotope study on the water-rock interaction of the Yinshan (Cu) Pb-Zn-Ag ore deposit, Jiangxi Province: Acta Geologica Sinica (Engl. edition), v. 9., no. 3, p. 274-289. Indexed under FI (E.R.)

ZHANG, Lisheng, On genesis of a new type – vein tetrahedrite-type of copper deposits (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 730. Author at Chengdu Inst. of Geol. and Mineral Resources, CAGS, China.

A new type – vein tetrahedrite-type of copper deposits is discovered in Lanping and Simao basins, Yunnan, China. The orebodies are steeply dipping veins confined to limestone and clastic rocks. Tetrahedrites predominate over other ore minerals. Main gangue minerals are barite, calcite, ankerite, siderite and quartz. The host rock under-went silicification, carbonatization and baritization.

The tight clustering of $\delta^{13}C$ for the hydrothermal carbonate and for CO_2 I in quartz is between -3‰ and -7‰ which is identical with that of $\delta^{13}C$ for mantle-derived volcanic gas and for CO_2 I in oceanic ridge basalt. The very tight clustering of $\delta^{34}S$ for sulfides from the ores suggests that ore material was derived from mantle or deep-seated crust other than the host rocks.

T of the ore F was 100-300°C. The sal was more than 5-10 eq. wt% NaCl. The ore F contained Cl^-, SO_4^{2-}, Na^+, Ca^{2+}, K^+, Mg^+ and CO_2, N_2, CH_4, CO. The pH and Eh values are estimated at 5.9 - 9.24 and -0.38 - +0.38, respectively. $\delta^{18}O$ values of water of the FI are -11.56 - +9.77‰, δD values -- -60 - -135.6‰. Plot of δD versus $\delta^{18}O$ suggests that water of the ore F was derived from meteoric water, initial magmatic water and metamorphic water. (From author's abstract by E.R.)

ZHANG, Mingxian, 1996a, Discussion on hydrothermal solution boiling and gold mineralization (abst.): Abstracts, Fluid Inclusions and Hydrothermal Experiments, IGC Workshop/Shortcourse, Aug. 10-11, p. 4. (Note: this abstract was distributed at the I.G.C. Workshop/ Shortcourse, but was not printed in the official 30th I.G.C. Abstracts volumes) Author at Inst. of Southwest Geol. Exploration Bureau, MMI, Chengdu, China, 610051.

There is close relation between gold mineralization and boiling of hydrothermal solution--boiling [may] lead to physical-chemical condition change of gold-bearing hydrothermal solution.

The study on FI in Chucha-Luanshigou gold deposit in Henan province of China shows that the I during main mineralization period are boiling ones, which indicates [that the] ore F had been in non-miscible boiling state. Main mineralization period contrast to S one; further study of the I shows sal increase by 30-50%, pH value increase 0.5, and $\log fo_2$ reduce to -26 to --36. All these clearly indicate boiling of hydrothermal solution may lead to change physical-chemical condition of ore solution.

Because hydrothermal solution boiling result in T reduction, CO_2 and H_2S escaping, pH value of F increasing, pyrite and silicate precipitating, further, base metal sulfide are also precipitated and wall rock altered, reducing sulfur of the F violently lost, gold-bearing complex dissociated, so base metal vein type gold mineralization in geothermal system is formed. This gold precipitation mechanism should be understood more clearly from the facies map of gold solubility that A. Lewis made in 1984, i.e., main control gold precipitating factor is solution reduction, secondary is the decrease of T and increase of pH value. The study on FI geochemistry shows that hydrothermal solution boiling action may make hydrothermal ore-forming solution change toward the physical-chemical condition in favour of gold precipitation.

The decrease of P is the necessary condition that make hydrothermal solution boil. The hydrothermal solution boiling action due to structure depressurization may be considered an important mechanism of base metal vein type gold mineralization in geothermal system. This is perhaps a certain revelation that main place of gold mineralization occurs in S fault depressurization zone near deep dissection fracture. (Author's abstract.)

ZHANG, Mingxian, 1996b, Discussion on hydrothermal solution boiling and gold mineralization (abst.): APIFIS (Asian and Pacific Int'l. Fluid Inclusion Society) Newsletter, Special Issue from Workshop at 30th I.G.C., p. 52-53. Author at Southwest Geol. Research Inst., MMI.

See previous abstract. (E.R.)

ZHANG, Ronghua and **HU, Shumin**, 1996, Observation of two phase immiscible region of NaCl solution through diamond anvil cell at high pressures and temperatures (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 3, p. 556. First author at Open Research Laboratory of Geochem. Kinetics, Ministry of Geol. and Mineral Resources, Chinese Acad. of Geol. Sci., Inst. of Mineral Deposits, Baiwanzhuang Rd. 26, Beijing 100037, China.

Authors report that the hydrothermal diamond anvil cell (HDAC) has been used to observe the phase relations of NaCl-H_2O system by optical microscope at P up to 9-10 kb and T from 25 to 850°C. HDAC was described by Bassett and Chou in several papers. A single crystal of halite was placed in distilled, NaCl solution (deionized water saturated with halite) and along with an air bubble inside of the sample chamber. By using a microscope connected to HDAC, the visual observations of the phase relationship of the NaCl solutions (near wt. 35%) are carried out in the 3 phase (S+L+V) co-existence region, starting at room T and P. S+L+V means solid + liquid + vapor. The sample was then heated until the bubble disappeared (homogenization, Th). By repeat heating and cooling, obtain the accurate T of the air bubble disappearance, Th. Once this easily recognized phenomenon was observed, the heating was halted and sample was cooled along an isochrone [sic] Ic until a V bubble reappeared. According to the state equation of NaCl solution, each isochrone is corresponded to one Th. The heating path line is along an isochrone for a constant L-V Th (iso-Th) in P-T space for a given sal of brine solution. As sample was further heated, both the T and P of the homogeneous F (or supercritical one) increased. Then continue to heat the HDAC and observe the phase transition. The isochore of L after halite dissolving (V+L+S —> L+S —> L), isochore of L from L+V+S —> L, and isochore of L from L+V+S —> L+V —> L have been studied by many scientists, and can be figured out theoretically. In this study, test the phase relation is along the isochrone (V+L+S —> L+S —> L), at first. The observations found the path along the isochrones at Th of 193, 208, 216 and 226°C. The isochrone density was determined from the Th along the L-V curve and the transition P was determined from the T of fringe movement along the isochrone. As heating you may find that the solid dissolves and disappears at 246°C (L+S —> L), if cooling again, then solid appears. So we correct the T of solid disappearance, T(L+H —> L), called Tm, which ranges from 246 to 258°C. As continue to observe one L phase, to heat up to >800°C in the supercritical F region. While cooling, it was found: there is a two phase immiscible region (L+V), as T reach about 700°C. The highest immiscible T, Tim, is about 721°C. The P could be estimated by theoretical calculation, as [by?] assume the path of increasing T along the theoretical isochrone. These important phenomena were observed almost in the range of 550 to 700°C (P is about 3-5 kb). The two phases are the high P V and L. As T lower than 650°C, it looks like a boiling phenomenon, that phase transition between V and L is very rapid, where bubbles are exploding. Note that the study of critical state of brine solutions has been investigated in the last 10 years, but a few studies work on the saturated NaCl solution at P above 2 kb. Authors consider that the phenomenon observed in this study likes the phenomenon of water critical point, which authors have observed in Pr. Bassett's laboratory, Cornell Univ. Authors believe this immiscible two phase region is near to the critical line of NaCl-H_2O solution at high T and P. At least, this region has the nature of the extended critical state region for brine solution. In the two phase immiscible region, it is found that the V bubbles charged and they are pulled to each other by charged bridge, which would be made of the charged aq species. From the microscopic observation, it is found that the NaCl in V phase has the high dissociation constant of NaCl than that in L phase. For this observation, that authors recorded this phenomena by video system, and suggest a subcritical region called ??? Authors will continue to check and to illustrate these phenomena. One can apply the perturbation theory, a new equation of state for water is developed in which water molecules are "softened" hard spheres with dispersion, dipole and induction interactions. Then, a new equation of state of NaCl-H_2O solution is futher developed in which the ionic hard sphere mixture is taken as reference state and ion-dipole and ion-induced dipole interaction as perturbation terms. (Authors' abstract, sic)

ZHANG, Ronghua, HU, Shumin and **WANG, Jun**, and 1996, Fluorite deposition in the Mesozoic continental volcanic area, in the East-Southen China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 711. Authors at Open Research Laboratory of Geochemical Kinetics, Ministry of Geol. and Mineral Resources, Chinese Acad. of Geological Sci., Inst. of Mineral Deposits, Beijing, China.

Large mineral deposits of fluorite occur in the Mesozoic continental volcanic area in the East-Southern China. In the Dalingco Pb/Zn mineral deposit, Zhejiang province, the big vein is associated with strong alteration: silicification, argillaceous alteration including kaolinite and sercite. Main mineral deposition sequence is: quartz + manganese spar, galena + sphalerite, fluorite + barite. It was found that the Pb/Zn mineral deposition occurs in a repeat aperiodic oscillation process, in a chaotic oscillation process.

This mineral deposition formed in three stages: a) quartz-sulfide stage, filling T of FI, Th is from 290 to 350°C; b) Pb-Zn sulfide stage, with Th of 154 - 332°C and sal of 9.6 - 11.2%; c) quartz-sphalerite, with Th of 180 - 220°C, and sal of 3.1 - 4.2%. The $\delta^{34}S$ in galena ranges from -0.2 - 5, $\delta^{34}S$ in sphalerite: 3 - 7.3; $\delta^{34}S$ in pyrite: 2.9 - 4.3. The initial $\delta^{34}S$ in hydrothermal fluid is about 3.5 - 5. Some $\delta^{34}S$ in sphalerite changes with depth of their location. (From authors' abstract by E.R.)

ZHANG, Wenhuai, ZHANG, Zhijian, MING, Houli, WU, Gang and **YE, Song,** 1996, A study on organic inclusions in clastic reservoir rocks and their application to the assessment of oil and gas accumulations: Chinese J. of Geochem., v. 15, no. 3, p. 249-257 (in Engl.). Authors at China Univ. of Geosci., Wuhan, 430074.

The study shows that organic I are mostly distributed in the S fissures and pores which were formed in the process of oil-rock interaction, rather than in the cements or S enlargements. The organic I are dominantly organic G-rich or are composed of pure hydrocarbons. Th range mainly from 120°C to 130°C, which shows a relatively high maturity of organic matter. Vertical and horizontal T changes provide the grounds for the investigation of basin evolution and thermal F-kinetics model. Fluorescence spectral characteristics of the organic I indicate that oils and G in the area studied probably have experienced two-stage or two-time migration. Micro-fluorescence research is one of the effective approaches to oil/source correlation and oil migration-stage determination. The abundance and occurrence of organic I is one of the indicators of oil and G abundance and accumulation in rock layers. With the help of other information, organic I can provide the basis for the prospective assessment of oil and G in clastic reservoir rocks. (From authors' abstract by E.R.)

ZHANG, Wenhuai, ZHANG, Zhigian and **WU, Gang,** 1996, Ore-forming fluid and mineralization mechanism: : Earth Sci. Frontiers (Dixue Qianyuan), Special Issue on Fluids of the Earth's Interior, v. 3, no. 4, p. 245-252 (In Chinese; Engl. abst.). Authors at China Univ. of Geosci., Wuhan, 430074.

According to the data of FI, as the sample of ore-forming solution, there are several types of ore-forming F. Up to now we have known: (1) silicate M + metals, (2) $H_2O + NaCl$ + metals, (3) $H_2O + CO_2$ + metals, (4) H_2O + organic matter + metals. In the (2), (3), (4) H_2O consist of Na^+, K^+, Ca^{2+}, Mg^{2+}... and Cl^-, F^-, $(SO_4)^{2-}$, $(HCO_3)^-$... and so on. CO_2 also may include a few CH_4, CO, N_2, H_2, H_2S. Different metals and ore genesis are related to a certain type of ore-forming F. That is to say, some mineralizations are originated from the same type of ore-forming F. By studying the base of ore-forming F, several mineralization models have been recognized: mineralization mechanism of (1) two or more F mixed. (2) sole F immiscibility. (3) mixed organic and salt-bearing solution. (4) water-rock action. (5) changing physical-chemical conditions. (Authors' abstract)

ZHANG, Zhaochong, 1996, Characteristics of H and O isotopes and fluid evolution in Dongping gold deposit: Gold Geol., v. 2, no. 2, p. 36-41. Author at Inst. of Geol., Chinese Acad. of Geol. Sci., Beijing, 100037.

The characteristics of H and O isotopes in the Dongping gold deposit [Hebei] show that more and more meteoric water evolved in the ore-forming hydrothermal F from early to later mineralizations, and the water of the last hydrothermal stage of carbonate-barite consisted of almost [all?] meteoric water. Compared with the $\delta^{18}O$ value of the primary rock, the $\delta^{18}O$ value of the intense K-feldspathization rock decreases remarkably. It implies that the meteoric water played a role in the main metallogenetic stage. (Author's abstract)

ZHANG, Zheru, 1996, Frontier study of thermodynamics of fluid: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 80-88. Author at Inst. of Geochem., Chinese Acad. of Sci., Guiyang, 550002.

The frontier aspects of thermodynamics of F have been summarized as follows: (1) experimental and theoretical study on *p-V-T-x* phase relationship of multicomponent systems such as H_2O-CO_2-salt at high P and high T, (2) study on solubility of minerals and species in F and their thermodynamic properties–equilibrium constants and standard molal properties, (3) thermodynamic modeling of F. A number of software [programs] have been developed including the data base of thermodynamic properties of minerals and aq species in F and practical programs for simulating F equilibrium, mineral solubility, path of reaction and interaction of water-rock, (4) a number of specialities of chemical reaction and phase relationship in supercritical F are very important for understanding the evolution of the Earth, (5) the development of new analytical techniques and methods makes it possible to analyze the composition of individual I. (Author's abstract)

ZHANG, X. C., HALLS, Chris, SPIRO, Baruch, YANG, K. Y., 1996, A geological and geochemical study of black shale-hosted gold deposit; Lannigou SW Guizhou, P.R. China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 707. First author at Royal School of Mines, London, U.K.

The Lannigou gold deposit is located in Carboniferous carbonates, Permian reef limestones and Triassic clastic sediments. No igneous rocks are exposed in the area. Gold mineralisation occurs in a sequence of fine grained sandstones, siltstones and carbonaceous shales of Middle Triassic age.

The hydrothermal mineral assemblages consist of quartz-chalcedony, quartz-pyrite-arsenopyrite and quartz-carbonate-realgar-cinnabar-stibnite. Hydrothermal silicification is prominent, and gold is associated with its early stages, followed by the formation of quartz and carbonate veinlets.

FI in quartz are mostly L-V two phase with degree of fill of 0.8-0.9, and CO_2 G-bearing I with degree of fill of 0.65-0.75. The Th of L-V I 200-295°C and their calculated sal 3.8 to 6.9 wt% NaCl eq. The CO_2-bearing I have Th of 335-355°C and sal of about 7 wt% NaCl eq.

The $\delta^{34}S$ of sulphides is in the range 8.4 to 13.6‰ CDT showing a systematic equilibrium decrease: realgar> cinnabar>stibnite, and a normal distribution suggests common source. The $\delta^{18}O$ of quartz suggest that the early mineralising F was dominated by basinal brines while an increasing proportion of meteoric water affected the later F.

The mineralisation at Lannigou is related to intense faulting within the Triassic clastic succession during the

Late Yanshanian, where basinal brines consisted the source of F and sulphur in the mineralisation process. Although no indication for local igneous activity which could be the source of heat driving the hydrothermal system, other phenomena of high thermal gradients in the area have been identified. (From authors' abstract by E.R.)

ZHANG, Xiangxun and **DU, Shengbao**, 1996, The initial study of hydrochemical origin significance of mineral fluid inclusions (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 485. First author at Guangxi Dept. of Geol. and Mineral Resources, China.

Wide ranges of composition and concentration are given for each of a number of "types" of ore deposits. Deposit names and analytical methods not given. (E.R.)

ZHANG, Zhijian and ZHANG, Wenhuai, 1994, Study on the mechanism of organic inclusion in the fragmental reservoir: Geological Sci. and Technol. Information (Dizhi Keji Qingbao), v. 13, no. 1, p. 53-59 (in Chinese; Engl. abst.). Authors at China Univ. of Geosci., Wuhan.

The mechanism of organic I may be quite different from that of inorganic I, the organic I may be mainly formed from the process of oil-rock interaction. A study on the new mechanism, this paper shows that the I within the cracks, secondary enlargement edges of quartz and between minerals in the fragmental reservoirs are the result of oil-rock interaction. They are formed when oil and G, especially the carboxylic acid anions in them dissolve quartz, aluminosilicate and carbonate and form a certain space in which oil and G infill. I in different occurrences are actually the different forms of the same process that takes place in the different structures of a rock. Our study is significant to the reservoir geochemistry, the mechanism of FI and application of organic I in exploration and evalution of oil and G resource [sic]. (Authors' abstract)

ZHANG, Zhijian and ZHANG, Wenhuai, 1995, Progresses in the study of organic inclusions: Geological Sci. and Technol. Information (Dizhi Keji Qingbao), v. 14, no. 3, p. 39-43 (in Chinese; Engl. abst.). Authors at China Univ. of Geosci., Wuhan.

This paper introduces five new methods which have been applied to the study of organic I and have proved fairly effective up to date. The basic principles and the advantages and weaknesses of each method are analysed. Furthermore, the paper introduces some new accomplishments of organic I used in ore deposits and petroleum geology, and the future trend of organic I applied to the solution of geological problems is also discussed. (Authors' abstract)

ZHANG, Zhong, ZHANG, Xingmao, ZHANG, Baogui, CHEN, Yanyu and **GONG, Guohong**, 1996, Typomorphic characteristics of realgar in the Nanhua As-Tl deposit: Acta Mineralogica Sinica (Kuangwu Xuebao), v. 16, no. 3, p. 315-320 (in Chinese; Engl. abstr.). Authors at Inst. of Geoch., Chinese Acad. of Sci., Guiyang, 550002.

Presents Th data for realgar in the As-Tl deposit (H.E.B.)

ZHAO, Jinsong, 1996, Geochemical characteristics and physicochemical conditions of mineralization of Lamo skarn Zn-Cu deposit in South China: Geochimica (Diqiu Huaxue), v. 25., no. 6, p. 591-599 (in Chinese; Engl. abst.). Author at Guangzhou Inst. of Geochem., Chinese Acad. of Sci., Guangzhou 510640.

Some geochemical characteristics and physicochemical conditions of mineralization of Lamo skarn deposit in Guangxi, China, have been discussed in this paper in the light of the bulk compositions, fluorine and chlorine contents, concentrations of trace and rare earth elements of skarns and granites, gold contents of various orebodies, results of mineral (FI) I study as well as calculation of P_{CO_2}, f_{S_2}, f_{O_2} and pH values of mineralization F. (Author's abstract)

ZHAO, Yiming, 1996, The metasomatic zoning of some major Pb-Zn-polymetallic skarn deposits in China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 736. Author at Inst. of Mineral Deposits, Chinese Acad. of Geological Sci., Beijing, China.

The metasomatic zoning in some major Pb-Zn-polymetallic skarn deposits of China, e.g. [Haobagao] and [Baiyinnuo], is very clear. Investigation of the FI of minerals suggests that from the contact zone to carbonate country rocks, the forming T of the ore-bearing skarns are reduced gradually: magnetite-bearing calcic skarn (600-400°C), Sn (Cu, Zn)-bearing calcic skarn (450-327°C), manganoan skarn with Pb-Zn(Ag) mineralization (400-300°C). (From author's abstract by E.R.)

ZHAO, Liqing, WANG, Xiaohua, LI, Zhijie and **YUAN, Baoqing**, 1996, The typomorphic characteristic of pyrite at Chengjia-Fujia gold deposits, Jiaodong Peninsula, China (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 763. Authors at Inst. of Gold Geol., Langfang, Hebei, China.

Average Td of pyrite tends to increase from the north to the south, and decrepitation frequency is opposite. The T of pyrite can be divided into two groups. One group is 150 to 200°C, another is 230 to 270°C. (From authors' abstract by E.R.)

ZHE, Chuande, 1996, Tectonic setting and mineralization of the Xiangshan uranium ore field (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 697. Author at Geological Party No.261, East China Bureau of Geol., Jiangxi, China.

The Xiangshan uranium ore field is the biggest volcanic rock type uranium ore field in China. Uranium ore deposits are generally located at the junction between volcanic structures and regional faults, uranium ore bodies are emplaced in the fractures and fissures subsidiary to the above mentioned major structures. There were three stages of hydrothermal activities and two ore-forming processes during postvolcanic activities. The early stage of sodio-rich alkali hydrothermal acitivities gave rise to alkali metasomatic type uranium mineralization characterized by albitization, the ore-formation T has been determined at 200-300°C and the age of ore-formation is 120 Ma. The late stage hydrothermal activities is fluorine-rich and is acidic to weak acidic, resulting in fluorite-hydromica type uranium mineralization with the ore-formation T of 115-160°C and ore-formation age of 100 Ma. The ore-forming F are mixtures of hydrothermal solution released by late volcano-degassing process and solidification of the magma and meteoric water seeping downwards along postdiagenetic tensional structures, and are rich in alkali, F, CO_2 and have high sal. (From author's abstract by E.R.)

ZHENG, Jianping and **LU, Fengxiang,** 1996b, Paleomantle fluid and its meaning in the evolution of continental craton mantle: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 187-194.

Palaeozoic kimberlite-borne and basalt-borne xenoliths occur in North China platform and offer a deep source probe on researching the continental lithosphere. The present formations of paleo-mantle F in north China platform are reported in this paper in detail. It is regarded that the mantle F are the results of mantle evolution, and they also react on the mantle evolution. The shear zones and metasome layers in mantle with abundant F acted as weak zones, representing the union of heat, F, chemistry and mechanism, are the major fields of lithosphere thinning and delamination. (From author's abstract by E.R.)

ZHENG, Qinnian, 1996, Geology of the Vankou Pb-Zn ore deposit, Guangdong, China (abst.): 30th Int'l Geol. Cong., Abstract, v. 2, p. 794. Author at Geol. Res. Inst., Guangdong Non-ferrous Metal Geol. Survey, China.

The ultra-large Vankou Pb-Zn ore deposit in northern Guangdong Province has Mid-Upper Devonian carbonates as the major ore-bearing horizon. Ore minerals are in simple assemblages, mainly pyrite, sphalerite, and galena; major gangue minerals are quartz, sericite, calcite, and dolomite. There are minor inclusions in ores, usually 3-5, L or L-G phases, sal 5.9%, and Th 120-150°C. Ore-forming L is of K^+- Ca^{2+}- Cl^- type. Ore-forming experiments show that Pb^{2+} and Zn^{2+} are absorbed on 0.5-15 μ lime mud; cystine may form insoluble Pb^{2+} and Zn^{2+} complex. Pb and Zn may be activated and transported in a $NaCl-H_2O$ system containing carboxyl, hydroxyl, and amino groups. (From author's abstract by E.R.)

ZHENG, Youngfei, FU, Bin and **GONG, Bin**, 1996a, The thermal history of the Hugangmeijian granite intrusion in Anhui and its relation to mineralization: Isotopic evidence: Acta Geol. Sinica (Engl. ed.), v. 9, no. 2, p. 168-180. Authors at Dept. of Earth and Space Sci., Univ. of Sci. and Tech. of China, Hefei 230026.

Whole-rock Rb-Sr, zircon U-Pb and hornblende, biotite and K-feldspar K-Ar ages are used to reconstruct the cooling history of the Huangmeijian intrusion in the Anqing-Luijiang quartz-syenite belt in Anhui.

U-Pb dating of pitchblende is done for the hydrothermal uranium deposit formed in the contact zone of the Huangmeijian intrusion. The result shows that the mineralization age is close to the closing time of the K-Ar system in biotite. The FI thermometry indicates that the mineralization T is in agreement with the closure T of the biotite K-Ar system. This suggests a close relationship between the slow cooling of the intrusion and the hydrothermal uranium mineralization process. (From authors' abstract by H.E.B.)

ZHENG, Youngfei, FU, Bin and **GONG, Bing**, 1996b, Physicochemical conditions of mineralization in no. 6217 granite-type uranium deposit: Acta Mineralogica Sinica, v. 16, no. 1, p. 20-27. First author at Dept. of Earth and Space Sci., Univ. of Sci. and Tech. of China, Hefei, 230026.

Physicochemical conditions of formation of the no. 6217 granite-type uranium deposit in Jiangxi Province are investigated in terms of FI data and thermodynamic calcuations in combination with known geological features. The relationship between reddening (hematitization) and uranium mineralization is discussed as well. The results show that the mineralization would take place under the conditions of meso- to low-T, medium P, low oxygen fugacity, high sulfur fugacity, and medium to weak alkaline, reducing environment. In the ore-bearing F, uranium would be transported dominantly in the form of $[UO_2(CO_3)_2]^{2-}$ and $[UO_2F_4]^{2-}$. The reddening could result from oxidation of the high-f_{O_2} alkaline metasomatic F in pre-ore stage to the ambient granites. The reddening rocks would provide a suitable redox condition, whereby the uranium in the F could be reduced to deposit pitchblende. (Authors' abstract)

ZHENG, Zuoping and **YU, Xueyuan**, 1996, Geochemistry of auriferous quartz veins in the Baguamiao gold deposit (abst.): Acta Petrologica et Mineralogica, v. 15, no. 4, p. 339-345. (in Chinese; Engl. abst.) Authors at Guangzhou Inst. of Geochem., Academia Sinica, Guangzhou 510640.

The Baguamiao gold deposit in a sort of mesothermal-hypothermal carbonate type gold deposit. Quartz, one of the major gangue minerals, is closely related to gold mineralization. According to modes of occurrence, auriferous quartz veins might be divided into three types: (1) bedding quartz veins; (2) ferriferous dolomite quartz veins; (3) quartz veins along NE-trending joints. These types show certain differences in compositional characteristics of trace elements and rare earth elements and were formed respectively at different ore-forming stages of gold, being evolutional products of gold in the process of ore-forming process. Thermometric measurements of inclusions quartz have provided evidence for mesothermal-hypothermal origin of the Baguamiao gold deposit. (Authors' abstract.)

ZHONG, Zengqiu, 1996, Fluid-rock interaction in shear zone: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese; Engl. abst.), p. 209-215. Author at China Univ. of Geosci., Wuhan 430074.

Shear zones are infiltrated by large volumes of F. The sources of the F are related to the tectonic setting, rheological regime and hydrologic environment of the shear zone. The flow of F is controlled by the porosity, the diffusivity and permeability of the F, the p-T conditions and the stress or loading gradient in the shear zone. The F composition, F flux and F flow fashion directly account for the rock rheology in the [shear] zone. The F-rock interaction and the chemical disequilibrium caused by strain localization and mechanical instability induce the readjustment of mineral and chemical compositions within a shear zone and the compositional variation depends on the protolith character, p-T conditions of the shear zone and the constitution and flux of the F. The F infiltration and F flow, as well as the F-rock interaction promote volume loss of the shear zone. The process of volume loss is an example of self-organization. The critical volume loss of shear zone in nature is about 65%, implying a large amount of percolating F which greatly affects the rheological behavior, the chemical behavior and the metallogenesis of the shear zone. (Author's abstract)

ZHOU, Chao-Xian, 1996, The origin of the mineralizing metals, the geochemical characteristics of ore-forming fluid, and the genesis of Qilinchang Zn-Pb deposit, northeast Yunnan Province, China: M. Sci. thesis, Inst. of Geochem., Chinese Acad. of Sci., 112 pp. (in Chinese, Engl. abst.)

The Qilinchang zinc-lead bedded deposit, which is located along the southwestern margin of Yangtze Craton, consists of sphalerite, galena, pyrite and calcite with a Ag grade of 98 g/t, occurs principally in Lower Carboniferous dolomite, i.e. Baizuo Formation (C1b). It is a Mississippi Valley-type ore, and belongs to the epigenetic [group] of deposits.

Studies of Pb (isotopics, source age and preferential leaching), $^{87}Sr/^{86}Sr$ of several kinds of geological bodies in the region and the Qilinchang deposit, etc., shows the mineralizing metals came predominately from the Later Proterozoic supercrustal-type, acidic, intermediate acidic volcanic and volcaniclastic rocks, not from the host rock, mantle and mantle-derived rock(s). The major source of hydrothermal calcite of Qilinchang ore is the incongruent dissolution of host rock(s).

Ths of sphalerite and calcite from this ore range mainly from 175 to 195°C. The mineralization (Tt) is about 250°C, and P ranges from 640 to 740 bars with the average value 690 bars. Tm for these two minerals range from -10 to -14°C. The sal is 10.0±wt.% NaCl eq., and the density about 0.96 g/cm^{-3}, during sphalerite precipitation. The parent solution was a near neutral, or very slightly acidic, strongly reducing, H_2S-rich, Na-K-Cl-type F.

On the base of thermodynamic calculation, C and O isotopes, theoretical water/rock interaction-mixing model mineral and FI studies, I find the mineralizing metals migrated as bisulfide complexes, i.e., H_2S (HS) and mineralizing metals migrated in the same solution (i.e. the parent ore-forming F). The sum of Zn, Pb concentration is several tens of ppm, even over 150 ppm in the parent F. When it entered into the site of mineralization, a_{H_2} decreased and H_2S (partially) oxidized. This resulted in pH decrease, the incongruent dissolution of hostrock and sulfide precipitation (because of the transformation of H_2S to polysulfide, and the consequent decrease of H_2S activity). Calcite deposited and some sulfide dissolved as the result of mixing when the later parent mineralizing solution came.

The Qilinchang deposit probably formed at the time of/or after the closure of eastern Tethyan palaeo-ocean, the collision between India Plate and Eurasia Plate, and its genesis may be related to this collision. (Author's abstract)

ZHOU, Fengying and **ZHU, Jinchu,** 1996, Geochemical studies on the magmatic-hydrothermal transition stage for some F-rich granites in south China (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 486. First author at Research Inst. of Petrol. Exploration and Development, Beijing, 100083, P.R. China.

Recent studies have proved that increase of F and Li contents in the granitic system may decrease the viscosity of granitic M, reduce their solidus and liquidus T, intensify their diffusion rate, and consequently the time and T range of the magmatic–hydrothermal evolution. With the purpose of studying the geochemical processes of magmatic–hydrothermal stage, we chose four F-rich granite bodies including Laiziling granite of HuNang province, Shui Ximiao granite of Guangxi province, Ya Shang granite of Jiangxi province and Suzhou granite of Jiangsu province.

On the basis of field geology, laboratory and experimental work, we proved that the magmatic–hydrothermal transition stage does exist in the F-rich granite system, and verified both that the Laiziling greisen and Shui Ximiao granitic pegmatic vein were formed in the magmatic–hydrothermal transition stage of granite evolution.

Through the combination of mineralogical, petrological and geochemical studies, it is proved in this paper that in the magmatic–hydrothermal transition stage, the feldspars formed are end numbers of alkaline feldspars. The K-feldspar is maximum microcline to coexistence of maximum microcline and orthoclase. The mica changes from zinnwaldite to lepidiolite. The I types in mineral are various: they are MI, F-MI, LI, GI, etc. The consolidation occur in the range of 800 to 400°C at 2000 to 500 bars. Its petrochemistry has dual character: SiO_2, Al_2O_3, Na_2O contents increase when magmatic process prevails in rock-forming granitic system; SiO_2, Na_2O contents decreased and K_2O contents increase when hydrothermal solution is enriched in granite system. It is also shown that the process of magmatic–hydrothermal transition is evolved from the coexistence of F, Na-rich residual M with Na^+, Cl^--rich supercritical F toward the K^+, F^-, Cl^--rich (as well as W, Sn, Nb, Ta-rich) supercritical F. This transition process has obvious effect on the formation of granite-related from rare-metal deposit.

Experimental studies for albite granite–NaF system show that the liquidus and solidus T of F-rich (2.44%), H_2O-undersaturated albite granite are slightly higher than 700°C and slightly lower than 580°C respectively. It is also proved that the fine-granite might be formed in the H_2O-undersaturated condition, but the pegmatitic texture might be formed in the H_2O-oversaturated condition.

Based on comprehensive studies, we find that the magmatism signature and metasomatic signature coexist in Laiziling greisen due to simultaneous magmatic crystallization, and water/rock interaction by coexisting F in the system. Shuiximiao granite pegmatitic vein is asymmetrically layered pegmatite and sodic aplite. It might be formed in the gradual changing process of crystallization with volatile-undersaturated to volatile-oversaturated magmatic differentiation. (Authors' abstract)

ZHOU, Hanming and **WANG, Wenbin,** 1996, Minerogenic environment and genesis of gold deposits at Yangmel region, Dehua, Fujian Province: Volcanol. & Mineral Resources, v. 17, no. 1-2, p. 41-53 (in Chinese; Engl. abst.). Authors at IGMR, Nanjing, 210016.

Minerogenetic F [FI data] data is a kind of low sal and density mixed solution which consists of meteoric water and magmatic water. Minerogenetic T varied between 140°C and 250°C. (From authors' abstract by H.E.B.)

ZHOU, Kaican and **DONG, Faqin,** 1996, The geology and genesis of Heimuling fibrous brucite deposit in the south of Shanxi, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 679. Authors at Southwest Inst. of Tech., Mianyang, China.

The giant fibrous brucite deposit occurs in the ultramafic rock at Heimuling in the south of Shanxi, China. The O, H isotope analysis, δO^{18}(‰) = +0.201 - +4.82, δD/smow = -43.389 ~ -124.6, shows that the fiber is the product of continent serpentinization. According to the FI study, the ore-forming T is 95 ~ 256°C. (From authors' abstract by E.R.)

ZHOU, Taihe and **ADSHEAD, Neil,** 1996, Chlorine-bearing silicate alteration and some fluid characteristics of the Osborne copper-gold deposit, Cloncurry District, Queensland (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 727. Authors at Key Centre in Econ. Geol. Dept. of Earth Sci., JCU,. Australia.

The Osborne deposit is one of the major copper-gold associations in the Cloncurry Proterozoic terrain, NW Queensland. The Osborne sequence has undergone upper amphibole facies metamorphism. FI and thermodynamic studies indicate that the early stage alteration equilibrated with high-T (> 450°C), high-sal (about 60% NaCl eq.) F, whereas during the main mineralization stage the F was cooler (about 300°C) and of a lower sal (< 20 to 37% NaCl eq.).

The T decrease may be due to a cooling down of the hydrothermal system, and may also be affected by phase separation. The decrease in F sal, however, has to be rationalized since there is not any evidence of F mixing. Detailed electron microprobe work has revealed that during early stage alteration at Osborne, secondarily biotite ± hornblende are substantially enriched in chlorine (up to > 2 wt.%). Moreover, the commonly observed alteration mineral ferropyrosmalite contains even more chlorine. (From authors' abstract by E.R.)

ZHOU, Yongzhang, LIU, Youmei, ZHANG, Haihua, WANG, Zuwei and YAO, Dongliang, 1996, Study on hydrothermal fluid inclusions from ductile shear zone-host type precious metal deposits in Yunkai metamorphic terrain, southern China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 756. Authors at Guangzhou Inst. of Geochem., Chinese Acad. of Sci., Guangzhou, China.

The Yunkai metamorphic terrain contains a series of large scale precious metallic deposits such as the Hetai Au deposit and the Pangxidong Ag-Au deposit, among which most are the ductile shear zone-host type. The deposits are closely associated with hydrothermal alteration within the shear deformation zones, and hydrothermal F are believed to have played an essential role in the gold mineralization. The main alterations include sericitization, chloritization, silicification, pyritization and carbonatization.

Both P and S FI related to gold precipitation were examined from selected gold deposits. The FI are commonly small, with diameter ranging from smaller than 1 to 25 μm, averaging about 3 μm. The P I are hosted both in the late stage sulfide-associated hydrothermal quartz and in the early stage hydrothermal quartz.

Three compositional types of FI are recognized. They are a low-sal (about 1.5-6 eq. wt. % NaCl) H_2O-CO_2 one, a moderate-sal (about 6-14 eq. wt. % NaCl) aq one, and a CO_2-dominated one. The Th for these three types ranges from 130° to 340°C with two statistical modes around 245° and 170°C. The confining pressure of the FI at Th approximately ranges from 50-170 MPa.

It is concluded that the low-sal H_2O-CO_2 I represents the P ore-forming hydrothermal F. It is a H_2O-NaCl-CO_2-dominated system, with probably presence of other components such as Ca^{2+} and CH_4. During the ascent of the P hydrothermal F, CO_2 effervescence and unmixing took place, with almost all the ore material remaining in the L aq phase. The unmixing of the primary hydrothermal F into a moderately saline aq phase and a non-saline CO_2-dominated phase was caused by sudden release of P.

The δD and $\delta^{18}O$ values indicate that the P ore-forming hydrothermal solution is a mixture of metamorphic and meteoric waters. Included in the key factors that led to the precipitation of gold from the hydrothermal F are T drop, sudden release of confining P, and the unmixing of the hydrothermal F into a G phase and a saline aq phase.

This project was financed by the Open Laboratory of Ore Deposit Geochem. and the President Fund of The Chinese Acad. of Sci. (Authors' abstract.)

ZHU, Chuande, 1996, Tectonic setting and mineralization of the Xiangshan uranium ore field (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 697. Author at Geol. Party No. 261, East China Bureau of Geol., CNNC, Lean, Jiangxi 344305, China.

The Xiangshan uranium ore field is the biggest volcanic rock type uranium ore field in China. Uranium ore deposits are generally located at the junction between volcanic structures and regional faults, uranium ore bodies are emplaced in the fractures and fissures subsidiary to the above mentioned major structures.

There were three stages of hydrothermal activities and two ore-forming processes during postvolcanic activities. The early stage of sodic-rich alkali hydrothermal activities gave rise to alkali metasomatic type uranium mineralization characterized by albitization, the ore-formation T has been determined at 200-300°C and the age of ore-formation is 120 Ma. The late stage hydrothermal activities is fluorine-rich and is acidic to weak acidic, resulting in fluorite-hydromica type uranium mineralization with the ore-formation T of 115-160°C and ore-formation age of 100 Ma.

The ore-forming F are mixtures of hydrothermal solution released by late volcano-degassing process and solidification of the magma and meteoric water seeping downwards along postdiagenetic tensional structures, and are rich in alkali, F, CO_2, and have high sal. (From author's abstract by E.R.)

ZHU, Bingyu, WU, Changnian, CHEN, Peirong, YANG, Shenzu and ZHU, Jinchu, 1996, Magmatic-hydrothermal evolution and genesis of Keketouhai No. 3 rare metal pegmatite body, Altai, China (abst.): 30th Int'l Geol. Cong., Abstracts, v. 2, p. 629. First author at Nanjing Univ., Nanjing.

The Keketouhai No. 3 Li-Be-Ta-Nb-Cs bearing pegmatite body is characterized by a well developed internal zonation. From the border wall inwards the following 9 mineralogical-textural zones were subdivided: I / Graphic and pseudo-graphic pegmatite zone; II / Saccharoidal albite zone; III / Blocky alkali feldspar zone; IV / Muscovite-quartz zone; V / Cleavelandite-spodumene zone; VI / Quartz-spodumene (-cleavelandite) zone; VII / Thin sliced albite-muscovite zone; VIII / Lepidolite-thin sliced albite (-pollucite) zone; IX / Blocky quartz (-K feldspar) core. The saccharoidal albite of zone II occurs as discontinuous nests in the peripheral part of zone III. The zone VIII is found as lens lying above the zone IX and cutting through the zones VI and VII.

The thermometric and compositional studies on the M I, silicate crystal-fluid inclusions and FI in quartz, beryl, spodumene etc. minerals of the pegmatite show that zones I and III crystallized first from the volatile-understaturated silicate melt; zones IV, V, VI and VII crystallized later from the volatile-oversaturated rare metal-rich residual silicate melt at the magmatic-hydrothermal transition stage where the residual M phase, silicate crystal phase and exsolved hydrothermal solution phase coexist. The blocky quartz of zone IX might be crystallized last directly from the high T hydrothermal solution. The zones II and VIII might be considered as metasomatic units. (From authors' abstract by E.R.)

ZHU, Meixiang, 1996, Geothermal solid products in the Rehai geothermal field, Yunnan (abst.): 30th Int'l Geog. Cong., Abstracts, v. 1, p. 380. Author at Geol. Dept., Peking Univ., China.

In the Rehai geothermal field, hydrothermal alteration of wallrock is widespread and intense. The clay minerals are characterized by lower values of $\delta^{18}O$ and higher [of] δD which are 2.1~12.3‰ and -75~-142‰ respectively.

The Th of 39 FI of quartz in siliceous caps and hydrofracture breccias taken from the ground within the south and the northeast are as high as 110°~250°C. All these T exceed the local boiling point which indicate that these geothermal products were formed in the depths of the reservoir in the past, but are now exposed on the surface owing to the tectonic [uplift]. 6~10 layers of siliceous cap existing underground have been revealed by drillholes in the south area. Most of the distributions of Th of these caps have no regular pattern in proportion to the increasing depths. (From author's abstract by E.R.)

ZHU, Yongfeng, CHANG, Zhaoshan and ZHAO, Yongchao, 1996, Volatile in magma and its petrologic significance: Earth Sci. Frontiers, v. 3, no. 3/4–Special Issue on Fluids of the Earth's Interior (in Chinese, Engl. abst.), p. 195-199. Authors at Dept. of Geol., Peking Univ., Beijing, 100871.

The solution and states of volatile[s] in magma, as well as the constraints on the solubility of H_2O in M, are discussed in this paper. The significance of volatile[s] for magma evolution and its petrogenesis is considered. H_2O dissolved in magma can influence the crystallization consequence and the evolution trace of M. (From authors' abstract by E.R.)

ZHU, Yongfeng, ZENG, Yishan and **AI, Yongfu,** 1996a, Experimental evidence for a relationship between liquid immiscibility and ore-formation in felsic magmas: Applied Geoch., v. 11, p. 481-487. Authors at Dept. of Geol., Peking Univ., Beijing 100871, P.R. China.

Geological studies demonstrate that L immiscibility in felsic magma closely associates with the ore forming process. In order to obtain experimental evidence demonstrating the relationship between the ore forming process and L immiscibility in felsic magma, we carried out a series of experiments at high T and atmospheric pressure in the system KBF_4~Na_2MoO_4. This system is a homogeneous M at high T. With decrease in T, however, the M decomposes into two immiscible M; silicate M and ore-forming M. The present experimental results suggest that liquation in felsic magma can be the first step in the ore-forming process during granitoid evolution. (From authors' abstract by E.R.)

ZHU, Yongfeng, ZENG, Yishan and **AI, Yongfu,** 1996b, Liquid immiscibility in felsic magma and its ore-forming potentiality (abst.): 30th Int'l. Geol. Cong., Abstracts, v. 2, p. 624. Authors at Dept. of Geol., Peking Univ., Beijing 100871, China P.R.

The experimental results show that granite-KBF_4-Na_2MoO_4-WO_3 system is a homogeneous M at high T; with decrease in T, however, the M decomposes into three immiscible M: silicate M, ore-forming M, and M with volatiles. (From authors' abstract by E.R.)

ZHUANG, Hanping, RAN, Chongying, HE Mingqin and **LU, Jialan,** 1996, Interactions of copper, evaporite, and organic matter and genesis of sandstone-hosted copper deposits in the Chuxiong Basin, Yunnan Province: Acta Geologica Sinica, v. 9, no. 4, p. 407-419 (in Engl.). First author at Inst. of Geochem., Chinese Acad. of Sci., Guiyang, Guizhou.

Studies on organic geochemistry indicate that the origin, type and maturity of organic matter are different among coal-bearing, copper-bearing and evaporite formations in the Mesozoic continental Chuxiong Basin, Yunnan, China. A mechanism has been proposed that (1) during the diagenetic mineralization stage the short-chain organic acids derived from kerogen played an important role in remobilizing copper from source beds, while oils acted as important carrier of copper, and that (2) during the transformation or remolding mineralization stage, meteoric water leached the evaporite layers and formed downward-percolating oxidizing SO_4^{2-}-rich F; meanwhile, the copper-bearing F migrating upwards along growth faults from the basement was contaminated by the coal-bearing series on the way and formed reducing organic-rich F; oxidation-reduction occurred and sulfides formed when the two kinds of F met within sandstones (Authors' abstract)

Extensive FI compositional data is given. (H.E.B.)

ZIEMANN, M.A. and **LÜDERS, Volker,** 1996, Characterization of IR-transmittance of sulfides and other opaque minerals by FTIR-spectroscopy (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 149-151. First author at Univ. of Potsdam, Inst. of Geosci., Telegrafenberg C 7.

FTIR-spectroscopic investigations of doubly polished sections (90 μm) of various opaque minerals have been performed in order to characterize their IR-transparency in the range $\lambda = 1.0$ to 3.3 μm (= 1,000 to 3,300 nm). The IR-transmittance was measured by a Perkin Elmer 2000 FTIR-spectrometer with a microchamber facility, which allows a spatial resolution up to 20 μm. Using a high-resolution Hamamatsu IR camera with a selected tube, infrared-microscopy observations in the near infrared (NIR) up to 2.6 μm are possible. FTIR spectra of several opaque minerals indicate varying qualities of IR-transmittance at different wavelengths. FI and internal features can be observed in the wavelength range $\lambda = 0.8$ - 1.2 (1.3) μm (IR resolution capacity of Research Devices Model-F IR microscope and usual video cameras with removed IR filter, respectively) in some opaque minerals such as wolframite, stibnite, Sb-rich sulfosalts and dark sphalerite [figures omitted]. Since most of the FTIR spectra of opaque minerals indicate better IR-transmittance at higher wavelengths, the use of high-resolution IR systems must be favored. (From authors' abstract by E.R.)

ZIMBELMAN, D.R. and **RYE, R.O.,** 1996, Dynamics of hydrothermal systems in an active stratovolcano-Mount Rainier, Washington (abst.): Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. A334. First author at P.O. Box 1878, White Salmon, WA 98672; e-mail (ZimbelmanD@aol.com)

Episodically throughout the > 466 ka history of Mount Rainier volcano, hydrothermal systems have evolved and the summit and flanks of the volcano has collapsed catastrophically along zones of altered rock. Filling T in FI in barites are 235 ± 30°C and sal range up to 24 wt.% NaCl eq. δD, $\delta^{18}O_{SO_4}$, $\delta^{34}S$ values of alunite range from −121 to −85‰, 9.3 to 15.4‰, and 7.5 to 17.3‰, respectively, and corresponding values for jarosite range from −174 to −135‰, −12.0 to −4.3‰, and 1.5 to 3.3‰, respectively. δD and $\delta^{18}O$ of smectite and mixed clays of undermined mineralogy range from −177 to −110‰ and −5.8 to 13.0‰, respectively. $\delta^{18}O$ and $\delta^{34}S$ values of gypsum (after anhydrite) range from −4.0 to 3.6‰ and 3.6 to 10.7‰, respectively. The geochemical data indicate that both saline magmatic L and magmatic steam hydrothermal F reached the present summit and mixed with meteoric water derived from the melted glacial ice. The data also indicate that alunite was probably derived both from the disproportionation of SO_2 during condensation of magmatic V (magmatic hydrothermal environment) and from the auto-oxidation of SO_2 during high T depressuring of magmatic steam (magmatic steam environment). Jarosite formed either from the surficial oxidation of sulfides or hydrothermal H_2S. Such dramatic variation in magmatic hydrothermal F systems would be expected in a summit environment susceptible to huge influxes of meteoric water and to sudden sector collapse. (From author's abstract by E.R.)

ZIMBELMAN, D.R., RYE, R.O., PLUMLEE, G.S., CROWLEY, J.K., and **SKEWES, M.A.,** 1996, Importance of glaciers to the geologic and geochemical evolution of Mount Rainier Volcano, Washington: in Chapman Conference Abstracts, Crater Lakes, Terrestrial Degassing, and Hyper-Acid Fluids in the Environment, September 4-9, 1996, Crater Lake, Oregon, Johan C. Varekamp and Gary L. Rowe, convenors, p. 30. First author at P.O. Box 1878, White Salmon, WA 98672.

Mount Rainier is a glacially clad, active stratovolcano that has hosted episodic hydrothermal and edifice collapse events, commonly localized along zones of altered rock, throughout its >466 ka history. Most areas of altered rock have characteristics indicative of epithermal conditions. Results from chemical reaction path modeling studies document the oxidized nature of the volcanic F during hydrothermal events. Filling Ts in FI in barites are 235± 30°C and sal range up to 24 wt% NaCl eq. Alunites have δD, $\delta^{18}O_{SO_4}$, $\delta^{34}S$ values ranging from -121 to -75, 9.3 to 15.4 and 7.5 to 17.3, respectively, and corresponding values for jarosite range from -174 to -135, -12.0 to -4.3, and 1.5 to 3.3. δD and $\delta^{18}O$ of smectite and undifferentiated clays range from -177 to -110 and -5.8 to 13.0, respectively. $\delta^{18}O$ and $\delta^{34}S$ values of gypsum (after anhydrite) range from -4.0 to 3.6 and 3.6 to 10.7, respectively. The geochemical data indicate that both saline megmatic L and magmatic steam hydrothermal fluids reached the present summit and mixed with meteoric water derived from melted glacial ice. The data also indicate that the environment of acid sulfate alteration varied from magmatic-hydrothermal (SO_2 disproportionation) to magmatic steam (auto-oxidation) during alunite deposition and was probably steam-heating (oxidation of H_2S) during jarosite deposition. Rapid and dramatic P-T-X changes accompanied some of the hydrothermal events, as would be expected in an environment where sector collapse and (or) rapid influxes of meteoric water accompanied magmatic-hydrothermal events. The volcano's extensive mantle of glacial ice is similar to a (frozen) crater lake in at least two ways: (1) it serves as a ready and abundant supply of meteoric water and (2) it acts as a condenser for magmatic volatiles, preventing the volatiles from venting to the surface. The oxidized and acidic nature of the magmatic F and the presence of this frozen "crater lake" have contributed to producing extensive areas (> 10 km^3) of altered rock in the volcano's edifice. (From authors' abstract, by H.E.B.)

ZIMMERMAN, Heide, 1996, Changes in brine and fluid inclusion composition during the precipitation of halite out of evaporating seawater (abst.): Abstracts, PACROFI VI, Univ. Wisconsin Madison, WI, May 30-June 1, 1996, p. 152. Author at IGDL, Universität Göttingen, Goldschmidtstr.3, D-37077 Göttingen.

FI > 200 µm were extracted using a microdrill and a capillary with a uniform inner diameter of 25 µm. 100 µl of distilled water were added to the extracted brine. Brines and extracted FI samples were analyzed for Cl^-, SO_4^{2-}, Br^-, F^-, Na^+, K^+, Mg^{2+}, Ca^{2+}, and Li^+ by ion chromatography (IC) using a DIONEX 500. B, Ba, Cs, I, Li, Mo, Rb, and Sr were measured with a FISONS INSTRUMENTS Plasmaquad mass spectrometer PQ^{2+} (ICP-MS).

The collected brines represent degrees of evaporation (D.E.) between 1 and 30. The precipitation of aragonite starts at D.E.=1.8, gypsum crystallizes at D.E.=4, and finally halite at D.E.=10. Sr, Ba, and I are removed from the brine at a D.E.of about 6. The observed decrease of iodine contents during evporation is not yet resolved. Li, Rb, B, and Br are almost quantitatively accumulated in the evaporating brines, whereas the continuously increasing concentration of Mo reaches only 80% of the expected value at D.E.=10. During evaporation the molar ratios of Rb/Br (0.0025) and B/Br (0.5) remain fairly constant, so that Caribbean seawater and evaporating brines plot on a distinct area in a Rb/Br - B/Br diagram. (From author's abstract by E.R.)

ZIMMERMANN, J.L. and **MORETTO, Robert**, 1996, Release of water and gases from halite crystals: Eur. J. Mineral., v. 8, p. 413-422. First author at Centre de Recherches Pétrographiques et Géochimiques, UPR du CNRS, 15 rue N.D. des Pauvrew, BP 20, F-54500 Vandoeuvre-lès-Nancy Cedex.

Qualitative and quantitative analyses of F, by thermogravimetry and by coupled manometry-mass spectrometry, were carried out on clear halite crystals with few macroscopic I (1 mm) and on cloudy halite crystals with many small I (<30 µm) of the Bresse evaporitic basin (France).

Water is the most abundant F in the two types of halite and there is up to five times more water in cloudy halite (0.2–0.5 wt.%). Carbon dioxide and hydrogen contents are much lower: $CO_2/H_2O \leq 0.01$ and $H_2/H_2O \leq 0.005$. Organic compounds, with CH_4, are always present ($\leq 0.05\%$ H_2O), and are twice as abundant in cloudy samples. There are also traces of nitrogen and, in some samples, hydrogen sulphide and sulphur dioxide.

The release histograms and the kinetics characteristics of the release of each F in the in the clear and cloudy halites were determined by an incremental heating study, from 80 to 460°C. Nitrogen is released below 240°C and is probably of atmospheric origin. About 90% of the water is expelled from 280 to 420°C, corresponding to the decrepitation of I. Likewise, CO_2 liberation occurs mainly between these T, but above 420°C, an additional part comes from carbonate dissociation through heating. Hydrogen, whose content is <0.5% that of H_2O, is extracted continuously from 200 to 460°C, with a single activation energy of 30 kcal/mol; more than 60% of its extraction occurs above 360°C. Most of the hydrogen originates from dissociation of organic matter present in the halite crystals and from water reduction during heating. (Authors' abstract)

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 again 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.

To keep the indexing chore manageable, I have deleted the isotopes of C, H, O and S except where they apear to deal with the fluid inclusion composition itself, not the host. Much ambiguity remains in some index entries, e.g., some high temperature, silicate-water-salts items (i.e., "melt-salt" in the Russian literature) might be under Aqueous and/or Silicate melt; items on basins might be under Organics... and/or Inclusions in sediments. Some new entries, e.g., "Mantle metasomatism" were introduced partway through the indexing.

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.

Liaoning diamonds, PRC—Lu
Liba Au, Limin, Gansu, PRC—Chen
Liberty Bell Au, AK—Yesilyurt
Limin Au, Gansu, PRC—Chen
Lindsley PGE, Sudbury, Ontario, Canada—Watkinson
Linglong Au, Shandong PRC—Lu
Lishene MVT, Ireland—Eyre
Little Stobie Ni-Cu-PGE, Sudbury, Ontario, Canada—Molnar
Livingston Island porph Cu, Shetland Island—Armstrong
Lizard ophiolite, UK—Hopkinson
Lockne impact breccia, Jämtland, Sweden—Forsberg
Logtung W-Mo, Yukon Territory, Canada—Lowenstern
Loihi seamount, HI—Hauri
Lone Tree Au, NV—Kamali
Long Lake CaF_2, Central Adirondacks, NY—Bird
Los Broncos-Rio Blanco pipe, Chile—Skewes
Los Pelambres pipe, Chile—Skewes
Lucky Hill Au-Sb, Sarawak, Malaysia—Dill
Lushan Au, PRC [Rushan?]—Zhai
Lushui Sn-W, W. Yunnan, PRC—Qiu
Lyon Mt. gneiss, Lyonsdale, NY—Cunningham
Maghreb Pb-Zn, Tunisia—Perthuisot
Maisk-type Au, Ukraine—Sivoronov
Manson impact structure, Iowa—Boer, Leroux
Manto Verde Cu, Chile—Vila
Manus Basin geothermal, W. Pacific—Scott, Yang
Maodeng Sn-Cu, Inner Mongolia, PRC—Liu
Maojiadian Au, Liaoning, PRC—Liu
Maotang Au, Henan, PRC—Feng
Marathon PGE, Coldwell Complex, Canada—Watkinson
Mari Rosa Sb-Au, W. Spain—Ortega
Mato Dentro CaF_2, S. Brazil—Ronchi
Mauna Kea Volcano, HI—Hauri, Kurz
Mauna Loa Volcano, HI—Hauri
Mayor Island peralkaline rhyolites, New Zealand—Barclay
McDuffie Co., Au belt, GA—German
Meguma Terrane Au, Nova Scotia—Kontak
Melilitolites—Veksler
Melbourne Trough Au, Australia—Changkakoti
Mengyin diamonds, PRC—Liu
Merida contact meta. OD, Spain—Fernandez
Metaggitsi-Salonikio W, Greece—Kilias
Metalore-Golden Highway Au, NE Ontario, Canada—Kowalski
Mianning REE, Sichuan, PRC—Niu
Mid-Atlantic Ridge gabbro—Casey
Mid-Atlantic Ridge geothermal—James
Minamikayabe epithermal Au, Hokkaido, Japan—Watanabe
Mina Capillitas epithermal Te, Argentina—Marquez-Zavalia
Missouri Au, W. Australia—Mernagh
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Mt. Charter barite, Tasmania—Rand
Mt. Elliott Cu-Au, Australia—Garrett
Mt. Etna volcano, Sicily—Kamenetsky
Mt. Gibson VHMS, W. Australia—Straub
Mt. Todd, Au field, N. Territory, Australia—Hein
Muli Sb, Yannan, PRC—Wang
Muping-Rushan Au, Shandong, PRC—Gao
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Muteh Au, Iran—Moritz
N. Guangxi Au-As-Ag, PRC—Wang
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Nalgonda U district, India—Manjunath
Namseon Cu-Zn-Pb, Korea—Yun
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Nellore mica belt pegmatite, Andhra Pradesh, India—Jadhav
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Nevados del Famatina Cu-Mo-Au porph, Argentina—Losada-Calderón
Nevoria Au, Yilgarn block, Australia—Bouchot
Nippewalla Group evaporite, KA—Benison
Niuxinshan Au, Hebei, PRC—Morteani, Yao
No. 570 U, Ag, Mo, N. Fujian, PRC—Zhang
No. 6217U, Jiangxi, PRC—Zheng
North Sea oil-gas fields—Girard, McNeil, Oelkers
Northern NV gold deposits—Saunders
Nukhul petroleum reservoir, Egypt—Barakat
Ogiri geothermal, W. Kirishima, Japan—Etoh
Ohtani W, Hyoto Pref., Japan—Shibue
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Olary Block polymetallic, S. Australia—Bierlein
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Oman ophiolite, chromite—Schiano
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Otoge epithermal Au-Ag, Yamagata, Japan—Zeng
Pahtohavare Cu-Au, Kiruna, Sweden—Lindblom
Palo Duro evaporite basin, TX—Ghazi
Pan d'Arco amethyst, Brazil—Cassini
Panarea xenoliths, Aeolian Islands, Italy—Lima
Pangxidong Ag-Au, Yunkai, PRC—Liu, Zhou
Papuan oil basin, PNG—Krieger
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Piandi Celle volcano, Umbria, Italy—Sharygin
Piaotang Sn-W, S. China—Ivanova
Pilgrim's Rest Au, Transvaal, SA—Tyler
Pine Point OD., NW Territories—Fowler, Qing
Placentia Bay, polymetallic, Newfoundland—Morgan
Pogera Au, Papua New Guinea—Cameron

Index of Non-First Authors

First authors are found alphabetically in Abstracts and Citations. Note: Please see caveats about the spelling of 'authors' names on page 1.

ERRATA

Volume	Page	Item or ¶	Line**	Change
28	vii	2	2	“Bin Liu” should be entered as “Liu Bin”
	vii	2	-9	Add Shumlyanskiy, V., Kiev, Ukraine
	vii	2	-3	Add Vanko, D.A., Atlanta, GA
				Change “Xi” to “Xu”
	viii	2	7	Roedder phone now is (978) 281-6193
	x	12	2	Add, after “three volumes, ”(1995 pages)”
	x	12	3	Add “in Vol. 2”
	38	R5	6	After “Layered” add “[zoned?]”
	65, 66			Pages 65 and 66 are misplaced; shift to between pp 64 and 67
	88R	4	-13	Line duplicated–delete
	101L	3	5	Add author at “Echo Bay Alaska, 3100 Channel Drive, Juneau, AK 99801
	132R	6	3	Add “[evaluation of?]”
	133L	3	2	First author “QUILEZ”
	142R	3	5	Change to “p. 169”
	146R	2	4	Change to “p. 181”
	151R	3	5	Add: “P.M. Iblen, M. Pedersen, and H. Stendal, eds.”
	171R	7	5	Add p. 178-183
	176	L3	6	After “disseminated” add “or”
	178R	2/3	–	Four items omitted here; will be in vol. 29.
	190R	4	2	Change to “Toquepala”
	191L			Under “Chlorine,” change “Michel” to “Michael”
	194L			Under “Fluids and gases,” change “Akinfryev” to “Akinfriev.”
	195L			Under “Topaz,” change “Mexzies” to “Menzies”
	195R			Under “Metamorphic, Medium,” change “Philipott” to “Philippott”
	200L			Change to “Khibiny intrusions”
	201R			Under “Val d'Or,” change “Abatiba” to “Abativi”

* Includes partial items

** Minus lines refer to lines up from end of item