FLUID INCLUSION RESEARCH

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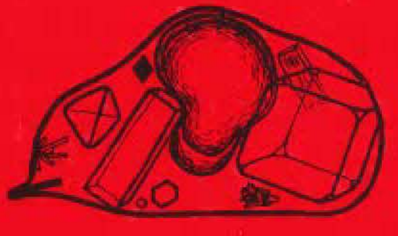

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1997

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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 and major shortening 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 1197 abstracts, citations or annotated citations, of which 21% are from non-English publications. A total of 14 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.

February 26, 1999 Edwin Roedder, Editor

CONTENTS

PREFACE v

CONTRIBUTORS vii

SUBSCRIPTION INFORMATION viii

REPEAT OF EDITOR'S SPECIAL REQUEST TO USERS ix

NOTICES OF MEETINGS, SYMPOSIA, AND SPECIAL PUBLICATIONS x

ABBREVIATIONS xiii

MICROTHERMOMETRY ABBREVIATIONS ix

ANALYTICAL METHOD ACRONYMS x

ABSTRACTS AND CITATIONS, 1997 1

ILLUSTRATIONS 230

INDICES
  Subject Index 239
  Locality Index 250
  Non-first author Index 258

ERRATA 267

CONTRIBUTORS, VOLUME 30

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. The 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 each year.

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Volume 30 (1997); 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 29–$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 publications 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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February 26, 1999

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,* 1996, v. 29; 1997, v. 30; 1998, v. 31.

Past Meetings

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

IAVCEI, European Union Geoscience, Strasbourg, March, 1997.

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

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

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

The Chinese Society on Petrology, Mineralogy and Geochemistry conference on fluid inclusions, Wuhan, Hebei Province, China, Oct. 6-8, 1997, with about 25 abstracts and 40 participants.

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.

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 was held August 17-19, 1998.

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

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

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

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

AGU/MS/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.

17th General Meeting of IMA, Toronto, Canada, August 9-14, 1998, with a special session on fluid and melt inclusions.

8th Annual V.M. Goldschmidt Conference, Toulouse, France, Aug. 30 to Sept. 3, 1998, with a special session on hydrothermal reactions.

European Union Socrates - Intensive Program, Modern Trends in fluid-phase petrology, Siena, Italy, Sept. 12-18, 1998.

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

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

Workshop on fluids and fractures in the lithosphere, Nancy, March 26-27, 1999, Convenor M. Lespinasse; email (lespinasse@ciril.fr).

Future Meetings

European Union of Geosciences 10th Biennial Meeting, Strasbourg, France, March 28-April 1, 1999; email (eug@eost.u-strasbg.fr).

Mineralogical Society (U.K.) meeting on Hydrocarbon-bearing Inclusions in Crustal Rocks–Study Methods, Applications, and Case Histories, April 7-8, 1999, Nat'l. Univ. of Ireland, Galway. Keynote speakers: Aplin, Bodnar, Burruss, Parnell, Piperon and Rankin. Convenor Dr. Martin Feely, Dept. of Geol., Nat'l. Univ., Ireland, Galway; email (martin.feely@ucg.ie).

GAC/MAC Joint Meeting, Laurentian Univ., Sudbury, Ontario, May 26-28, 1999. Contact Dr. P. Copper, Dept. of Earth Sci., Laurentian Univ., Sudbury, Ontario P3E 2C6. Telephone 1-705-675-1151 (ext. 2267); fax 1-705-675-4898; email (gacmac99@nickel.laurentian.ca).

AGU Spring, Boston, May 31-June 4, 1999; email (meetings@Kosmos.agu.org).

Models of volcanic-sedimentary ore-forming systems, St. Petersburg, Russia, June 7-10, 1999. Contact Dr. Mikhail P. Torokhov; email (TOROKHOV@g-ocean.spb.su). Field trip "Precambrian oceanic complexes and associated ore deposits, southern Karelia."

ECROFI XV, June 21-24, 1999, Potsdam, Germany; Rainer Thomas, Volker Lueders, and Andreas Schmidt-Mumm; email (ecrofi@gfz-potsdam.de).

IUGG '99, The 22nd General Assembly of the Int'l. Union of Geology and Geophysics, including IAVCEI, Univ. Birmingham, July 19-30, 1999; email (IUGG99@bham.acMk).

SGA/IAGOD 5th Biennial Conference, Society for Geology Applied to Mineral Deposits. "Mineral Deposits: Processes to Processing," Aug. 22-25, 1999. Imperial College/Natural History Museum, London, U.K., Contact Dr. Chris J. Stanley, Associate Keeper of Mineralogy, Dept. of Mineralogy, Natural History Museum, Cromwell Road, London SW7 5BD, U.K. Telephone 44-171-938-9361; fax 44-171-938-9268; email (cjs@nhm.ac.uk). For circular, see http://www.nhm.ac.uk/mineralogy/course/sga.htm. Of interest to the fluid inclusion community is a special session entitled "Fluid inclusions and ore formation processes" to be organized by Jon Naden (JNA@WPO.NERC.AC.UK); Jamie Wilkinson (j.wilkinson@ic.ac.uk); and Bob Bodnar (bubbles@vt.edu).

9th Goldschmidt Conference, Cambridge, MA, Aug. 22-27, 1999; email (goldschmidt@eps.harvard.edu).

GSA Annual, Denver, CO, Oct. 25-28, 1999, including a two-day SEG short course on Techniques in Hydrothermal Ore Deposits. Web site: http://www.geosociety.org. Telephone: 1-303-447-2020.

AGU Fall, San Francisco, CA, Dec. 13-17, 1999; email (meetinginfo@kosmos.agu.org).

Symposium Geology and Ore Deposits 2000: The Great Basin and Beyond, Reno/Sparks, NV, May 15-18, 2000; Geol. Soc. of Nevada, SEG, etc. Registration phone (775) 323-4569; email (kcluer@aol.com).

COPLSE, Workshop on melt inclusions, "Early 2000", Rhone Valley, France. Org. Committee: N. Arndt, J. Blichert-Toft, A. Sobolov, E. Hauri, J. Touret; email (Nicholas.Arndt@univ-rennes1.Fr)

AGU Spring, Washington, D.C., May 30-June 3, 2000; email (meetings@Kosmos.agu.org).

31st Int'l. Geol. Congress, Aug. 6-17, 2000, Rio de Janeiro, Brazil; email (31igc@31igc.org.br).

Goldschmidt 2000, Oxford, U.K., Sept. 3-8, 2000; email (Gold2000@campublic.co.uk).

GSA Annual, Reno, NV, Nov. 13-16, 2000.

4th Int'l. Conf. Mineralogy and Museums, Dec. 4-8, 2000, Melbourne, Australia; email (bbirch@mov.vic.gov.au).

AGU Fall, San Francisco, CA, Dec. 15-19, 2000.

GSA Annual, Boston, MA, Nov. 5-8, 2001.

IMA 2002, Edinburgh, Scotland, Sept. 9-13, 2002. Mr. K. Murphy, Min. Soc., 41 Queen's Gate, London SW7 5HR; email (IMA@minersoc.demon.co.uk). See web site at http://www.minersoc.org.

GSA Annual, Denver, CO, Oct. 28-31, 2002.

11th IAGOD Quadrennial Symposium S. Africa, 2002.

ABBREVIATIONS

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

aq	aqueous
CL	cathodoluminescence
dm	daughter mineral†
dp	daughter phase†
dxl	daughter crystal
eq.	equivalent
F	fluid; degree of fill§
FI	fluid inclusion
FIP	fluid inclusion panes
FIR	Fluid Inclusion Research
G	gas
H	homogenization
I	inclusion
M	melt
Mt	metric tonnes

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

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

*For explanation, please see next page. The abbreviation "Tf" is exceedingly ambiguous and should be avoided. Some papers use "Tf" for "temperature of formation" (i.e., Tt), some use it as equivalent to Th, others use it for "temperature of freezing," meaning Tm ice (on heating), and still others mean Tn ice (on cooling). A few use "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
HC	hydrocarbon
F	degree of fill
ppb	parts per billion (10^9)
ppm	parts per million (10^6)
µg/g	parts per million (10^6)
‰	parts per thousand
ppt	parts per thousand
per mil	parts per thousand
per mille	parts per thousand
%	parts per hundred
percent	parts per hundred
Ka	thousand years

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

The 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 = 10^9 Pa = 10^4 bar = 10 kbar. Still others use N/m^2 for newtons per square meter (10^5 N/m^2 = 1 bar).

MICROTHERMOMETRY ABBREVIATIONS

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

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

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

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

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 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 electron (imaging)
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
EA-MS	Coupled elemental analysis-Mass spectrometry
EBSD	Electron backscattered diffraction
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
FSE	Fore-scattered electrons
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 microspectography
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-AES	Laser activiated-Inductively coupled plasma-Atomic emission spectrometry
LA-ICP-MS	Laser ablation [activated?]-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 activated-Optical emission spectrometry (French usage)
LA-OES	Laser activated-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
LS ICP MS	Laser sampling-Inductively coupled plasma-Mass spectrometry
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
RNNA	Radionuclide neutron activation analysis
RS	Raman spectrometry

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-MS	Time-of-flight mass spectrometry
TOF-SIMS	Time-of-flight-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, 1997

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 its original language. The first author's address (and email address, if available) are 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.

ABART, R. and **SPERB, R.,** 1997, Grain-scale stable isotope disequilibrium during fluid-rock interaction. 1: Series approximations for advective-dispersive transport and first-order kinetic mineral-fluid exchange: American J. of Sci., v. 297, p. 679-706. Authors at Institut für Mineralogie und Petrographie, ETH-Zentrum, CH-8092 Zürich, Switzerland.

ADABI, M.H. and **VAN MOORT, J.C.,** 1997, Application of oxygen and carbon isotopes as evidence for alteration in carbonates: Second Internat'l. Conference on Isotopes, Oct. 12-16, 1997, Millennium Sydney, Australia, Handbook, p. 99-xx. First author at Geol. Dept., Univ. of Tasmania, GPO Box 252-79, Hobart, Tasmania, Australia.

[A] large stratabound, carbonate replacement tin deposit is situated at Renison Bell on the west coast of Tasmania, Australia. The heaviest $\delta^{18}O$ and $\delta^{13}C$ values are in the least-altered dolomite, whereas highly altered dolomites are more depleted in both $\delta^{18}O$ and $\delta^{13}C$ values. The lightest isotopic data is in vein dolomites.

The $\delta^{18}O$ and $\delta^{13}C$ values of the least altered Renison dolomite correspond to formational T of ~20°C, whereas the oxygen isotopic values of the most altered dolomites indicate that they were magmatically derived Devonian hydrothermal F of approximately 350°C. These T are similar to those obtained from FI studies and from calculations based on $\delta^{18}O$ variation in vein quartz. (From authors' abstract by E.R.)

ADAM, John, GREEN, T.H., SIE, S.H. and **RYAN, C.G.,** 1997, Trace element partitioning between aqueous fluids, silicate melts and minerals: Eur. J. Mineral., 1997, no. 9, p. 569-584. First author at ARC Nat'l. Key Centre for the Geochemical Evolution and Metallogeny of Continents, School of Earth Sci., Macquarie Univ., NSW 2109, Australia.

A series of experiments was conducted to examine the capacity of H_2O F to concentrate and transport incompatible elements (including Rb, Sr, Ba, Y, Zr, Hf, Nb, Ta, La, Lu, Th and U) in the peridotitic mantle and subducted ocean crust. An electron microprobe and proton microprobe were used to measure concentrations of major and trace elements in solutes from aq F equilibrated (at 900-1100°C, 2.0 GPa) with water-saturated M of trondhjemitic and basanitic composition. The compositions of coexisting mineral phases (including staurolite, amphibole and clinopyroxene) were also determined.

Solutes in equilibrium with both trondhjemitic and basanitic M have granitic compositions. Total solute concentrations in F equilibrated with trondhjemitic M are between 34 and 48 wt.%. The F equilibrated with basanitic M contains about 30 wt.% of solutes. F in equilibrium with trondhjemitic M are moderately enriched in Rb and K. Other trace elements partition either neutrally or are moderately depleted in the F. Cl-bearing F are enriched in alkalis relative to non-alkaline trace elements, whereas F has little effect on element partitioning between F and M. F in equilibrium with basanitic M is moderately enriched in Rb and K, but depleted in Sr, Ba, Y, Ti, Zr, Hf, Nb, Ta, La, Lu, Th and U. Except for alkalis, minor and trace element concentrations are greater in amphibole and clinopyroxene than in co-existing F.

The results from this study show that H_2O F in equilibrium with mantle peridotites will not be efficient metasomatic agents. They also indicate that, at 2.0 GPa and 900°C, H_2O F and hydrous M in equilibrium with eclogitic mineral assemblages will have broadly similar compositions. The data, when combined with recent partitioning results between eclogitic minerals and trondhjemitic M (Jenner et al., 1993; Rapp & Shimizu, 1995), suggest that H_2O F derived from subducted ocean crust will be a viable source of incompatible elements for the mantle beneath volcanic arcs. Moreover, the distinctive incompatible element concentrations found in volcanic arc magmas (including Nb and Ta depletions) are more likely to be the result of crystal-chemical controls than due to the properties of H_2O F. (Authors' abstract)

AHAMDACH, Noureddine and **PAGEL, Maurice,** 1997, Parent magma chemistry through melt inclusions in quartz and apatite crystals: The case of the highly altered cinerites from the Lodève basin (Herault, France): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 1-2. Authors at CREGU et EP 578, B.P. 23, 54501 Vandœuvre-lès-Nancy, France; email (nour@cregu.cnrs-nancy.fr)

Perfectly preserved MI have been found in apatite crystals of three cinerites and in quartz from [host conglomerate]. Their study allowed the determination of the chemical nature of the volcanism in the Lodève basin and the assessment of uranium potential of the volcanic material.

The P MI in quartz and apatite crystals range from 20 to 100 µm. At room T, most of MI contain only one phase (glass), although a small number contains a shrinkage bubble, ±dxls. Chemical analyses of MI by electron microprobe show a hydrous rhyolitic M composition. The total sum of oxides ranges from 91 to 94%. The difference is assumed to be H_2O and CO_2.

In quartz, SiO_2 contents of M I range from 71 to 74%, Al_2O_3 contents are constant around 11-12%, Na_2O and K_2O concentrations range respectively from 2.3 to 3.4% and from 4 to 5%, FeO_t contents range from 0.6 to 0.9%, CaO contents range from 0.3 to 0.9%, MgO, MnO and TiO_2 concentrations are very low, and the K_2O/Na_2O ratios range from 1.2 to 1.8.

In apatite crystals from cinerites, SiO_2 contents of M I range from 70 to 73%, Al_2O_3 contents range from 11 to 14%, Na_2O and K_2O concentrations range respectively from 2.2 to 3.7% and from 3.6 to 5.5%, FeO_t contents are constant around 0.6 to 0.9%, CaO contents range from 1.1 to 1.8%, MgO, MnO and TiO_2 concentrations are very low, and the K_2O/Na_2O ratios range from 1.1 to 2.3.

The Lodève basin contains several uranium deposits. It is therefore very interesting to determine the U content of the parent magma. The strong alteration of the cinerite does not allow such [an analysis]. The induced fission track technique was used to determine the U content of the MI. The average uranium content of quartz MI is 7 ppm. The range of U and Th contents of the cinerites are 0.1 and 12.5 ppm and 0.4 and 16.5 ppm respectively [sic].

These results suggest that: 1) The Lodève basin volcanism is calc-alkaline. The REE distribution of the cinerite and zircon typology are in agreement with the MI data; 2) this volcanic material could be a potential source of uranium in the basin despite a low uranium content because a large percentage of uranium is located in the glass phase. Uranium could be easily leached [from the glass] during surficial and diagenetic processes; 3) the presence of perfectly preserved MI in apatite crystals suggests that no chemical exchange occurred during diagenesis and demonstrates that mineralogical barriers made possible the glassy material's retention for extended geological times despite intense alteration. (From authors' abstract by E.R.)

AKCAY, Migraá, ÖZKAN, H.M., MOON, C.J. and **SPIRO, Baruch,** 1997, Fracture controlled and stratabound stibnite, and cinnabar deposits of western Turkey: A genetical approach: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 37-xx. First author at Karadeniz Teknik Üniversitesi, Müh. Mim. Fak., Jeoloji Müh. Böl., Trabzon, Turkey.

The stibnite deposits in the Emirli region (western Turkey) have crosscutting and stratabound subtypes occurring in association with each other. Cinnabar deposits, however, are all structurally controlled. Stibnite deposition was initiated at about 300°C due to a T drop as a result of a possible F immiscibility and continued till low T conditions. With further cooling below 170°C, cinnabar deposition took place. The F responsible for the crosscutting mineralisation have low sal (<3 wt.% NaCl eq.) and are dominantly of meteoric origin. $\delta^{34}S$ values of pyrite, stibnite and marcasite from both crosscutting and stratabound stibnite mineralisations are similar and show a wide span ranging from -5.6 to -13.1‰, whereas those from cinnabar have consistent values (-6.5 to -6.8‰). This indicates that sulphur of crosscutting stibnite mineralisation is derived from stratabound sulphide mineralisation and that input of magmatic sulphur may have increased towards the cinnabar deposition. (Authors' abstract)

AKINFIEV, N.N., 1997, Thermodynamic description of H_2O-gas binary systems by means of the Redlich-Kwong equation over a wide range of parameters of state: Geokhimiya, 1997, no. 1, p. 226-234 (in Russian; translated in Geochemistry Internat'l., v. 35, no. 2, p. 1881-96). Author at Moscow State Geological Prospecting Acad., ul. Miklukho-Maklaya 23, Moscow, 109180 Russia.

A thermodynamic description of binary systems H_2O-neutral species based on the Redlich-Kwong equation is proposed. This approach uses only the thermodynamics of pure components and no fitting parameters for H_2O-nonpolar G (CO_2, H_2) mixtures. To describe dissolved, weakly dissociated polar molecules (H_2S^0), a small correction independent of T and P is needed. With this approach, even neutral species of strong electrolytes (HCl^0, $NaCl^0$) can be described. The approach is valid from 100 to 600°C and 1 to 4000 bar. Using this method, it is possible to calculate not only thermodynamic properties of components at infinite dilution, but their concentration dependencies as well. This point is of principal importance for studying the chemistry of natural F enriched with volatile components. (Author's abstract)

AKSYUK, A. M., 1997, The SiO_2-H_2O system along the lower three-phase curve and approximate values of critical end-point temperature: European J. of Mineral., 1997, no. 9, p. 975-986.

ALDERTON, D.H.M., 1997, The genesis of gold-silver-tellurium deposits in the southern Apuseni Mountains, Romania (abst.): Mineral Deposits Studies Group Ann. Gen. Meeting, Jan 8-11, 1997, Glasgow Univ., Programme with Abstracts Volume, p. 1.

A multidisciplinary mineralogical and geochemical study has been carried out on the epithermal Au-Ag-Te deposits of the southern Apuseni Mountains, in the vicinity of the town of Certej (Saccarimb, Bocsia).

Hydrogen and oxygen isotopic analyses of minerals and FI have been used to estimate the isotopic composition of the mineralizing F. It is calculated that at 300°C the F would have had a composition of $\delta^{18}O$=+6.5 to +11.1, and δD=-29 to -55 per mil. These compositions are quite different from those associated with classic epithermal gold mineralization and therefore unmodified meteoric water was probably not dominant in the system. It is possible that these compositions are the result of boiling or the involvement of large components of magmatic water, although these sources are not favoured. (From author's abstract by E.R.)

ALDERTON, D.H.M. and **BEVINS, R.E.**, 1995, P-T conditions during formation of quartz in ironstone nodules from the South Wales Coalfield: Evidence from coexisting-hydrocarbon and aqueous fluid inclusions (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). First author at Dept. of Geol., Royal Holloway (Univ. of London), Egham, Surrey TW20 0EX, U.K.

See FIR, v. 29, p. 3 (E.R.).

ALËSHIN, A.P., GÓLUBEV, V.N., KRYLÓVA, T.L., VÉLICHKIN, V.I., CUIGNET, M. and **POTY, B.**, 1997, The geochemical features, Sm-Nd systematics, and homogenization temperatures of fluid inclusions as typical indications of fluorite in deposits from eastern Transbaikalia (Russia): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 211-212, ISBN 5-88918-002-9 (in Russian; English translation courtesy Dr. D. B. Brown). First author at IGEM, RAS, Moskvá, Russia.

In eastern Transbaikalia, fluorite mineralization is typical of the deposits of various associational kinds. Its formation took place during the course of several hydrothermal stages which occurred during Mesozoic time. This suggests that fluorite is one of the most informative minerals in a comparative study of the conditions of hydrothermal mineral-formation and for estimating the possible sources of the mineral resources associated with it.

Specimens of fluorite have been examined from the Strél'tsovskoe Mo-U deposit (ore and post-ore stages), the Abagaitui fluorite deposit, and the Garsonui polymetallic deposit. The comprehensive studies have included methods of paragenetic analysis, mineralogical geochemistry (ICP-MS on 42 elements), Sm-Nd isotopes, and TBG. The following results have been obtained.

1. Two groups of trace elements have been revealed, using a factorial analysis according to which fluorite from various deposits can be most clearly distinguished. The first group includes Hf, Zr, Th, and Sb, and the second includes Sr, Ba, U, and Nb. In order to define the composition of the fluorite, we have used additive indexes (respectively K_1 and K_2), calculated as the sum of the standardized amounts of elements of each group (with a mean equal to 0 and a dispersion of 1), normalized into factorial loadings of elements. Both generations of fluorite from the Strél'tsovskoe deposit are marked by large amounts of elements of both groups (K_1 and K_2>0), those from the Abagaitui deposit by low amounts of elements of both groups (K_1 and K_2<0) and those from the Garsonui deposit by low amounts of elements of the 2nd group (K_1<0). The content of elements of the first group in the fluorite from this last deposit regularly diminished from early to late generations.

2. Among the rare-earth elements (REEs), the most stable feature for fluorite from different deposits appeared to be the Eu/Sm ratio, marking a europium anomaly. The light REE (La, Ce, Pr and Nd), medium REE (Sm, Eu, Gd and Tb), and heavy REE (Dy, Ho, Er, Tm, Yb and Lu) ratios appeared less stable. A distinguishing feature of the fluorite composition of both generations from the Strél'tsovskoe deposit is the maximum value of the Eu/Sm ratio (0.32-0.5, as compared with a chondrite value of 0.38) and a marked predominance of MREEs over LREEs and HREEs. The Abagaitui deposit is typified by a marked negative europium anomaly (0.04-0.1) against a background of flat curves for REE distribution, with insignificantly low values for LREEs. An increase in total REEs has been noted from the early to the late generations of fluorite in this deposit. The early generations of fluorite in the Garsonui deposit are marked by an insignificant predominance of LREEs over MREEs, and of the latter over HREEs, whereas the late generations are marked by a sharp deficit of LREEs. All generations are marked by a relatively feeble europium anomaly (0.25-0.35).

3. The Sm-Nd isochron age fluorite of ore generation in the Strél'tsovskoe deposit has been determined at 127±20 MY, which agrees with the results of U-Pb dating of the uranium ores (133-135 MY). The value of ε^t_{Nd} is -0.31, which is close to the null value for the standard chondrite reservoir (SNUR). Marked deviations of points on the isochron diagram (ε_{Nd} reaches 1.6) most probably reflect a difference in the P isotope composition of Nd of various generations of fluorite.

4. Th for FI in the fluorite are: in the Garsonui deposit, they regularly diminish from the early (380°C) to late generations (220°C), which agrees with a gradual change in colour and in the amounts of elements of the first group in sequential zones.

The following conclusions may be reached from the results of these studies:

A) the content of trace elements is a distinguishing sign for fluorite from different deposits, whereas the distribution of REEs may alter significantly even within single rhythms of incrustate veins;

B) Values of Eu/Sm ratios, similar to the chondrite model, established for both generations of fluorite from the Strél'tsovskoe deposit, may point to a deep-seated source of the material, appearing during the ore and also the post-ore stages. This conclusion is supported by the ε^t_{Nd} values for fluorite of ore generation close to null;

C) The sharp negative europium anomaly, revealed in fluorite from the Abagaitui deposit, may be regarded as evidence of a crustal source of the material. (Authors' abstract)

ALLARD, Patrick, JEAN-BAPTISTE, Philippe, D'ALESSANDRO, Walter, PARELLO, Francesco, PARISI, Bianca and **FLEHOC, Christine**, 1997, Mantle-derived helium and carbon in groundwaters and gases of Mount Etna, Italy: Earth and Planet. Sci. Letters, v. 148, p. 501-516. First author at Centre des Faibles Radioactivités, CNRS-CEA, Orme de Merisiers, 91191 Gif sur Yvette Cedex, France.

We report the first detailed investigation of both helium and carbon isotopes in groundwaters and G of Mt. Etna, providing new insight into the distribution, origin and budget of magmatic G release at this very active volcano. The $^3He/^4He$ ratio of the magmatic G end-member coincides with that of helium trapped in the He-rich olivine crystals of Etna basalts (mean range: 6.7±0.4 R_a, pointing to its negligible dilution by radiogenic He from the crustal basement and further constraining the $^3He/^4He$ ratio of the present-day Etna magma. The estimated outputs of mantle-derived CO_2 and ^3He from Etna account for 10% and 15%, respectively, of estimates for global subaerial volcanic emissions. This huge contribution results from continuous degassing of mostly unerupted He- and C-rich alkaline basaltic magma. (From authors' abstract by E.R.)

AMEND, J.P. and **HELGESON, H.C.,** 1997, Group additivity equations of state for calculating the standard molal thermodynamic properties of aqueous organic species at elevated temperatures and pressures: Geochim. Cosmo. Acta, v. 61, no. 1, p. 11-46. Authors at Dept. of Geol. and Geophys., Univ. of California, Berkeley, CA 94720.

Group additivity equations of state for aq organic molecules have been generated by combining the revised Helgeson-Kirkham-Flowers (HKF) equations of state with experimental values of the standard molal properties of aq alkanes, alkanols, alkylbenzenes, carboxylic acids, amides, and amines. EOS parameters for the groups represented by $-CH_2$, $-CH_3$, $-CHCH_3$, $-C_6H_5$, $-CH_2OH$, $-COOH$, $-CONH_2$, and $-CH_2NH_2$ were determined by regression of the experimental data. (From authors' abstract by E.R.)

ANDERSEN, Tom, BURKE, E.A.J. and **WHITEHOUSE, M.J.,** 1997, Fluid inclusions in Scourian granulites from the Lewisian complex of NW Scotland: Evidence for CO_2-rich fluid in late-Archaean high-grade metamorphism: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 3. First author at Mineralogical-Geological Museum, Sars gate 1, N-0562 Oslo, Norway.

The Late Archaean gneisses of the central region of the Lewisian Complex of NW Scotland, generally termed the Scourian gneisses, are a classic example of extremely LILE-depleted granulites. The nature and role of a Scourian metamorphic F has frequently been debated, but no systematic study of the relationship between F composition and properties and the metamorphic history of the Scourian granulies has yet been carried out. This study presents the first data on the composition and properties of FI in Scourian gneisses from some key localities.

Pure CO_2 or CO_2-dominated FI are moderately abundant in pristine granulites. These I show Th ranging from -54 to +10˚C with a very prominent histogram peak at -16 to -32˚C, and only slight variations between different areas of the central region. Isochores corresponding to this main histogram peak agree with P-T estimates for granulite-facies recrystallization during the Badcallian (750-800˚C, 7-8 kbar) as well as with Inverian P-T conditions (550-600˚C, 5 kbar). The maximum densities encountered could correspond to F trapped during an early, higher P-T phase of the Badcallian metamorphism (900-1000˚C, 11-12 kbar). Th substantially higher than the main histogram peak may represent Laxfordian reworking (500˚C, <4 kbar). In the pristine granulites, aq FI are of very subordinate importance and occur only along late S healed fractures, suggesting that the influence of new, aq F during the Inverian and Laxfordian events is negligible in areas away from major shear zones. In rocks which have been retrograded to amphibolite facies from Inverian and/or Laxfordian shear zones, CO_2 I are conspicuously absent; only S aq I are present, presumably related to post-granulite hydration processes.

These data illustrate the importance of CO_2-rich F for the petrogenesis of Late-Archaean granulites, and demonstrate that early FI may survive subsequent metamorphic processes as long as no new F is introduced into the system. Although probably not the main cause of LILE depletion in Lewisian granulites, this F phase was an integral part of the high-grade phase assemblage, which should not be neglected in discussions of metamorphic processes in the Lewisian. (From authors' abstract by E.R.)

ANDERSEN, T., WHITEHOUSE, M.J. and **BURKE, E.A.J.,** 1997, Fluid inclusions in Scourian granulites from the Lewisian complex of NW Scotland: Evidence for CO_2-rich fluid in Late Archaean high-grade metamorphism: Lithos, v. 40, p. 93-104. First author at Mineralogisk-Geologisk Museum, Sarsgt. 1, N-0562 Oslo 5, Norway.

In this paper the first FI data are presented from Late Archaean Scourian granulites of the Lewisian complex of mainland northwest Scotland. Pure CO_2 or CO_2-dominated FI are moderately abundant in pristine granulites. These I show Th ranging from -54 to +10˚C with a very prominent histogram peak at -16 to -32˚C. Isochores corresponding to this main histogram peak agree with P-T estimates for granulite-facies recrystallization during the Badcallian (750-800˚C, 7-8 kbar) as well as with Inverian P-T conditions (550-600˚C, 5 kbar). The maximum densities encountered could correspond to F trapped during an early, higher P-T phase of the Badcallian metamorphism (900-1000˚C, 11-12 kbar). Th substantially higher than the main histogram peak may represent Laxfordian reworking (≤500˚C, <4 kbar). In the pristine granulites, aq FI are of very subordinate importance and occur only along late S healed fractures. In rocks which have been retrograded to amphibolite facies from Inverian and/or Laxfordian shear zones, CO_2 I are conspicuously absent; only S aq I are present, presumably related to post-granulite hydration processes. These data illustrate the importance of CO_2-rich F for the petrogenesis of Late Archaean granulites, and demonstrate that early FI may survive subsequent metamorphic processes as long as no new F is introduced into the system. (Authors' abstract)

ANDERSON, A.J. and **MAYANOVIC, R.A.,** 1997, High temperature X-ray absorption analysis of transition metal complexes in magmatic fluids (abst.): Atlantic Geoscience Society Abstracts, 1997 Colloquium and Ann. Gen. Meeting, Amherst, Nova Scotia, published in Atlantic Geol., v. 33, p. 52. First author at Dept. of Geol., St. Francis Xavier Univ., P.O. Box 5000, Antigonish, Nova Scotia B2G 2W5, Canada.

The synchrotron microprobe was used to collect X-ray absorption fine structure (XAFS) spectra from aq Fe, Cu and Zn complexes in FI at T ranging from 25 to 500˚C. High sal FI, believed to contain magmatically generated brines, were selected from the Bingham porphyry Cu deposit, Utah, and from a granite pegmatite in the Granulite Massif, Germany. In all I the chloride concentrations are about 9 m. Analysis of the Zn K-edge XAFS spectra indicates that the tetrahedral chlorozinc complex ($ZnCl_4^{2-}$) is dominant at high T in the studied magmatic F. Furthermore, the Zn-Cl bond length decreases by nearly 0.01 Å for every 100˚C increase in T. (From authors' abstract by E.R.)

ANDERSON, A.J., MAYANOVIC, R.A., HORN, Ingo, JACKSON, Simon and **THOMAS, Rainer,** 1997, Element partitioning and ore-metal transport in a two-phase hydrothermal system: Evidence from fluid inclusions in pegmatites and associated polymetallic sulfide veins in the Saxonian granulite massif, Germany: abst., XIV ECROFI, Proc. of the

XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 4-5. First author at Dept. of Geol., St. Francis Xavier Univ., Antigonish, Nova Scotia, B2G 2W5 Canada.

Granitic pegmatites and associated polymetallic sulfide veins in the Saxonian Granulite Massif, Germany, display a transition from high T oxide mineralization in the pegmatites to a lower T sulfide and sulfosalt paragenesis in the quartz veins.

Inclusion petrographic features and microthermometric data indicate simultaneous trapping of a V and high-sal brine in both the pegmatites and the hydrothermal veins. Coeval V and brine I in the pegmatite homogenize at 410±10°C. Multiphase brine I in the pegmatite and quartz veins yield sal ranging between 34 and 38 wt.% NaCl eq. Dm identified in the high sal FI include halite, sylvite, jamesonite, calcite, wavellite and an Fe-chloride. V-rich I consist mainly of CO_2 and minor nitrogen. Brine and V I were separately analyzed using: 1) synchrotron X-ray fluorescence (SXRF), 2) laser Raman spectroscopy, 3) laser ablation microprobe-inductively coupled plasma-mass spectrometry (LAM-ICP-MS) and 4) X-ray absorption fine structure (XAFS) spectroscopy in order to determine the chemical controls of transport and deposition of ore-forming metals in this granite-related hydrothermal system.

Quantitative and semiquantitative analysis using LAM-ICP-MS and SXRF of B, P, S, Cl, Ca, Fe, Cu, As, Br, Rb, Sr, Mo, Ag, Sn, Sb, W, Au, Tl, Pb and Bi in individual FI reveals high concentrations of Na, Cl, K, Ca, Mn, Fe, Sb, Pb, Zn with minor Sr, Mo, Ag, Sn, Au, Tl, Hg and Bi in the high sal FI. In contrast, B, S and Cu partition strongly in the V phase. This is consistent with PIXE results obtained on brine and V I in the Mole granite (Heinrich et al., 1992). As, Sb and P are also detected in the V (Fig. 1). Zn and Fe K-edge XAFS spectra obtained from highly saline I at Tt show that both Zn and Fe are transported as tetrahedral chlorocomplexes. Destabilization of the Zn chlorocomplex is due in part to decreasing T, dilution and interaction with a sulfur source during F migration. (From authors' abstract by E.R.) *See figure on page 237.*

ANDRE, A.-S., BOIRON, M.-C., CATHELINEAU, Michel, LEROY, J.L. and LESPINASSE, Marc, 1997, Fluid inclusions planes (FIP) geometry and P-T-X conditions of fluid migration in the St. Sylvestre granite (NW French Massif Central): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 6-7. First author at Univ. Henri Poincare-Nancy 1, UMR EP578, BP239, 54506 Vandœuvre-lès Nancy cedex, France.

Outside major F pathways, F percolation occurs through sets of microcracks which can be considered for their most part as mode I cracks. After healing, microcracks form FI planes (FIP). The objective of this study was thus to depict the distribution of F and microfractures. The dip directions are plotted on stereographic projections. The microthermometric and Raman characteristics of each FI are determined in accordance with their dip direction. The two main families of FIP (NW and EW) are characterized by two distinct F types. F from the EW striking FIP belong to the H_2O-NaCl system. Some FIP are characterized by small V phases (5 to 15%) and a low sal (Tm ice: -3 to -2.6°C, corresponding to a sal of 4.3 to 4.9 wt.% eq. NaCl). Other planes contain I displaying V phases ranging from 50 to 90% and a lower sal (Tm ice: -1.8 to -1°C; 1.7 to 3.0 wt.% eq. NaCl).

F in the NS striking FIP are aquo-carbonic F. The volatile phase is dominated by CO_2 (90 to 95 mol%), and contain smaller amounts of N_2 (4 to 8 mol%) and CH_4 (0.6 to 1.5 mol%). Tm CO_2 is in the range of -58.8 to -58.2°C, Tm clathrate is between 5.3 and 6°C and Tm ice is in the range of -4 to -8°C. Th CO_2 occurs between 23 to 27°C in the V phase. Total homogenisation is observed mainly in the L phase, sometimes in the V phase at 350°C or more.

The N150° striking FIP present both H_2O-NaCl and aquo-carbonic I in the same plane. The sal of the aq I are highly variable (2 to 15 wt.% eq. NaCl) but the aquo-carbonic I present the same characteristics of those in the N20° FIP. These cracks should have been successively opened and healed, leading to a complex superimposition of distinct F in the same FIP.

Estimation of the P and T have been made using the Raman and the microthermometric data. At an estimated T of 350 to 450°C, P would have reached 50 to 150 MPa corresponding roughly to a depth of 1.5 to 5 km assuming an average density of 2.6 g/cm^3 for the rock column and a lithostatically pressured F. These results are compatible with an intermediate stage within the P-T path.

In this study, the FIP appear to be excellent markers of the microfissural paleopermeability and provide some quantitative data which can be used for the description of the paleofluid migration in rocks. More, the microfissural parameters appear to be rather sensitive to the distance to a regional fault. (From authors' abstract by E.R.)

ANDREEVA, I.A., NAUMOV, V.B., KOVALENKO, V.I. and KONONKOVA, N.N., 1997, Primary phosphate-silicate melts for the rocks of the magmatic alkaline-carbonatitic complex from the Mushugai-Khuduk, South Mongolia: Results of melt inclusions study: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 8-9. First author at Inst. of Geol., of Ore Deposits (IGEM) RAS, 35 Staromonetny, Moscow 109017, Russia; email (vik@igem.msk.su).

We investigated the composition and PT conditions of magmas entrapped as MI in apatite phenocrysts of leucite phonolite and shonkinite, using optical and thermometric methods and X-ray microprobe.

P MI of both leucite phonolite and shonkinite are represented by crystallized silicate and silicate-salt M. Dm discovered in the MI from leucite phonolite are as follows: 1) diopside, K-Na feldspar in silicate MI; 2) diopside, phlogopite, K-Na feldspar, ankerite, anhydrite, celestite, magnetite in silicate-salt I. Dm recognised in the MI from shonkinite are as follows: 1) diopside, phlogopite, alkaline amphibole, magnetite in silicate I; 2) diopside, K-Na feldspar, phlogopite, calcite, sodalite, anhydrite, barite-celestite, apatite, magnetite, pyrrhotite in silicate-salt I.

Th of the silicate MI from leucite phonolite is 1190-1220°C. Silicate-salt I from leucite phonolite and MI from shonkinite were not homogenized at 1300°C. After heating at 1155-1220°C and following quenching they consisted of a glass and bubble.

Glasses of the silicate and silicate-salt I from both leucite phonolite and shonkinite differ essentially from one another by P_2O_5, SiO_2, Al_2O_3, MgO, CaO-content.

Two glassy phases, with clear boundary between them, were found in some homogenized silicate-salt I of shonkinite. One of these phases of homogenized glass [was] similar [in] composition with the silicate-salt I. The phase is enriched in P_2O_5, CaO and depleted in SiO_2, Al_2O_3, MgO.

This fact is indicative of L immiscibility. During our MI studies we found that the P_2O_5 content regularly decreases with the rise of SiO_2, Al_2O_3, and the decrease of MgO and CaO content in the I. From these results it is evident that phosphorus is predominantly concentrated in silicate-salt M. Our data evidence the existence of natural phosphate-silicate M containing up to 20 wt.% of P_2O_5. (From authors' abstract by E.R.) *See table on page 237.*

ANOVITZ, L.M., BLENCOE, J.G. and **HORITA, J.**, 1997, Precise measurement of the activity/composition relations of H_2O-N_2 and H_2O-CO_2 fluids at 500°C, 500 bars: *in* Proceedings of the Fifth Int'l. Symposium on Hydrothermal Reactions, Palmer, D.A. and Wesolowski, D.J., eds., 1997, Gatlinburg, TN USA, p. 232. Authors at MS 6110, Bldg. 4500S, Oak Ridge Nat'l. Laboratory, Oak Ridge, TN 37831-6110; e-mail (iz9@ornl.gov).

The activity/composition (a/X) relations of H_2O-N_2 and H_2O-CO_2 fluids have been measured at 500°C, 500 bars. The results are more accurate, and much more precise, than any currently available. (From authors' abstract by H.E.B.)

APPEL, P.W.U., 1997, High bromine contents and low Cl/Br ratios in hydrothermally altered Archaean komatiitic rocks, West Greenland: Precambrian Research, v. 82, no. 177-189. Author at Geological Survey of Denmark and Greenland, Øster Voldgade 10, DK 1350, K, Copenhagen, Denmark.

In Archaean supracrustal rocks in West Greenland komatiitic and tholeiitic rocks have undergone alteration by circulating hydrothermal solutions, whereby the rocks were partly transformed into calc-silicate assemblages. The alteration, which also formed extensive stratabound scheelite mineralizations, took place partly at the sea floor and partly below the sea floor prior to metamorphism and deformation of the volcano-sedimentary pile was altered by hot brines which had attained high halogen contents by reaction with mafic and ultramafic rocks. During brine-rock interaction the Cl/Br ratio of the brines decreased and the metal contents increased. The metalliferous bromine-enriched brines ascended towards the sea floor. The bromine and some of the metals precipitated in the upper part of the volcano-sedimentary pile and in the volcanic rocks at the sea floor. High bromine contents and low Cl/Br ratios may indicate presence of major orebodies. (Author's abstract)

ARANOVICH, L.Ya. and **NEWTON, R.C.**, 1997, H_2O activity in concentrated KCl and KCl-NaCl solutions at high temperatures and pressures measured by the brucite-periclase equilibrium: Contrib. Mineral. Petrol., 1997, no. 127, p. 261-271. Authors at Dept. of Geophys. Sci., Univ. of Chicago, Chicago, IL 60637.

H_2O activities in supercritical F in the system KCl-H_2O-(MgO) were measured at P of 1, 2, 4, 7, 10 and 15 kbar by numerous reversals of V compositions in equilibrium with brucite and periclase. Measurements spanned the range 550-900°C. A change of state of solute KCl occurs as P increase above 2 kbar. The great similarity of the NaCl-H_2O and KCl-H_2O systems suggests that H_2O activities in the ternary NaCl-KCl-H_2O system can be described with reasonable accuracy by assuming proportionality between the binary systems. Concentrated salt solutions seem, from this standpoint, and also because of high mechanical mobility and alkali-exchanging potential, feasible as metasomatic F for a variety of deep-crust and upper mantle processes. (From authors' abstract by E.R.)

ARCOS, D. and **AYORA, C.**, 1997, The use of fluid inclusions in halite as environmental thermometer: An experimental study: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 10-11. First author at Dept. Cristal.lografia, Mineralogia i Dipòsits Minerals, Univ. de Barcelona, c./Martí i Franqués s/n. 08028 Barcelona, Spain.

The usefulness of FI in halite crystals as a potential thermometer has been tested by Roberts and Spencer {Geóch. Cosmo. Acta, v. 59, p. 3929, 1995], [but the] wide range of variation found makes interpretation difficult. In order to adress such questions Th of FI in halite grown at different T were measured.

FI from halite formed at 30 and 40°C do not contain shrinkage bubbles, whereas those from crystals grown at 50 and 60°C, usually have shrinkage bubbles at room T. Very large FI from all T experiments with high bubble/L ratios were probably due to stretching during crystal manipulation and were not considered. Halite crystals grown at 30 and 40°C were introduced in a freezer between -10 and -20°C for two weeks, in order to nucleate a V bubble. All samples were transferred to a -10°C precooled stage and then heated at slow rate (≤0.4°C/minute) until homogenization. When apparent homogenization was achieved freezing [i.e. cooling?-heating]-cycles were conducted until bubble did not grow again (real homogenization).

Th recorded are represented in Figure 1. As can be seen in the histograms, high-T experiments have low dispersion with the maximum coincident with the growth T. Results are less accurate at lower experimental T results, increasing gradually the number of I homogenizing at T lower than that of the experiment. In all cases not the mean but the maximum Th recorded are the values closest to the formation T within the analytical deviation. Furthermore large FI have Th lower than formation T, whereas smaller FI have Th closer to the formation ones (Fig. 2). We interpret the dispersion of the results from low T experiments as due to disequilibrium between the brine and the halite wall during the heating process. Diffusion of ions from the walls to the bulk of the brine may be a rate timing step and make dissolution slower. This would decrease the V/L ratio and thus Th. This process will be enhanced in larger I. As T increases diffusion transport also increases and the proceses upon heating are closer to equilibrium as in higher T experiments. (From authors' abstract by E.R.) *See figures on page 240.*

ARCOS, D. and **SOLER, A.**, 1997, Fluid origin for the copper-gold mineralization of Carlès, NW Spain: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 137-140. Authors at Departamento de Cristalografía, Mineralogia i Dipòsits Minerals, Universitat de Barcelona, Spain.

The Carlès copper-gold deposit is related to a shallow intrusive body. The mineralization is characterized by four alteration types: skarn, K-feldspar alteration of the granite, greisen-type alteration, and actinolite-arsenopyrite replacement of limestones that host the deposit. The skarn alteration was formed in three stages, the first one was developed simultaneously with the intrusion (305±6 Ma), whereas the other two stages, as well as the other types of alteration, were formed later (287±7 Ma) in a younger hydrothermal event. O-, C-, and H-isotopic composition of minerals from the granite and from the four alteration types point to a magmatic source for the mineralizing F, although during the last stage meteoric water, probably equilibrated with regional limestones, mixed with the former F. (Authors' abstract)

ARCOS, D. and **TORNOS, F.**, 1997, Hydrocarbon fluid inclusions in quartz crystals from the fluorite stratabound deposit of Berbes (NW Spain): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 12-13. First author at Dept. Cristal.lografia, Mineralogia i Dipòsits Minerals, Univ. de Barcelona, c./Martí i Franqués s/n. 08028 Barcelona, Spain.

The fluorite deposits of the Berbes area occur as stratabound MVT-like orebodies located along the unconformable contact between Namurian black limestones and dolostones and red beds of Triassic age. The fluorite is associated with quartz, barite, calcite and minor sulphides. Solid organic matter occurs as cm-sized pods interstitial of the hydrothermal minerals or as solid and FI in quartz and fluorite.

The massive fluorite orebodies are hosted by an external aureole of dolomitization and an internal silicification zone. A key feature of the hydrothermal dolostones is the presence of abundant bipyramidal and well-developed quartz crystals up to several cm as well as abundant vugs filled with fluorite, barite, calcite and solid organic matter. The quartz crystals host P petroleum-rich FI, that are also found in S trails in the fluorite. The FI in the quartz are very large, from a few microns to >2 mm. Most are grouped along growth bands parallel to the edge of the crystal, generally oriented perpendicular to the crystal growth direction. The I define a clear core to edge zonation pattern defined by: a) solid organic matter or brown asphalt; b) brown asphalt + hydrocarbon F + gas bubble; c) hydrocarbon F + gas bubble + several graphite crystals; and d) hydrocarbon F + gas bubble. In some crystals, rare I of the b-, c- or d-type include an aq L immiscible with the L hydrocarbon.

Th ranges from 100 to 170°C, but within a single crystal, Th range is within 15°C, without any zonation pattern. Th are highly variable from one crystal to another.

FTIR infrared analysis of the four types demonstrate that the L hydrocarbon has no aromatic compounds and all bonds, though variable, correspond to an n-alcane type of hydrocarbon.

Geological evidences point to a sedimentary origin for the organic matter trapped in the FI. This organic matter was located in the black Carboniferous limestones and released during the dolomitization process. The quartz precipitated from the brine that produced the dolomitization. There are only very few relicts of this F in the FI due to the wetting effect of hydrocarbons on the quartz crystal surfaces. (From authors' abstract by E.R.)

ARIAS, D., CORRETGE, L.G., VILLA, L., GALLASTEGUI, G., SUAREZ, O. and **CUESTA, A.**, 1997, A sulphur isotopic study of the Navia gold belt (Spain) (abst.): J. of Geochemical Exploration, v. 59, no. 1, p. 1-10.

The host rocks of the mineralization are quartzites, sandstones and black shales of Cambro-Ordovician age. The ores belong to at least four associations having contrasting mineralogies and textures. The $\delta^{34}S$ values for individual mineral phases reflect the polyphase metallogenic history. The observed isotopic homogeneity likely implies isotopic equilibrium at the scale of the gold vein. The relatively tight clustering of $\delta^{34}S$ values of the Au-related sulphides, and the results of FI and paragenetic studies, can be interpreted to indicate that the hydrothermal F of the last three stages were dominated by H_2S. In the H_2S predominant field, sulphide materials precipitating from solutions would exhibit $\delta^{34}S$ values similar to the $\delta^{34}S$ of the Navia F is consistent with leaching of sulphur from the host rocks. (From authors' abstract by E.R.)

ARMSTRONG, R.N., ROBERTS, S. and **WHITE, N.C.**, 1997, The ore forming potential of porphyry copper systems: A preliminary study using melt inclusion chemistry (abst.): Mineral Deposits Study Group Annual General Meeting, Glasgow Univ., 1997, Programme and Abstracts Volume, p. xxx. First author at Dept. of Geol., Univ. of Southamptom, U.K.

In this poster we present and discuss the techniques and some of the preliminary data obtained from several different systems using SIMS, PIXE and EPMA. The samples analysed are from the younger granodiorite of the Morenci Porphyry Copper deposit; a copper-rich andesite from Haha Jima island; and a barren rhyolite from La Coipia. These results highlight the potential of this approach as well as some of the pitfalls. (From authors' abstract by E.R.)

ARNE, Dennis, 1996, Thermal setting of the Cadjebut Zn-Pb deposit, Western Australia: J. of Geochem. Exploration, v. 57, p. 45-56. Author at School of Sci., Univ. of Ballarat, P.O. Box 663, Ballarat, Vic. 3353, Australia.

No thermal anomaly was detected in the vicinity of the Cadjebut Zn-Pb deposit by apatite fission track analysis (AFTA) of detrital apatite grains from Devonian sedimentary rocks. Evidence for regional heating is commonly found in major Mississippi Valley-type ore districts, probably due to a combination of burial to depths > ~ 1 km and lateral F migration, and this may serve as a general exploration guide. (From author's abstract by E.R.)

ARRIBAS, A., Jr., and **HEDENQUIST, J.W.**, 1997, Coupled hydrothermal processes between the porphyry and high-sulfidation epithermal environments (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 93-94 (in English), ISBN 5-88918-002-9. First author at Placer Dome Exploration, San Jose, CA 95125.

The Lepanto enargite-Au epithermal ore body overlies the Far Southeast Cu-Au porphyry ore body; both are contemporaneous at 1.5 to 1.2 Ma, though locally enargite cuts porphyry ore. Early K-silicate alteration formed from a hypersaline L of magmatic origin, while an overlying hypogene advanced argillic assemblage hosting the epithermal veins was formed by absorption of magmatic V by meteoric water, with the component of groundwater increasing away from the porphyry. The porphyry system was overprinted by quartz-sulfide-illite veins by a hydrothermal system that was still magmatic-water dominated; the relation of this event to the timing of epithermal ore deposition, and the degree of magmatic F involvement in forming enargite and Au ore can be inferred but not proven.

A Pliocene dacite pyroclastic unit (age = 2.2-1.8 Ma) that hosts the epithermal ore is postdated at depth by quartz diorite dikes. Potassic (biotite) alteration is centered on the dikes and formed at 1.4±0.05 Ma (6 published K-Ar biotite dates, ±2s). Hypersaline L and V-rich I with Th 550-500°C are associated with this early stage of alteration and related Cu ore. Within the porphyry deposit 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 northwest along the contact between the basement and Pliocene pyroclastic rocks, synchronous with potassic alteration. Alunite shows chemical and sulfur isotopic zonation along the orebody, reflecting thermal and redox variations characterized by lower T and more reduced conditions away from porphyry. Leached and alunite-altered rock served as the host for subsequent enargite-Au epithermal ore. Infrared microscopy study of enargite-hosted FI indicates that the mineralizing F cooled from 285 to 190°C as it flowed northwest, away from the porphyry, accompanied by a decrease in sal from 4 to 2 wt.% NaCl eq. (Mancano and Campbell, 1995). The dated minerals were also analyzed for their oxygen and hydrogen compositions, and hydrothermal water values calculated. Biotite water averaged $\delta^{18}O$ and δD=+6.5 and -40 permil, respectively, typical of hypersaline L exsolved from andesitic magma; later illite water had a 10-20% component of local meteoric water ($\delta^{18}O$ and δD=-10 and -70 permil, respectively). The acidic alunite water formed through the absorption of magmatic V (+7 and -25 permil) 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. (From authors' abstract by E.R.)

ARVANITIDIS, N.D. and **KILIAS, S.P.,** 1997, Vein-quartz deposits of northern Greece – Exploitable resources for industrial uses: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 701-704. First author at Inst. of Geol. and Mineral Exploration, Thessaloniki, Greece.

Significant quantities of vein-type quartz reserves amounting to 2.5 Mt hosted by Paleozoic or older metasedimentary two-mica gneisses of the Serbomacedonian, Pelagonian, and Rhodope Zones have been located in northern and central Greece. Structural, textural, mineralogical, chemical, FI, and genetic studies were conducted to serve evaluation of quartz as raw material for the production of ultra-pure qualities for the European market. FI studies have assisted in genetically relating vein formation to regional post-Jurassic greenschist facies metamorphism and gradual uplift of the gneissic host-rocks, as well as deciphering the role of I in degrading elemental contaminants to market-quality requirements. (Authors' abstract)

ASENSIO, Belén, SIERRA, Josefina and **ARRIBAS, Antonio,** 1997, Exploration implications of large temperature and salinity variations in Cu-bearing vs. barren quartz veins in Sierra Morena, Spain: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 14-15. First author at Inima, Zurbarán, 28, 28010 Madrid, Spain.

Three main types of veins are present: 1) quartz-barite veins, 2) quartz veins containing Cu mineralization, and 3) barren quartz veinlets. A FI study was conducted to complement petrographic analysis and help to identify the genetic environment of the hydrothermal veins.

The quartz-barite veins are composed of quartz with Fe hydroxide, pyrite, white mica and carbonaceous matter as accessory minerals. Tabular quartz crystal (pseudomorphic after barite) are common. Three generations of quartz (Q1 to Q3) have been distinguished.

From these data the existence of two fundamental hydrothermal episodes (Q1, Q2) can be inferred. The second one, Q2, has greater sal (8 to 2 eq. wt.% NaCl) and T (380 to 250°C) than the first one and widespread silicification and barite replacement is attributed to this stage. Q3 FI correspond to a lower T (145-205°C), dilute (1-3%) a hydrothermal solution. Thus there are two well-differentiated hydrothermal F: 1) a low-sal F associated with barren quartz and 2) a hypersaline L which is associated with Cu sulfide mineralization. The implication at the batholith is that a rapid FI, which might only require simple petrographic observation, with heating-freezing measurements, may provide a useful tool to distinguish veins related to Cu mineralization from barren veins. (From authors' abstract by E.R.)

ASKEROVA, Janna, IGNATIKOV, Evgeny and **CHEBOTAREV, Mihail,** 1997, Thermodynamical regime of the development and fluid inclusions in quartz veins of the Amantaitau gold-deposit (western Uzbekistan): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 16. Authors at Inst. of Geol. and Geophys., Acad. of Sci. of Uzbekistan, 49 Khodzhibaev Str., Tashkent, 700041, Uzbekistan; email (ingeo@rubin.gov.uz).

The Amantaitau gold deposit is located in sedimentary rocks that have been subjected to two alterations: early pre-folded regional metamorphism of phyllite and greenschist facies and late hydrothermal-metasomatic processes. The S quartz can be subdivided into several types.

Quartz from concordant veins gave the decapitations [decrepitation?] T from 300 up to 350°C. T peaks of late intersecting veins are estimated to be around 400-450°C. The values increase from early quartz generation (200°C) up to a late one (370°C). The latest intersecting quartz veins are characterized by a T decrease (120-200°C). [These results are] in conformity with those obtained from other gold deposits, e.g. Daugiztau, Muruntau, Mardjanbulak (Kotov et al., 1995).

FI with around 60% V phase have Th 300-335°C with subsequent decrease up to 260°C. Secondary filled I with gas amount up to 80% also occur here that relates to further quartz deformations. Cryometric method has established that the productive quartz on the Amantaitau deposit was formed at P=1-1.5 kbar. [The deposit is thus of the mesothermal gold-sulfide type]. (From authors' abstract by E.R.)

AUDÉTAT, A., GÜNTHER, D., FRISCHKNECHT, R. and HEINRICH, C.A., 1997, Quantitative analysis of major and trace elements in individual fluid inclusions by LA-ICP-MS: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 17-18. Authors at Swiss Federal Inst. of Tech. Zürich, Inst. of Isotope Geol. and Mineral Resources, CH-8092 Zürich, Switzerland; email (audetat@erdw.ethz.ch).

From the wide range of single FI analytical techniques, LA-ICP-MS is one of the most promising as it combines a relatively fast analytical technique with high sensitivity. Quantitative data has been published for synthetic FI, based on Sr as an internal standard (Shepherd and Chenery, 1995; Moisette et al. 1996). However, the quantification of natural FI was not possible, because values obtained for Na and Cl– the only elements suitable for use as internal standard in natural I–were significantly too low and not very reproducible. A SEM-picture which was published in Shepherd and Chenery (1995) demonstrates very clearly that fractionation occurred, caused by the precipitation of salts during the ablation process. This problem could now be solved using a new 193 nm excimer laser system specially designed for FI ablation (Günther, this volume), in which switching between different beam diameters during the ablation process is allowed.

In view of the problems [with pre-analysis homogenization], experiments were carried out to test means to reduce the loss of dm during ablation at room T. The best results have been obtained with a two-step opening procedure: first, a small hole was drilled into the I to prevent early decrepitation, and then the rest of the I was drilled out with a larger beam diameter. The switch to the larger beam diameter was made during the ablation process.

Thirty-nine FI along a pseudosecondary trail in vein quartz from a Sn- and W- mineralized granite (Mole Granite, Western Australia) were opened in this way and analysed [quantitatively] for 19 elements simultaneously. The I measured 15-50 µm in diameter, contained 50 wt.% NaCl eq. and homogenised at 450°C into the L phase (some small daughter phases remained undissolved.

The quantification of the I is based on Na as internal standard. NaCl eq. values based on Tm NaCl and calculated with a formula published in Bodnar and Vityk (1994) were corrected for selected other cations. More information about this correction will be reported in Günther et al. (J. Anal. At. Spect., 1997, in prep.).

Besides the reproducibility-tests along homogeneous FI trails, experiments were carried out on coexisting V and brine I to evaluate metal partition coefficients between the two phases. The occurrence of both I types (inclusive of intermediate members) in one FI trail proves that it is a true boiling assemblage. Copper concentrations in V I are about 200 times higher than in brine I, a feature which has been reported also by Heinrich et al. (1992). A similar partitioning of copper into a V-rich phase has been observed also in M I (Löwenstern, 1991). Further tests are planned to reconstruct the evolution of magmatic-hydrothermal F and to study the role of a V phase in the formation of ore deposits. (From authors' abstract by E.R.)

AWWILLER, D.N. and SUMMA, L.L., 1997, Quartz cement volume constraints on burial history analysis; an example from the Eocene of western Venezuela (abst.): Ann. Meeting abstracts - American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, 1997, no. 6, p. 6.

We have used recently published quartz cement precipitation kinetics to help constrain the complex burial history of Eocene sandstones from the foothills of the Venezuelan Andes. These sandstones underwent a significant burial and uplift cycle in the Eocene-Oligocene, but conventional burial history indicators do not unambiguously constrain the event. Vitrinite and FI data indicate that maximum burial T were 130-150°C. Cooling below the annealing T of apatite occurred 36-32 Ma. However, the time spent near maximum T prior to uplift was unknown. We analyzed quartz cement volumes at several outcrops of known stratigraphic age to address this problem. The optimum time-T window is approximately 10-100 million years at maximum T of 80-140°C. Outside these bounds, quartz precipitation kinetics are such that the rocks tend to be either completely cemented or not cemented at all. (From authors' abstract by E.R.)

AYSHFORD, Shaun, OFFLER, Robin and SECCOMBE, P.K., 1997, Geology and origin of the Tallawang magnetite skarn, Gulgong, NSW: Geological Society of Australia, Abstracts No. 44, p. 5. First author at Dept. of Geol., Univ. of Newcastle, Callaghan, NSW 2308.

Skarn formation developed in two major stages. An anhydrous skarn assemblage comprising magnetite, garnet (grossularite-andradite) and hedenbergite formed by contact metamorphism at shallow levels in a continental arc environment (P~1 kb; T~600 to 650°C). Brecciation of the magnetite preceded a hydrous stage of skarn formation involving deposition of further magnetite, accompanied by ferro-pargasite, quartz, apatite and pyrite. Veins containing a retrograde metamorphic assemblage of chlorite + epidote + calcite + quartz or actinolite were established under greenschist facies conditions, consistent with mean Th data in the range 350 to 365°C for carbonic and aq FI from vein quartz and epidote. Emplacement of the Early Carboniferous Gulgong Granite has had little effect on the skarn deposit and represents the onset of late brittle deformation and minor sulphide mineralisation. (From authors' abstract by H.E.B.)

AYT OUGOUGDAL, Mohammed, CATHELINEAU, Michel, BANKS, David, BOIRON, M.C. and POTY, Bernard, 1997, Fluid and mass transfer around alpine fissures: A comparison between the Mont Blanc granite and the Aar granodiorite: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 19-20. First author at CREGU and EP 578, BP 23, 54501 Vandœuvre-lès-Nancy, France; email (ayt@cregu.cnrs-nancy.fr).

The objective of this work was: i) to describe the F flow path outside major channels, especially the role of microfractures in the F transfer around the cleft networks,

ii) to characterize the time/space changes in the F chemistry and P-T conditions as a function of deformation, and iii) to determine the main factors responsible for differences in the F pathways.

Oriented samples from the granites have been studied using optical and SEM CL imaging, microthermometry, quantitative in-situ analysis of gas and molecular species contents by Raman spectroscopy and FTIR, and crush-leach procedures (Yardley et al, 1993).

The data obtained on F chemistry at the scale of the studied alpine clefts seem rather similar indicating that F have similar sources (the surrounding sedimentary series) and produce the same effects on granites at the scale of the alpine belt.

The two studied localities were subjected to nearly identical geodynamic events. F chemistry and the transfer of matter are qualitatively the same, and produce nearly the same mineral assemblages. Nevertheless, the fissure formation and especially their numerical density are different. These differences can be explained essentially by the rheo-logy of the rock, and the slightly higher P-T pairs are maintained in Aar during the main alteration process (300-400 MPa, 400-420°C) although in Mont Blanc, slightly lower P-T conditions (380°C, 380 MPa) are then recorded. The lack of retrograde alteration and lower T F in the two cases could indicate a rather quick uplift and the lack of F percolation after the main deformation stages. (From authors' abstract by E.R.)

AYT OUGOUGDAL, Mohammed, CATHELINEAU, Michel, ELIE, Marcel, RUCK, Régine and TROUILLER, Alain, 1997, Low temperature diagenesis of Oxfordian shales in the Paris basin: A multidisciplinary study of fluid inclusions, organic matter and clays: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 21-22. First author at CREGU and EP 578, BP23 54501 Vandœuvre-lès-Nancy Cedex, France; email (ayt@cregu.cnrs-nancy.fr).

The evaluation of maximal T and thermal evolution of the series has been investigated by a combination of techniques including: i) FI on authigenic calcite formed in the limestone series above and below the clay rich formations, ii) the analysis of the organic matter in order to determine the maturation state of the kerogen in clay rich sediments, iii) the study of swelling clays which could be used as possible thermal index.

Most FI contain only one L phase, the result of probable metastability. No V phase nucleation could be obtained after a thermal shock at low T. Such FI were probably were probably trapped at 40-50°C. The few two-phase I homogenize between 31.0 and 37.9°C, and show the melting of the ice around -1.5°C (2.57 wt.% eq. NaCl).

Geothermometric indications from solid phases in clay rich sediments, using X-ray data obtained on glycolated samples and artificial maturation experiments estimate a maximum burial T of 50°C over the time of burial.

Therefore, it can be considered that the sedimentary formations of the eastern part of the Paris basin underwent a rather unsignificant thermal evolution since their formation and burial. (From authors' abstract by E.R.)

AZIMOV, P., 1997, The role of water in high-pressure fluids: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 11, Lunar and Planetary Inst., Houston. Author at Inst. of Precambrian Geol. and Geochron., RAS; email (az@lnpi.spb.su)

F composition in subduction zones is now debatable. Some researchers suggest, based on results of FI investigations in high-pressure rocks, that the F consist primarily of N_2, CO_2, and, in some cases, light hydrocarbons such as CH_4. Other researchers believe that H_2O is the main component of the F in subduction zones.

To ascertain the role of H_2O in the eclogitic F, eclogites from the Marun-Keu high-pressure complex (Polar Ural, Russia) have been examined. Special attention has been paid to the mechanisms that form minerals and mineral assemblages.

Most of the assemblages, even formed under HT-HP metamorphism (700-900°C, 13-24 kbar) contain hydrous minerals, so the breaking of P magmatic plagioclase [sic] from troctolites during earlier stages of eclogitization [to form zoisite and kyanite] confirms the removal of silica through aq solution.

Numerous small (~0.01-0.1 mm) garnet grains in bimineral eclogites are located along cleavage cracks in the large (2-6 cm) omphacite crystals (see Fig. 1). The garnet forms "bands" along F-flow pathways. Such a location of garnet grains cannot be explained by simultaneous crystallization of garnet and omphacite, because garnet crystallized later than pyroxene. Hypothesis of the intergranular silicate M cannot be applied either, since the M at 800°C is ~107-108X more viscous than F. The M could not penetrate through cleavage cracks in omphacite grains. Hence this garnet should be crystallized from F.

However, nonaqueous F have very low solvency. The transportation of large amounts of solute by CO_2, N_2, or CH_4 F seems doubtful.

Other processes of breaking up unsteady assemblages and forming new ones, both HT and LT (zoisitization, kyanitization, silicification, and so on), also proceeded in the presence of H_2O. During the latest, low-T stages of the eclogitic metamorphism, mass transfer was on a much larger scale than earlier. At that time numerous quartz veins and zones of silica enrichment formed. It is difficult to explain such a mass transfer by transportation with nonaqueous F, in which solvency is negligible.

Thus the character of mineral reactions demonstrates that both high- and low-T eclogitic metamorphism of the Marun-Keu complex was accompanied by F fluxes. Transporting F were mainly aq, and intergranular silicate M was lacking at that time. (From author's abstract by E.R.)

BACHILLER, N., CASQUET, C., GALINDO, C. and QUILEZ, E., 1997, Hydrothermal alterations in leucogranites from the Burguillos del Cerro intrusive complex (Badajoz, SW Spain) – Evidence for the pulsatile mixing of igneous and meteoric fluids: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 605-608.

Peraluminous leucogranites from the Burguillos del Cerro Plutonic Complex show superimposed alterations consisting of quartz-rich albitites and younger Au-bearing quartz veins. The second show similarities with other Au-bearing quartz veins from NW Iberian Peninsula. Rb-Sr dating, Sr and O isotope compositions, and FI evidence, suggest that the alterations took place in a unique hydrothermal process, close in time to magmatism (circa 330 Ma). F involved in the formation of albitites were moderate to high sal brines in the system H_2O-NaCl-KCl-$CaCl_2$-$FeCl_2$, probably magmatic in origin. Quartz veining took place during three subsequent major hydrofracturing events. Involved F were similar to those of the albitite stage but show a progressive decrease of both maximum and minimum Th and sal, suggesting the involvement, at the beginning of each event, of progressively more dilute magmatic F, and the subsequent mixing with cold dilute meteoric waters. The alterations took place at a depth of circa 3.5 km, F P evolving from close-to lithostatic during the albitite stage to hydrostatic in the last veining stage. (Authors' abstract)

BACHILLER, Nuria, CASQUET, César, QUÍLEZ, Encarnacion and GALINDO, Carmen, 1997, Trends of fluids during the hydrothermal evolution in the leucogranites from the Burguillos del Cerro intrusive complex (Badajoz, SW Spain). Model of mixing of fluids: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 23-24. First author at Centro de CC. Experimentales y Técnicas, Univ. San Pablo-CEU, 28668 Boadilla del Monte, Madrid, Spain.

These leucogranites show superimposed hydrothermal alterations consisting of massive quartz-rich albitites and Au-bearing quartz veins. The aim of this work is to determine whether these alterations represent different processes, significantly separated in time, or a single and evolutionary hydrothermal process, related to the cooling of the host granitic bodies.

FI in quartz from the albitites and from quartz veins have been studied using microthermometry and SEM+EDS analyses of solid phases. On the basis of composition and phase ratios observed at room T, two main types of FI have been recognized:

Type I: FI belonging to the H_2O-NaCl-KCl-$CaCl_2$-$FeCl_2$ system. Three subtypes of FI can be distinguished:

Subtype I.1: High sal aq FI (28-68 wt.% NaCl eq.) with one or two dm (halite and sylvite) and sometimes a third solid phase. Solid phases are Na, K, Fe and Ca chlorides. These FI have been found both in the albitites and the quartz veins and they show isolated occurrence.

Subtype I.2: Two-phase FI at room T, with Vg/Vt ratios <20%, and moderate sal (7-22 wt.% NaCl eq.). These FI are only found in the quartz veins largely forming trails.

Subtype I.3: Two-phase low sal aq FI (3-9 wt.% NaCl eq.), with Vg/Vt ratios between 25 and 35%. These FI are only found in the quartz veins, forming trails.

Type II: Very scarce carbonic-aq FI of varible density, belonging to the H_2O-NaCl-CO_2-CH_4 system.

The different subtypes of FI of the Type I define convergent trends of decreasing sal and T, suggesting that in all the cases repetitive mixing of a progressively-less saline, lower-T brine with a low-sal cold meteoric F, probably took place. (From authors' abstract by E.R.)

BAKER, Judy, MATTHEWS, Alan, MATTEY, D., ROWLEY, D. and XUE, F., 1997, Fluid-rock interactions during ultra-high P metamorphism, Dabie Shan, China: Geochim. Cosmo. Acta, v. 61, no. 8, p. 1685-1696.

BAKER, T., LANG, J.R. and MORTENSEN, J.K., 1997, Au-mineralization associated with the Mid-Cretaceous Tombstone-Tungsten magmatic belt, Yukon and Alaska (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A7. Authors at Mineral Deposit Research Unit, Dept. of Earth and Ocean Sci., 6339 Stores Rd., Univ. of British Columbia, Vancouver, BC, V6T 1Z4.

The Tombstone-Tungsten magmatic belt is ~700 km in length and extends from southeastern Yukon to east-central Alaska. The Tungsten Suite occurs in the eastern portion of the belt and has significant overlap with the more extensive Tombstone Suite to the west. The Tombstone Suite comprises metaluminous, subalkaline, predominantly intermediate intrusions that form multiphase complexes and are locally well-zoned. Granodiorite to monzonite are the main rock types but elsewhere syenite predominates. The Tungsten Suite is characterized by peraluminous, equigranular to megacrystic granitic intrusions.

Mineralization associated with Tombstone Suite intrusions includes: 1) Pb-Zn-Ag veins (e.g. Keno Hill), 2) W-Sn-Cu skarns (e.g. Mar) and 3) Au deposits (e.g. Fort Knox). Au-W-Bi-As-Sb-Hg-(Sn-Mo) is the characteristic metal assemblage of the deposits. Preliminary FI studies of intrusion-hosted deposits indicates that the mineralizing F were CO_2-rich to hypersaline-aq (30-35 wt.% NaCl eq.), with Th between 200 and 350°C. (From authors' abstract by H.E.B.)

BAKKER, R.J., 1997a, Clathrates: Computer programs to calculate fluid inclusions V-X properties using clathrate melting temperatures: Computer & Geosci., v. 23, no. 1, p. 1-18. Author at CREGU, B.P. 23, 54500 Vandœuvre-lès-Nancy, France; email (ronald.bakker@urz.uni-heidelberg.de).

Knowledge of final clathrate melting T is essential for estimates of sal, bulk composition and density in H_2O-G-rich FI by nondestructive methods. The sal calculated strongly depend on the thermodynamic model used, which involves many independent intensive properties and related parameters, such as osmotic coefficients, fugacity coefficients, G solubilities. Four programs have been developed (Density, Ice, Q2 and Nosalt) using Turbo C++ version 3.0 to handle clathrate melting T with several initiation procedures. These programs allow the calculation of bulk densities and compositions (V-X properties) for H_2O-CO_2-CH_4-N_2-NaCl-KCl-$CaCl_2$-rich FI using the clathrate melting T in combination wth L-V equilibria, data from Raman spectroscopic analysis of the non-aq phases, and volume fraction estimates of the phases present. Calculations are restricted to F compositions less eutectic sal. If volume estimates are not provided, the programs calculate only the properties of the individual phases present in FI during clathrate melting, including the sal. Errors in measured parameters and in volume fraction estimates, which may be relatively large, are also handled by the programs. (Author's abstract)

BAKKER, R.J., 1997b, Up to date clathrate modelling: Excess energies for mixed gas hydrates: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 25-26. Author at Geologisch-Paläontologisches Institut, INF 234, D-69120 Heidelberg, Germany; email (ronald.bakker@urz.uni-heidelberg.de).

Modifications proposed by Bakker et al. (1996) for pure CO_2 clathrate with various salts are further developed in this study for a complex F system including H_2O-CO_2-CH_4-N_2-C_2H_6. Differences between model predictions and experimental data on pure gas hydrate melting conditions are minimized at selected Kihara parameters, which describe molecular interaction between encaged gas molecules and a H_2O molecule from the clathrate cavity wall. A very important implication of this method is that all irregularities and deviations in principle assumptions for other parameters (fugacity, gas solubility, thermodynamic constants) are projected on these Kihara parameters. The optimum parameters give an excellent fit over a wide range of T for all types of pure gas hydrates. Reported values from other studies appear to disagree to a large extent, which is, however, merely a reflection of the use of insufficient amount of data. The variation is perfectly corresponding to the amount of experimental data used to fit the Kihara parameters. (From author's abstract by E.R.)

BAKSHEEV, Ivan, SPIRIDONOV, Ernst, USTINOV, Vladimir and **PROKOFIEV, Vsevolod,** 1997, Physico-chemical and isotope parameters of the genesis of the gumbeite and accompanying vein mineralization, Urals: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 27-28. First author at Dept. of Geol., Moscow State Univ., 119899 Moscow, Russia; email (mineral@geol.msu.ru).

Gumbeite is a result of mid-temperature alteration by CO_2, yielding potash feldspar + carbonate assemblage. This study deals with the Gumbeyskoe mine located near Magnitogorsk, South Urals and occurrence Shartashskoe located within the Berjozovskoe goldfield near Ekaterinbug, Middle Urals.

Potash feldspar + carbonate assemblage is stable in the most inner zone of the early gumbeite alteration column; in the late gumbeite potash feldspar + sericite-pengite assemblage is stable.

Studies of the four stages of scheelite, and coexisting quartz, from Gumbeyskoe show ranges of +9 to +13 (quartz) and +1 to +6 (scheelite). From these values gumbeite alteration is said to be much higher T than beresite (From authors' abstract by E.R.)

BANERJEE, Arun and **GHIURCA, Virgil,** 1997, Investigation of fluid inclusions in quartz crystals from Romania by FTIR spectroscopy: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 29-30. Authors at Dept. of Mineral., Cluj-Napoca Univ., Romania.

The present paper deals with the investigation of FI in quartz crystals, so-called "marmures {marmarosh] diamonds", from Romania by FTIR-absorption microspectrometry. The following were detected (bands in cm^{-1}): water (1604), carbonyl (1640, 1787), carbon dioxide (gas) (2361), hydrogen sulfide (2598, 2163), CH_2 (2930), CH_3 (2960), and CH_4 (3013). (From authors' abstract by E.R.)

BANKO, A.G., BRANDSTÄTTER and **NIEDERMAYR, G,** 1997, Unusual mineral inclusions in beryls from Nigeria: Z. Dt. Gemmol. Ges v. 46, no. 1, p. 13-20 (in German; English abst.). Characteristic F and solid I are described. (H.E.B.)

BANKS, D.A., TRITLLA, J., McCAIG, A.M. and **HENDERSON, I.,** 1997, The use of halogen systematics in deducing fluid sources and processes in the Pyrenees: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 31-32. First author at Dept. of Earth Sci., Univ. of Leeds, Leeds LS2 9JT, U.K.

Previous studies of quartz veins and fractures (Banks et al, 1991) formed late in the Alpine thrusting of the Central Pyrenees, showed them to contain hypersaline brines which probably originated from Triassic sequences beneath the thrusts. The sal and Cl/Br ratios of the F are shown in two plots of Cl ppm vs. Cl/Br (wt), and Na/Br (molar) vs. Cl/Br (molar). The highest sal, (~30 wt.% NaCl) and lowest Cl/Br ratios (~50) are found in the Neouvielle massif, with slightly less saline (~25 wt.% NaCl) and less Br rich F (Cl/Br ~110-20) at the Pic de Port Vieux. At Plan de Larri F are, in comparison, quite dilute (<10 wt.% NaCl) with a wide range of Cl/Br ratios (~60-450). Similar low sal F are present in the samples collected from the Triassic redbeds beneath the evaporites and the Cl/Br ratios cover an even greater range (~120-820).

The highest sal F are substantially enriched in Br for their sal relative to that expected for evaporating seawater. Their position to the left of the seawater evaporation line indicates that the original F has been diluted. The F are most likely the bitterns in equilibrium with evaporites at particular points in the evaporation of seawater i.e. precipitation of halite for Pic de Port Vieux F and sylvite for Neouvielle F. This is confirmed where the Pic de Port Vieux F lie on or close to a 1:1 line passing through seawater, showing that the large variation in Cl/Br is due to removal of NaCl. Two of the Neouvielle F are indicative of the precipitation of another chloride, probably sylvite.

The low sal F, enriched in Br relative to seawater, are likely to represent continued dilution of F similar in origin to those above. (From authors' abstract by E.R.)

BARANOV, E.N., KARPUKHINA, V.S. and **SUSHCHEVSKAYA, T.M.,** 1997, The heterogeneous nature of hydrothermal fluids in the Ural pyritic deposit (KMs) (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 23-24, ISBN 5-88918-002-9 (in Russian; English translation courtesy Dr. D. B. Brown). Authors at Vernadsky Inst. of Geochem. and Analytical Chem.

A.G. Betékhtin has evaluated A.N. Zavaritsky's ideas about the spatial and genetic links between the pyritic deposits (KMs) of the Urals and volcanism as being extremely plausible and noteworthy (1953, p. 10). Up to the present, these concepts have received general acceptance and have been verified by long-term geological-exploratory work. The principal discrepancies in the working genetic models of the Ural KMs are expressed in an estimate of the nature of the ore-forming F: endogenic (mantle) (Prókin et al., 1982, etc.) or, mainly, seawater, in accordance with the convective model (Baránov et al., 1988; Baránov, 1992).

On the basis of a systemic study of FI in the minerals of the peri-ore rocks, eight KMs have been identified in the South Urals: Uzel'ginskoe, Chebach'e, Talganskoe, West Ozërnyi, Rzhávtsy in the Verkhneurálsky ore region, Uchalinskoe, and Podól'skoe, and it has been established that the orebodies were formed above discharge channels of hydrothermal flows onto the floor of marine paleobasins. Narrow (up to 50-100 m), high-T (250-370°C) zones, spatially connected with sub-ore sericite-chlorite quartz-metasomatites, also define the ore-conduits in the deposits. They alternate relatively sharply with low-T (<150°C) flank zones, associated mainly with propylitizd rocks. From the results of cryometric studies on the FI (Karpúkhina and Baránov, 1995), two main kinds of F have been recognized: 1) hydrocarbonate-chloride, which predominate in the ores and in the high-T zones of sub-ore metasomatites, and 2) chloride, with a predominance of Na, distributed mainly in the flank zones. They have a similar sal (up to 11 wt.% eq. NaCl). Other kinds of F are highly mineralized chloride (21-23 wt.% eq. NaCl), with a predominance of Na and Ca, and the low-sal hydrocarbonate F (<5 wt.% eq. NaCl) have a markedly minor distribution.

In some KMs, heterogeneous, three-phase, CO_2-water I are widely developed, indicating boiling of the hydrotherms during their approach to the surface of the paleobasin floor. In the Uzel'ginskoe deposit, boiling of the F has been identified some 50 m below the orebody, and in the West Ozërnyi, immediately below the orebody. In the Chebach'e deposit, signs of boiling have been identified at 200-250 m from the orebody, and it was evidently more intense lower down. Boiling of the hydrotherms has not been accompanied by the formation of an ore mineralization.

Differentiation of F in the Ural KMs has also been manifested in their G composition. This composition (CO_2, CO, CH_4, N_2) of the S FI in quartz from acid volcanics in the Verkhneurálsky ore region has been examined by G chromatography (Baránov et al., 1997). Contrasting differences between the F within the ore-conduits and in the flank zones have been identified. The ascending high-T F are marked by a predominance of CH_4 and/or CO, and consequently, a high reducing capacity. During local manifestation or absence of signs of boiling (Chebach'e and Rzhávtsy), CH_4 predominates in the G composition of the F, whereas during widespread manifestation of boiling (Ugel'ginskoe), there is a predominance of CO and CO_2. The F of the flank zones are marked by a predominance of N_2, the virtual absence of CH_4, and consequently greater oxidation capacity.

The revealed differentiation of the salt and G composition of the F indicates their heterogeneous nature, and matches the convective model of formation of the Urals KMs, devised mainly on the basis of deep geochemical mapping data of the KM orefields (Baránov, 1992). The high-T reduced F of the axial zones of the ore-conduits have been formed through the significant involvement of deep-seated magmatogenic components. The low-T, relatively oxidized F of the flank zones have been interpreted as seawater, transformed as a result of interaction with the country rocks. The predominance of seawater in the composition of the ore-forming F has been established from a study of the H and O isotopes in sericites from the sub-ore metasomatites of the Ugel'ginskoe and Uchalinskoe deposits (Baránov et al., 1989). The proportion of magmatogenic water in the composition of the F of the axial zones reached 60%, whereas in the composition of the F in the flank zones, it did not exceed 10%. Sulfur-isotope data for the sulfides in the KMs examined do not contradict the involvement of seawaters in the composition of the F. A relative weighting of the sulfur isotopes (up to +7-10 ppt) in pyrites from ore-conduit zones, has been established. Hematitization of the sub-ore rocks on the flanks of the orefields is an indicator of reduction of the seawater sulfates.

The involvement of seawater in the composition of the ore-forming F is a convincing support for the convective model of pyritic ore-formation. The concentrated rising flow of high-T F, having a P endogenic (magmatogenic) nature, is a strengthening element in the hydrodynamic structure and energy base of the convective systems. It determines the heating of the rocks and the pore solutions in them, and in the end it causes convective migration of the seawaters in large volumes of the highly permeable volcanogenic rocks and their intense miscibility with the P magmatogenic F in the rising currents.

Thus, the main conflict of ideas in developing a single genetic model for the pyritic systems in the Ural KMs is man-made. In the ore-forming convective systems, there is a regular blending of channelled, rising F flow involving deep-seated (endogenic) components and a dispersed descending migration of seawaters, which ensures mobilization of the principal amount of ore material from the rocks. (Authors' abstract)

BARANOVA, N.N., AKINFIEV, N.N. and **IVANOVA, G.F.**, 1997, Modeling of the nitrogen-bearing fluids role in the Au-Sb-W mineralization formation: *in* Proceedings of the Fifth Int'l. Symposium on Hydrothermal Reactions, Palmer, D.A. and Wesolowski, D.J., eds., 1997, Gatlinburg, TN USA, p. 307. First author at Vernadsky Inst. of Geochem. and Analytical Chem., Kosygin str.19, Moscow, 117975 Russia.

It is known that the dissolution of nonpolar G (N_2, CO_2, CH_4) in the water solutions decreases the dielectric permeability of solutions which results in the shift of the equilibrium towards the formation of the associated species. The purpose of the present investigation is to model the influence of the nonpolar G N_2 on the complex formation processes in the high-T chloride F saturated regarding gold, antimonite and scheelite.

The calculations were carried out for the solutions containing 1.7 m NaCl, 10^{-2} m S_{tot} saturated with N_2 under 150-360°C and 1 kbar based on the program BALANCE for the investigation of the equilibria in the multisystems. It was found that the nitrogen influence is essential if the dominant solution forms of the ore mineral in the natural hydrothermal systems are represented by charged ions such as $AuCl_2^-$; $Au(HS)_2^-$ for gold, HWO_4^- and WO_4^{2-} for tungsten. If the dominant forms are represented by neutral species such as $Sb(OH)_3^0$ for stibium, the nitrogen influence is essentially lower.

Increasing mole fraction of N_2 (X_{N_2}) up to 0.2 results in a decrease of the water activity and the dissociation constants of other component-forming ligands (NaCl, H_2O). It causes the pH to increase on 1.5-2 units. If $X_{N_2}>0.1$ the scheelite solubility is characterized by a negative T coefficient in the range equal to 300-400°C. According to the preliminary calculations, the scheelite solubility decreases if the X_{CO_2} is increasing similar to X_{N_2}. Therefore, the amount of nonpolar volatile components influences and leads to the peculiarities of F transportation and ore-forming ability of the F. (From authors' abstract by E.R.)

BARANOVA, N.N., AFANAS'EVA, Z.B., IVANOVA, G.F., MIRONOVA, O.F. and **KOLPAKOVA, N.N.**, 1997, Mineralization at the Olimpiada Au-(Sb-W) deposit: Evidence from mineral parageneses and fluid inclusions: Geokhimiya, 1997, no.

3, p. 282-293, (in Russian, translated in Geochem. Internat'l., v. 35, no. 3, p. 239-249). Authors at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, ul. Kosygina 19, Moscow, 117975 Russia.

The T-P-C-fO_2-fS_2 parameters of mineralizing processes and possible species of ore elements (Au, Sb and W) in the ore-forming F from the Olimpiada deposit, Yenisei Range, Russia, are reconstructed based on data on mineral parageneses and fluid inclusions. (Authors' abstract)

BARANOVA, N.N., IVANOVA, G.F. and **AFANAS'EVA, Z.B.**, 1997, T-P-C parameters of Au, Sb, W-bearing fluids enriched by N_2 and their ore-forming ability, the Olimpiada deposit (Russia): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 33-34. Authors at Inst. of Geochem. and Analytical Chem. RAN, Kosygin str., 19, Moscow 117975, Russia.

Reviews of previous FI work by Baranova et al. (Geochem. Int'l., v. 35, p. 239) and Prokof'ev et al. (Geokhimiya 1994, no. 7, p. 1011) are used to deduce the complexes for Sb, Au and W (E.R.).

BARASHKOV, Yu., and **TALNIKOVA, S.Y.**, 1997, Fluid components of the diamond crystallization environment: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 35-36. Authors at Inst. of Geosci., 39 Lenin pr., Yakutsk 677891, Sakha Republic, Russia.

The authors have determined compositions and concentrations of gas components in natural diamonds from Yakutian kimberlites using mass spectrometry. As distinct from earlier works, gaseous phase was studied by the authors in diamond crystals of known paragenesis defined from the composition of mineral I in them. Gases, released from the studied diamonds, consist of N_2, H_2, CO_2, H_2O, CO and CH_4 but vary [widely] in composition. A direct correlation was found to exist between gas concentrations and the presence of solid I in diamonds. Such a correlation indicates that gaseous phase was trapped by a growing diamond crystal together with I of syngenetic minerals. This permits us to refer gas admixtures in the studied diamonds to P FI. Higher concentrations of F components in diamonds containing mineral I appear to be related to sorption of volatiles at the diamond-I interface. Takaoka and Ozima (1978) also noted that diamonds with solid I released much more rare gases than diamonds containing no I. (From authors' abstract by E.R.)

BARGAR, K.E. and **OSCARSON, R.L.**, 1997, Zeolites and selected other hydrothermal minerals in the Cascade Mountains of nothern Oregon: U.S. Geol. Surv. Open File Report OF 97-0100.

Indexed under FI. (E.R.)

BARKER, Colin and **SULLIVAN, G.E.**, 1997, Composition of gases in individual FI from calcite cements associated with the deep Smackover Formation, Mississippi Salt Basin: Ann. Meeting Abstracts - American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, v. 6, p. 7.

Deep reservoirs in the Smackover Formation of the Mississippi Salt Basin have G compositions that cover a wide range, and extend from essentially pure methane to methane with very high concentrations of H_2S, N_2, and CO_2. The methane appears to be the product of thermal cracking of crude oil, with later thermochemical sulfate reduction producing H_2S, CO_2, and indirectly elemental sulfur. FI in overgrowths and fracture-filling cements provide samples of G that were present in the system at various times in the past. The composition of G in individual I has been determined mass spectrometrically. I in calcite cements were ruptured by heating in vacuum, where each I produces a 25 msec burst of G that is analyzed by a high-speed, computer-controlled mass spectrometer to give the G composition for the individual I. Typically several hundred individual I were analyzed for 10 mg samples. I in calcites from three wells–Mary Higgins (19, 177-19,460 ft.) Josephine (19,194-20,009 ft.), and USA No. 1 (20, 211-20,359 ft.)–have been analyzed, and show very variable $CH_4/CO_2/H_2S$, even locally. Supporting information for calcite growth T was obtained from FI Th, and free-energy minimization thermodynamic calculations were used to estimate equilibrium G composition. (From authors' abstract by E.R.)

BARNES, H.L., ed., 1997, The Geochemistry of Hydrothermal Ore Deposits, 3rd Edition, 972 pp. Wiley, 605 Third Avenue, New York, NY 10158. A revised version of the earlier second ed. (1979) (E.R.).

BARRAGAN, R.-M., PORTUGAL, E., ARELLANO, V.M., Del ROCIO TELLO, M. and **TELLO, E.**, 1997, Isotopic behaviour of fluids from the Los Humeros, Puebla (Mexico) geothermal field): Geotermia-Revista Mexicana de Geoenergia, v. 13, no. 2-3, p. 87-101.

BARRENECHEA, J.F., LUQUE, F.J., RODAS, Magdalena, and **PASTERIS, J.D.**, 1997, Vein-type graphite in Jurassic volcanic rocks of the external zone of the Betic Cordillera, southern Spain: The Canadian Mineralogist, v. 35, p. 1379-1390. First author at Dept. de Cristalografia y Mineralogia, Facultad de Geologia, Univ. Complutense de Madrid, 3-28040 Madrid, Spain.

Carbon isotopic compositions ($-23.0<\delta^{13}C<-20.7$‰) and other geological observations indicate that the carbon in the graphite was derived from organic matter included in the metamorphic basement. Cooling of a C-O-H fluid appears to be the most likely mechanism for precipitation of the graphite, although hydration reactions also may have played a role. (From authors' abstract by E.R.)

BASKIN, D.K., GARBER, R.A., HARRIS, P.M., WARNER, J.L., HALLAGER, W.S. and **SUISINOV, Kubentay**, 1997, Two-stage hydrocarbon migration model for the Tengiz Field, Kazakstan (abst.): Ann. Meeting Abstracts - American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, v. 6, p. 9.

The Tengiz Field bordering the Caspian Sea produces a light 42 gravity oil from Carboniferous and Devonian platform carbonates. In the upper 500 m, about one-third of the porosity (0-24%, average 7%) is filled with solid organic matter consisting of bitumen and thermally mature (spent) kerogen. Paleotemperature in the uppermost reservoir is estimated at 130°C from solid bitumen reflectances and spore coloration indices. Maximum T in the overlying Permian Artinskian shale is about 100°C from spore coloration. This 30°C difference across a 42 Ma unconformity supports a separate migration for oil which generated the solid bitumen and present-day producible crude as suggested by Soviet workers. Solid bitumen likely formed via deasphalteening of an originally emplaced Carboniferous oil; subsequent burial matured the bitumen to observed reflectances of 1.4-1.6%. Solid bitumen post-dates burial calcite cementation and dissolution, and compaction-related fracturing and stylolitization. Uplift and erosion breached the reservoir losing the L crude not converted to solid bitumen. Associated diagenetic features include solution enlarged porosity and formation of low-T, calcite spar veins that cross-cut and overlie solid bitumen. Present day oil was likely generated from a more-mature, Permian source which migrated into the reservoir during the present cycle of burial in a 18°C/km thermal gradient. This oil, which represents essentially all of the producible petroleum, formed S FI in calcite spar cements along with a distinct, tarry bitumen in vugs and veins. (From authors' abstract by E.R.)

BEBOUT, G.E., 1997, Nitrogen isotope tracers of high-temperature fluid-rock interactions: Case study of the Catalina Schist, California: Earth and Planetary Sci. Letters, v. 151, p. 77-90. Author at Dept. of Earth and Environmental Sci., 31 Williams Dr., Lehigh Univ., Bethlehem, PA 18015.

The results illustrate the potential of the N-isotope system to yield valuable information regarding fluid-rock interactions in the crust and mantle. The data for the Catalina Schist demonstrate the ability of N isotopes to trace the transfer of sediment-derived C-O-H-S-N fluids and silicate M, and show the expected benefit of the N-isotope system in having a differing fluid-rock mass balance, relative to the more commonly used stable isotope systems, that can yield unique constraints in quantitative models of crustal F processes. (From author's abstract by E.R.)

BEELER, N.M. and **HICKMAN, S.H.**, 1997, Crack healing in quartz via solution transport; experimental observations of healing morphology and kinetic implications (abst.): Eos, Transactions, American Geophysical Union, v. 78, no. 46, Suppl., p. 732.

Indexed under FI (E.R.)

BEGG, G.C., LOUCKS, R.R., GRAY, D.R., FOSTER, D.A., KENT, A.J. and **COOKE, D.R.**, 1997, Magmas, fluids and tectonics: The Emperor story (abst.): Geological Society of Australia Abstracts No. 44, p. 7. First author at WMC Resources Ltd., PO Box 91, Belmont, Western Australia 6104.

The giant intrusion-related Emperor epithermal gold deposit consists of telluride-rich bonanza gold grades formed on narrow post-caldera thrusts.

Pre-epithermal metal-poor porphyry-Cu-style alteration occurs associated with steep caldera faults along the caldera margin within the limits of the epithermal deposit. The two events (porphyry-style and epithermal) were essentially synchronous (~3.9 Ma). T within the porphyry-Cu-style system declined from ~350 to ~250°C by the time of initiation of ore-depositing epithermal conditions, to <170°C by the end of epithermal ore-depositing conditions. "Porphyry" F were dominantly low sal (<4 eq. wt.% NaCl) with a subordinate moderate-high sal brine (~15 eq. wt.% NaCl). Epithermal F decreased in sal with time (there is little spatial variation), from about 13.0 to 5.0 eq. wt.% NaCl. Precipitation of epithermal ores was through a combination of wallrock sulphidation reactions and boiling, reflecting F P fluctuations arising from "epithermal-fault-valve" behaviour. Isotopic (Sr, S, O, H) and thermochemical studies (Ahmad et al., 1987; Begg, 1996) indicate that hydrothermal F within both the porphyry-Cu-style and epithermal systems were sulphur-poor, mildly acidic, hybrid magmatic-meteoric F. Sulphur isotopic data also highlight a continuum between the porphyry and epithermal environments, with lighter sulphide isotopic values with time. Despite the spatial, temporal, isotopic, and T continuum between the two systems, the precious-metal-rich nature of the epithermal F, their higher sal and CO_2 content, indicate that the two systems tapped different F. This can be explained if a metal-rich magmatic-hydrothermal F exsolved from the crystallising Tavua Volcano magma chamber were trapped at depth within the upper portions of the chamber (~3.5 km below surface) by lack of vertical permeability due to both horizontal compression and mineral sealing. Slow upward leakage of small amounts of this F, and incorporation into a larger volume of freely convecting meteoric water, may have resulted in a F capable of producing porphyry-style alteration assemblages in the upflow path. The "switch" to a magmatic-hydrothermal gold-rich epithermal system is linked to a sudden and large increase in fracture permeability generated by "epithermal-fault-valve" behaviour, triggered by lithostatic F P arising due to near-surface sealing of the porphyry-Cu-style system upflow zone. Such a mechanism is consistent with observations of large amounts of anhydrite in the 'porphyry' upflow zone, which may have 'clogged' the F pathways, forcing F to deviate around the resulting low permeability zone. (From authors' abstract by E.R.)

BELKIN, H.E., DeVIVO, B. and **WEBSTER, J.D.**, 1997, Analytical chemistry of Vesuvius lavas (<1631 A.D.) silicate-melt inclusions (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 41. First author at U.S. Geol. Survey, Reston, VA, USA; e-mail (hbelkin@rgborafsa.er.usgs.gov)

Silicate-MI from phenocrysts (clinopyroxene, olivine, leucite and plagioclase) of Somma-Vesuvius activity >25 kyr B.P., between 25 and 14 kyr B.P. and between 472 and 1631 A.D. have been studied by microthermometry, electron microprobe and ion microprobe (SIMS) analytical techniques in order to examine pre-eruptive volatile contents, magma evolution and paragenesis. Electron microprobe analyses have been carried out on both non-homogenized and homogenized silicate-MI, and ion microprobe analyses on homogenized silicate-MI. Various microbeam techniques have been used to attempt to analyze dissolved volatiles quantitatively as well as light elements (Li, B) and elements of probable low abundance (REE, Zr, Y, Th, Sr, etc.). The diverse eruptive character of the Somma-Vesuvius volcanic system is a manifestation of the interplay amount (1) the magma's initial volatile content, (2) volatiles added through shallow rock/water interaction and, (3) various fractionation processes that tend to enrich the magma in volatiles. Electron microprobe and SIMS analyses of the MI indicate that SO_3, Cl, B, Li, Sr and Th show a systematic increase from older to younger products (i.e., from >25,000 kyr B.P. to 1631 A.D.). Zr and Y show the opposite behavior. Chondrite-normalized REE patterns (Ce, Sm, Dy, Yb) show moderate light-rare earth enrichment (Ce_N/Yb_N ranges from 5 to 20) with minor differences among different age samples. SIMS determined

H_2O content varies between 0.6 and 2.7%. Additional results from FTIR will refine the H_2O contents. (Authors' abstract)

BELL, T.H., HICKEY, K.A. and **WANG, J.**, 1997, Spiral and staircase inclusion trail axes within garnet and staurolite porphyroblasts from schists of the Bolton Syncline, Connecticut: Timing of porphyroblast growth and the effects of fold development: J. Metamorphic Geol., 1997, no. 15, p. 467-478.

BENGOCHEA, Leandro and **MAS, Graciela**, 1997, Fluid inclusions in quartz veinlets from the mineralization of the gold mine Hualilan, San Juan Province, Argentina: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 37-38. Authors at Dept. de Geología, Univ. Nacional del Sur, CONICET, San Juan 670-8000 Bahía Blanca, Argentina; email (lbengo@criba.edu).

Three kinds of FI have been determined: Type I: two-phase (L rich) I with <30% of V; Th 284-309°C; sal 9.22-10.5%; Type II: Two-phase (V rich); Th 303°C; sal 3.57%; and Type III: Three-phase I (H_2O_L+H_2O_V+halite); Th 274°C; sal 334%.

The zonal distribution of the FI, and their association with growing textures in the quartz crystals and with solid I of sulfides, suggest a contemporaneous origin with mineralization. On the other hand, the close association of types I, II and II inclusions in the same planar group indicates the trapping of two F of different densities. The coexistence of aq-V F together with an almost saturated F can be interpreted as a boiling evidence, and the determined Th can be considered the actual Tt.

Boiling caused the fractionation of F of contrasting densities: a dense F, that range from unsaturated (type I inclusions) to almost saturated (type III inclusions); and a less dense F (type II inclusions). The distribution of the V I is rather heterogeneous, either in each crystal or in the whole deposit. This fact suggests a boiling phenomena of episodic characteristics. (From authors' abstract by E.R.)

BENNETT, B. and **LARTER, S.R.**, 1997, Partition behaviour of alkylphenols in crude oil/brine systems under subsurface conditions: Geochim. Cosmo. Acta, v. 61, no. 20, p. 4393-4402.

BERAN, Anton and **KOEBERL, Christian**, 1997, Water in tektites and impact glasses by fourier-transformed infrared spectrometry: Meteoritics & Planetary Sci., v. 32, p. 211-216.

BERBELEAC, I., 1997, Gold metallogeny in Romania: modified version of abstract of paper submitted to 4th Biennial SGA Meeting, Aug 11-13, 1997, Turku, Finland, as reported in Int'l. Liason Group on Gold Mineralization Newsletter no. 26, p. 57-60. Author at Prospetiuni S.A., Bucharest, Romania.

A review of the many gold deposits in Romania. The orebodies show a vertical zonality: the simple gold parageneses are dominantly in the upper parts of the deposits, and at greater depths there is a gradual or even sudden transition to the complex parageneses of epithermal and porphyry copper-gold systems. The chemistry of the metal-bearing F was $NaCl-KCl(F)-FeCl_2-H_2O-CO_2-SO_2$ and the T and sal for epithermal mineralizations was low (100-300°C, 0-10 wt.% NaCl eq.) in comparison with the porphyry-type mineralizations (750-1250°C, 50-75 wt.% NaCl eq.). (From author's abstract by E.R.)

BERDNIKOV, N.V. and **KARSAKOV, L.P.**, 1997, Thermobarogeochemical evolution of early Precambrian metamorphic and magmatic complexes of the Djugdjur range (east Siberia): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 39. Authors at Inst. of Tectonics and Geophys., 65 Kim Yu Chen St., Khabarovsk 680063, Russia; email (tectonic@itig.khabarovsk.su).

More ancient Archean granulites of the Zverevsk-Chogarsky complex are characterized by high-T paragenesis of bronzite and sillimanite with sapphirine or magnesian garnet, sapphirine or spinel with quartz. The peak parameters of their metamorphism are T=1100°C, P=7.2-9.4 kbar. In the Late Archean the granulite complex experienced diaphthoresis at T=630°C, P up to 5.5 kbar. The corresponding FI in metamorphic minerals are represented by practically pure CO_2. The Djugdjur massif anorthosites crystallized at T=1300°C, P up to 5.5 kbar. The free F preserved in the I in the anorthosite plagioclase has also an essentially carbon-dioxidic composition. Water in the F appeared only at the late stages of evolution of the basite M when anorthosite-pegmatite veins were being formed (T=900-1000°C, P=3.2-3.7 kbar).

I in plagioclase and accessory apatite indicate the crystallization T of the Olomsky gabbrides of 1210°C, P up to 3.2 kbar; and quartz in hypersthene granite, up to 2.4 kbar at 1000°C. FI in gabbride and granite minerals contain liquefied methane. Water is present only in the I of minerals crystallized from the late ore-bearing liquators of the basite M.

The obtained data indicate an evolution of the studied complexes. Under discussion are the reasons for the change from CO_2 in granulites and anorthosites to methane in gabbrides and granites. (From authors' abstract by E.R.)

BERGER, B.R., 1993, The Muruntau gold deposits, Uzbekistan (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). Author at U.S. Geological Survey, Federal Center, MS973, Denver, Colorado 80225.

The late Palaeozoic Hercynian fold and fault belt of the Tien Shan in Uzbekistan hosts the major gold deposits of western Central Asia, with 40,000,000 oz. of past production and more than 100,000,000 oz. of reserves. The ore-bearing system is reported to stretch for about 20 km, and to generally average 2-3 g/t Au. Nearby, much smaller and perhaps related ore bodies include the Miutenbai, Besop and Tashkumyr deposits.

Muruntau is hosted in the Ordovician-Silurian Besopan sequence of metapelites. Igneous dykes intrude the Muruntau ore field, primarily along the regional shear zones. Deformation prior to gold mineralisation was important in developing high permeability within the Besopan sequence. Schistose and axial plane cleavage were developed during regional metamorphism and folding; these make up the P permeability for the largest proportion of the mineralisation. Most of the gold is contained within low grade (2.5-3 g/t) "banded" and "stockwork" quartz veins. Widespread albitisation is the earliest alteration stage. Geochemical analyses of the different mineralisation styles indicate that gold may have been introduced with each of the four alteration assemblages. The mineralogy of this ore deposit consists of pyrite, arsenopyrite, sphalerite, galena, freibergite, miargyrite, pyrargyrite, native silver and gold.

FI and stable isotope studies of quartz veins provide evidence of F immiscibility in many quartz grains, with many gas-rich end members containing 80-100 vol% V. Earliest stage, ductilely deformed veins have I ranging 5-10 microns, with similar phase relations to those observed within later stockwork veinlets and Central Veins that were only 1-2 microns in diameter. For two-phase I with variable L:V ratios, most CO_2 melting T range from -56.6 to -58.8°C, clathrate melting T range between 6.2-8.6°C, and CO_2 Th range between 5.0-14.8°C. These data are typical of those reported for H-O-C-N hydrothermal systems in metamorphic rocks. Thermally decrepitated I were analysed using a quadrupole mass spectrometer system. Data from an earliest stage vein and a Central Vein both indicated that the non-aqueous part of the ore F was made up of 50-80 mol% CO_2, with the remainder consisting of roughly equal amounts of nitrogen and methane. Final Th in the earliest stage quartz generally range from 350-400°C, with homogenizations taking place into both the L and V phases.

Preliminary stable isotope data show $\delta^{18}O$ quartz to range from +15‰ for the earliest stage quartz veins to +7.8‰ for the stockwork-like veinlets, to +12.3 to +13.1‰ for the Central Veins. Assuming formation of all the veins at 40WC [sic, probably °C], the $\delta^{18}O_{fluid}$ would be approximately +4 to +9‰. Values of δD of -79‰ and -97‰ were obtained for FI waters from the Central Vein and earliest stage quartz, respectively. Sulphur isotope analyses on pyrite and arsenopyrite from a Central Vein and stockwork-like quartz range from +2.8 to +5.5‰. (From author's abstract by E.R.)

BERNDT, M.E. and **SEYFRIED, Jr., W.E.**, 1997, Calibration of Br/Cl fractionation during subcritical phase separation of seawater: Possible halite at 9 to 10°N East Pacific Rise: Geochim. Cosmo. Acta, v. 61, no. 14, p. 2849-2854. Authors at Dept. of Geol. and Geophysics, Univ. of Minnesota, Minneapolis, MN 55455.

Experiments were conducted to assess Br/Cl fractionation during phase separation of seawater at 400°C and 250 to 275 bars. These conditions are applicable to the 9-10°N EPR system where low Cl concentrations and low Br/Cl ratios in vent F have been attributed to phase separation of seawater at conditions below the critical point of seawater (408°C, 300 bars). The level of Br/Cl fractionation observed in experiments is well below that needed to account for Br/Cl systematics at EPR 9-10°N. Based on our experimental results, we propose an alternative model involving dissolution and precipitation of halite to account for the anomalous Br/Cl data at 9-10°N. Halite can be predicted to form at P and T conditions prevailing during eruption of magma at mid-ocean ridges. Subsequent changes in physical conditions, however, would induce halite to dissolve, and thus, decrease Br/Cl ratios of vent F. (Authors' abstract)

BEURLEN, Hartmut, da SILVA, M.R.R. and **dos SANTOS, R.B.**, 1997a, Auriferous quartz veins from northeastern Brazil; a fluid inclusion study: Internat'l. Geology Review, v. 39, no. 7, p. 578-588.

Auriferous quartz veins crosscut muscovite schists. Sericite, chlorite, and epidote are the most common wallrock alteration products. FI were studied in samples of mineralized quartz veins and some samples of barren quartz veins also were studied for comparison. P and PS I in the mineralized veins are triphasic or biphasic aq-carbonic at room T. The wide range of the CO_2/H_2O volume ratio (between 2:1 and 1:3) in a single group or trail suggests the coexistence of two immiscible F during the penecontemporaneous processes of quartz crystallization, deformation, mineralization, and recrystallization. Total homogenization of these I beginning at 290 to 310°C and 1.3 to 1.8 kbar provides the trapping conditions of the heterogeneous, effervescent F. CO_2 melting T of differs from -57 to -59°C indicate low CH_4 or N_2 contents. Clathrate melting close to 6.3°C indicates a low sal of differs [sic] from 6.9% NaCl eq. In addition, the low CH_4 content of the F in equilibrium with sulfides and alteration minerals suggests an oxygen fugacity between 10^{-30} and 10^{-27}, a total sulfur activity of 10^{-2} to 10°, and a neutral pH of differs from 5. (From authors' abstract by E.R.)

BEURLEN, Hartmut, DA SILVA, M.R.R. and **dos SANTOS, R.B.**, 1997b, Auriferous quartz veins from Serrita, State of Pernambuco, NE Brazil: A fluid inclusion study: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 40-41. First authors at Depto. Eng. de Minas-UFPE, Rua Acadêmico Hélio Ramos s.n., 50740-530 RECIFE-PE, Brazil.

H_2O/CO_2 I from over two dozen veins show a Th range 200-420°C; the average for those with $CO_2 \ll H_2O$ is 320°C, and 341°C for those with $CO_2 \gg H_2O$. CH_4 and N_2 are negligible. Sal is 6.9%.

It is suggested that two immiscible aq-carbonic F, respectively CO_2 and H_2O dominated, coexisted during the penecontemporaneous processes of wallrock alteration, quartz crystallization, deformation and mineralization at about 300 to 340°C and 1.5 to 2.0 kb in the four prospects studied. These characteristics are similar to those found in other mesothermal gold lode deposits throughout the world (Xavier, 1994) and also to auriferous quartz veins in Archean greenschist metamorphic terrains in Australia (Mikucky and Ridley, 1993).

The absence of significant proportions of CH_4 in the CO_2 component, the supposed equilibrium of the F with pyrite and chalcopyrite, the absence of pyrrhotite and magnetite permits constraining the O_2 fugacity to 10^{-30} to 10^{-27}, and the sulphur activity to 10^{-2} to 10^{0}. The presence of sericite as main wallrock alteration product instead of kaolinite or albite suggests a neutral pH of about 5. These are also conditions that agree with the greenschist-related auriferous veins in Australia (Mikucky and Ridley, 1993). (From authors' abstract by E.R.)

BHOWMIK, S.K., 1997, Multiple episodes of tectonothermal processes in the Eastern Ghats granulite belt: Proceedings of the Indian Acad. of Sci.: Earth and Planetary Sci., v. 106, no. 3, p. 131-146.

A suite of rocks from Borra Carbonate Granulite Complex reveal multiple episodes of tectonothermal reworking of the complex under granulite facies condition. Five distinct episodes of deformation and four phases of metamorphism are recorded. Narrow intersecting shear zones acted as channelways for carbonic and still later hydrous F infiltration. The available thermobarometric data reveal that reworking ensued in a thermally perturbed regime. (From author's abstract by E.R.)

BI, Xianwu and **HU, Ruizhong**, 1997, The mechanism for formation and evolution of ore fluids of the Mojiang gold deposit, Yunnan: Geological Review (Dizhi

Lunping), v. 43, no. 4, p. 381-387 (in Chinese; English abst.). Authors at Inst. of Geochem., Chinese Acad. of Sci., Guiyang, Guizhou.

Using FI and stable isotope trace elements and REE geochemical means, the writers studied the geochemical characteristics of ore F, source of gold and formation and evolution mechanism of ore F of the Mojiang gold deposit. It is concluded that the deposit is a mesothermal-epithermal gold deposit; the ore F belong to intermediate to weakly alkaline sodic solutions; the water in the ore F was the mixture of meteoric water and magmatic water; the mineralizers, such as H_2S and CO_2, were mainly derived from the mantle and that gold was derived from Silurian low-grade metamorphic rocks and Hercynian ultrabasic rocks. The mechanism for the formation of the Mojiang gold deposit in the early Himalayan period is as follows: the mineralizer-rich F derived from depth ascended in the early Himalayan and was added to the mineralizer-poor F cycling in a shallow fracture system, thus the mineralizer-poor F converted to mineralizing F, which extracted a lot of gold from surrounding rocks; then the gold in the F precipitated at suitable places to form the gold deposits. (Authors' abstract)

BICKLE, M.J., CHAPMAN, H.J., FERRY, J.M., RUMBLE III, D. and **FALLICK, A.E.,** 1997, Fluid flow and diffusion in the Waterville limestone, south-central Maine: Constraints from strontium, oxygen and carbon isotope profiles: J. Petrol., v. 38, no. 11, p. 1489-1512.

BILAL, Ahmad, 1997, Fluid inclusions in Syrian Triassic formations-physico-chemical and paleothermal study: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 42-43. Author at Damascus Univ., Dept. of Geol., P.O. Box 9487, Damascus, Syria.

This study of FI, in 204 samples from 18 wells used several methods: crushing microscope stage, microthermometry, RAMAN, and stable isotope. FI of three types were recognized: inherited (indetrital grains), diagenetic (in overgrowths), and postdiagenetic (in crosscutting fractures). Then by using the density of aq diagenetic I, and the heaviness of the rock wall–according to the depth of the studied samples–thermal gradient could be determined. It has been found that it ranges between 5-7% [sic]. (From authors' abstract by E.R.)

BILLSTRÖM, K., BROMAN, C. and **JONSSON, E.,** 1997, Evidence for a prolonged fluid history at the Björkdal Au deposit, northern Sweden: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 153-156. First author at Laboratory for Isotope Geol., Swedish Museum of Natural History, Stockholm, Sweden.

Isotopic studies of FI (H, C) and on minerals (O, H, C, U-Pb, Pb-Pb) from the Björkdal Au deposit suggest that F of three different origins (magmatic water, sea water, and meteoric water) have affected the ore zone at specific stages. Ore deposition is considered to be premetamorphic in age and linked to the formation of the host intrusion and to the subsequent uplift process. (Authors' abstract)

BIN, Liu, LU, H.-Z. and **KUN, Shen,** 1997, Discovery of high-P metamorphic minerals and rocks, characteristics of FI and P-T-t path metamorphism in east Tianshan, Xinjiang, China (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A12. First author at Dept. of Geotechnical Engineering, Tongji Univ., Shanghai 200092, China.

East Tianshan is a junction of three convergent plates: Tarim, Kazakhstan and Siberian plates. High-P metamorphic minerals and rocks in the three tectonic belts have been discovered: 1) the Early Palaeozoic ophiolite melange belt in the south margin; 2) the Early Palaeozoic tectonic melange belts in north margin; 3) the Late Palaeozoic tectonic melange belt in the northwest margin.

In quartzes of glaucophane schist in Tonghuashan, the CO_2-rich FI are found. These I are distributed either in recrystallized quartz grains or grain boundaries. The FI with high-density CO_2 are also found in riebeckite schist in Houxia. Moreover, H_2O-CO_2 I are identified for the first time in type B eclogite in Yushugou. These I are preserved in the rim of garnets and may be trapped in the late stage of the formation of the eclogites.

All the glaucophane schist, riebeckite schist and eclogites have undergone a retrogressive metamorphism at the late stage. The I with CO_2-H_2O component are often preserved in the minerals related to the retrogressive metamorphism.

In order to establish a P-T-t path of the metamorphism we synthetically use three methods to determine the T and P conditions at the different stages of the metamorphism: 1) petrogenetic grid; 2) mineral thermometer and barometer; 3) thermometer and barometer based on FI.

The P-T-t path of the three high-P metamorphic belts is represented in Figure 1. (From authors' abstract by H.E.B.) *See figure on page 237.*

BJØRLYKKE, , 1997, Sediment-hosted lead-zinc deposits and their relationship to the underlying basement: Formation and Metamorphism of Massive Sulphides–Frank M. Vokes 70 Year Anniversary Symposium, March 16-19, 1997, at Norwegian Univ. of Sci. and Tech. in Trondheim, Norway, Abstracts (unpaginated). Author at Geological Survey of Norway, PO Box 3006 Lade, N-7002 Trondheim, Norway.

Lead isotope studies show at least two sources of lead of Laisvall type (LT) deposits and of Mississippi Valley-type (MVT) deposits and that the basement was a major contributor of metals in both types either through leaching of the basement or indirectly through leaching of arkoses derived from the basement. The lead isotopes also show that the basement [rocks; sic] under some deposits are depleted in lead. Mixing of two or more F in LT and MVT-deposits is also indicated by the wide range in T and sulphur isotope compositions and some data suggest a mixing between basinal brines. The mixing of the two types of brines is well demonstrated at Laisvall, where there is a vertical zonation of FI T, base metal ratios and in lead and sulphur isotope compositions, suggesting that the predominating ore-F flow was vertical rather than lateral. In SEDEX and MVT deposits we find a gradual change from one deposit type to another, which may indicate similarities in their origin. In most models of Sedex-deposits the ore F is brought vertically up along fault structures to the seafloor. If a Sedex-type ore solution does not make it to the seafloor and stops against a caprock in a permeable dolostone or sandstone, would it then form a MVT deposit? (From author's abstract by E.R.)

BLAKE, K.L. and **WILLIAMS, P.J.**, 1997, Magnetite-apatite deposits and their relationship to iron-oxide hosted Cu-Au mineralisation (abst.): Geological Society of Australia Abstracts No. 44, p. 10. First author at Nat'l. Key Centre in Economic Geol., Dept. of Earth Sci., James Cook Univ. of N. Queensland, Townsville, Qld 4811.

Magnetite (±apatite, actinolite, clinopyroxene) deposits exemplified by the Proterozoic Kiruna iron ores of northern Sweden through to the iron oxide systems of Chile show a marked similarity in their overall mineralogy, textural features and geochemistry and have led to them often being labeled as the "Kiruna type". Deposits of this affinity may also form the host to or be spatially associated with iron oxide-Cu-Au mineralisation (Olympic Dam, South Australia; Ernest Henry, Cloncurry district, NW Queensland).

The textures demonstrate that most, if not all, magnetite to be the product of precipitation from hydrothermal F. At Kiruna, the F are seen to be magmatic in origin with T in excess of 450°C and $\delta^{18}O$ of ca. 7‰ in isotopic equilibrium with the volcanic host rocks. Preliminary stable isotope investigations of the Cloncurry iron oxide hosted Cu-Au deposits which indicate ore stage iron oxides were in equilibrium with a $\delta^{18}O$ F compositions of 8 to 10‰ (Starra) and 7 to 8‰ (Osborne) and T of ca. 350°C (Starra) and 500°C (Osborne), reflecting different conditions/F compositions during their formation.

Where Cu-Au mineralisation is present it is typically associated with K-silicate alteration. Such mineralisation in the Cloncurry district often display a marked structural control to F localisation and magnetite (±hematite) may form at several different paragenetic stages within an ore body. The combined geological characteristics of this suite of iron oxide dominated deposits suggest similar overall formation processes, the result of high T, low sulphidation hydrothermal F associated with a distinctive alkali dominated alteration. (From authors' abstract by E.R.)

BLENCOE, J.G., ANOVITZ, L.M. and **SEITZ, J.C.**, 1997, A fundamental flaw in modified Redlich-Kwong equations for supercritical H_2O-CO_2 fluids: Eos Trans. AGU v. 78 (17), Spring Meet. Suppl., p. S335. Authors at Chemical and Analytical Sci. Div., Oak Ridge Nat'l. Laboratory, P.O. Box 2008, Building 4500-S, MS 6110, Oak Ridge, TN 37831-6110; email (glencoejg@ornl.gov)

Modified Redlich-Kwong (MRK) equations for calculating the thermophysical properties of water at high T and P (Holloway, 1977; Kerrick and Jacobs, 1981) yield three values for molar volume over substantial ranges of P below 350 bars at T from 375 to 432°C (Holloway equation) and 375 to 412°C (Kerrick and Jacobs equation). This flaw introduces serious errors into calculated excess volumes. Errors are particularly large for water-rich H_2O-CO_2 F.

New volumetric and activity-composition data indicate that both the Holloway (1977) and Kerrick and Jacobs (1981) MRK equations for H_2O-CO_2 F severely underestimate nonideality in the system. This has important implications for studies in which either formulation was used to: develop a thermodynamic model for H_2O+CO_2-bearing F, analyze FI, or interpret mixed-volatile phase equilibrium data. The inaccuracies in the models are partly attributable to the flaw in the MRK equations for water. Serious errors also arise, however, due to the use of oversimplified mixing rules.

It is concluded that the Holloway (1977) and Kerrick and Jacobs (1981) MRK equations for H_2O-CO_2 F should be applied with extreme caution in any study that requires accurate thermophysical properties for these mixtures. (From authors' abstract by E.R.)

BLENCOE, J.G., SEITZ, J.C. and **ANOVITZ, L.M.**, 1997, Excess free energies and activity-composition relations for H_2O-CO_2 fluids at 400°C and 1-4000 bars: *in* Proceedings of the Fifth Int'l. Symposium on Hydrothermal Reactions, Palmer, D.A. and Wesolowski, D.J., eds., 1997, Gatlinburg, TN USA, p. 113-116. First author at Oak Ridge Nat'l. Laboratory, P.O. Box 2008, Bldg. 4500S, MS 6110, Oak Ridge, TN 37831.

BODEN, D.R. and **HENRY, C.D.**, 1997, Volcanic setting, principal controls, and timing of contrasting styles of epithermal mineralization, Tuscarora, NV (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-360. First author at 1445 High Chaparral Dr., Reno, Nevada 89511.

Eocene Au-Ag deposits at Tuscarora are significant because they (1) illustrate the close connection between volcanism and ore deposition, (2) consist of two distinct types of mineralization of indistinguishable age, and (3) are the oldest volcanic-hosted epithermal mineralization in Nevada.

Production of ~200,000 oz Au and 7.3 M oz Ag, came from two deposit types: (a) base metal-bearing, high-grade Ag-Au veins (Ag/Au typically ≥100) that lie in the north and east parts of the district (e.g. the Navajo and Grand Prize veins), and (b) base metal-poor Au-Ag veins and stockworks (Ag/Au typically ≤15) that lie in the south and west parts of the district (e.g. the Dexter and Modoc zones). Both types contain quartz and adularia, but calcite, base-metal sulfides, rhodochrosite, and rhodonite are common in type (a) but are minor or lacking in type (b). Preliminary FI data (J. Cline, pers. comm., 1993) indicate that Th for the two vein types are similar (225-255°C), but Au-rich veins also include a population with evidence of boiling and that homogenized at 210-220°C. Estimated minimum paleodepths from I showing evidence of boiling range from about 250-400 m. (From authors' abstract by H.E.B.).

BODNAR, R.J., 1997a, Fluid inclusion evidence for a magmatic source for metals in hydrothermal systems (abst.): 1997 SME Ann. Meeting, Feb. 24-27, 1997, Denver, CO; Tech. Prog., p. 43.

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 that volatile elements such as Ag, Hg, Tl 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. (Author's abstract)

BODNAR, R.J., 1997b, Model for the origin and distribution of metals in porphyry copper systems with applications to exploration: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 32, Lunar and Planetary Inst., Houston. Author at Fluids Research Laboratory, Dept. of Geological Sci., Virginia

Tech, Blacksburg, VA 24061-0420, U.S.A.; email (bubbles@vt.edu)

Over the past decade remarkable advances have been made in our ability to obtain quantitative analyses of individual FI. Application of these techniques to study FI from porphyry Cu systems has provided abundant data related to the sources of metals and other ore-forming components in these economically important systems.

Analyses of FI from numerous porphyry Cu deposits from the southwestern U.S. porphyry province show a clear distribution of metal contents of ore F with respect to location within the porphyry system and alteration and/or mineralization stage. FI representing the earliest magmatic F in all systems studied contain from a few thousand to tens of thousands of ppm Cu. Similar concentrations of Fe, Mn, Zn, and Pb have also been detected. A systematic decrease in metal contents is noted as the early F migrate further from the source and cool and are diluted by F of meteoric origin. F that are clearly of wallrock origin contain no detectable metals. The results of these studies provide convincing evidence that metals in the porphyry copper deposits studied were sourced in the magma.

FI characteristics and the distribution of metals in FI within the porphyry environment are consistent with the V-plume model proposed by Henley and McNabb (1978). The Bingham Canyon, Red Mtn. (Arizona), and Butte deposits all contain FI that are thought to have trapped the "magmatic vapor," and analyses of these I using synchrotron XRF techniques prove these F were responsible for transporting metals into the ore-forming environment. Moreover, results of theoretical and experimental studies of partitioning of metals between coexisting L and V at magmatic conditions are consistent with analytical results and provide a plausible mechanism for transporting metals such as Au, Ag, Cu, As, Sb, Hg, etc., from the deeper porphyry environment to the near-surface epithermal environment. (From author's abstract by E.R.)

BODNAR, R.J. and **VITYK, M.O.,** 1997, Hydrocarbon fluid inclusion evidence for the P-T conditions of oil migration and accumulation in folded belts and foreland basins (abst.): Ann. Meeting abstracts-American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, 1997, no. 6, p. 12-13.

FI have been used to constrain the P-T history of hydrocarbon generation and accumulation in folded belts and foreland basins. This was accomplished using oil and G trapped in FI in quartz crystals from nappes of the Ukrainian Folded Carpathians. Hydrocarbon generation within the Carpathian orogen occurred in Late Oligocene-Early Miocene during compressional deformation of the accreted sedimentary cover. During this process, underthrusted Oligocene source rocks were buried to different depths, resulting in variable levels of maturity. FI in quartz crystals from the nappes record the P-T conditions during burial and were used to determine whether or not the host source rocks passed through hydrocarbon generation window and, if so, at what depth generation was initiated, peaked and terminated. The FI were thus used to place absolute constraints on the depths and T of the source rocks as a function of geologic time. The I were also identified the most likely zones in which petroleum could have migrated within the belt. For example, the Dukla nappe represents the least buried (1-2 km) nappe in the region. During the Miocene, quartz was precipitated in this nappe at P-T conditions within the oil window. Quartz from this nappe contains I of light paraffinic oil (approximately 40-45 degrees API). Conversely, the Krosno zone was one of the most deeply buried (10 km) parts of the Ukrainian Folded Carpathians during Miocene compression. Quartz from the Krosno zone contains only dry G (methane) I. These G I show the highest densities that have been recorded for the region, and are consistent with burial beyond the oil window. (Authors' abstract)

BOIRON, M.-C., MOISSETTE, Alain, FABRE, Cécile , DUBESSY, Jean, BANKS, David and **YARDLEY, Bruce,** 1997, Ion analysis in individual fluid inclusions by laser ablation-optical emission spectroscopy: Application to natural inclusions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 44-45. First author at CREGU and EP 578, BP23, 54501 Vandœuvre-lès-Nancy Cedex, France; email (boiron@cregu.cnrs-nancy.fr).

Recent developments using LA-OES, previously described by Boiron et al. (1991, 1995), have shown that it is possible to accurately determine the ratios of major elements, and obtain qualitative estimates of trace elements. More details of the apparatus and a description of the analytical conditions are given in Moissette et al. (1997, this volume).

Natural FI from four different locations were analysed using LA-OES. The selected samples had all been well-analysed by bulk crush-leach, and were as follow: i) quartz from Mont Blanc massif (Col des Cristaux, Bochard and La Gardette) where samples display different bulk F Na/K and Na/Li ratios, ii) gold-quartz veins from Brusson massif (Yardley et al, 1993), iii) quartz veins from Iron Quadrangle in Brazil displaying unusual Na/K; iv) quartz from the Muiane Li-pegmatite, Mozambique, rich in Li.

Na/Li, Na/K, K/Li, Ca/Li and Na/Ca emission line intensity ratios were calculated from the spectra and calibration curves established by Moissette et al. (1997) were used to obtain element ratios. Approximately 80 I have been analysed, with c. 400 spectra, in total, recorded in the 580-780 nm spectral range. Reproducibility for most of the element ratios is in the range 10 to 25% and the major element ratios are of the same order of magnitude as those obtained by crush-leach techniques (although commonly somewhat lower). Trends in Na/Li ratios are the same for each sample for both LA-OES and crush-leach analysis. For each sample, LA-OES analyses display a characteristic Na/Li ratio, whereas Na/K and Na/Ca ratios show different modes, probably attesting the existence of multiple FI groups having different Ca and K contents.

The first application of LA-OES to natural FI has demonstrated the power of such technique for major ion ratios. In addition, a number of trace elements have been detected in specific I in samples from Alps (Sr, Ba) and Brazil (Sr, Ba and Cu), while the Muiane pegmatite, despite having K below detection, yields a clear peak for Cs, in agreement with crush-leach data.

We conclude that the crush-leach data and LA-OES data are in acceptable agreement. The next step will be the calibration of further major ion ratios by LA-OES. (From authors' abstract by E.R.)

BOLDER-SCHRIJVER, Lieselotte, KRIEGSMAN, Leo and **TOURET, Jacques,** 1997, Carbonate/CO_2 Inclusions in sapphirine-bearing granulites from Hakurutale, Sri Lanka: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 46-47. First author at Dept. Petrology and Isotope Geol., VU Amsterdam, The Netherlands; email (schl@geo.vu.nl).

Pan-African sapphirine-bearing granulites from the Hakurutale locality in the Highland Complex, Sri Lanka (Kriegsman, 1993), contain CO_2-rich FI in a number of rock-forming minerals, notably garnet. From the topological study of mineral reactions, completed by mineral thermo- and barometry estimates and other local and regional data, the overall P-T path appears to be clockwise. Estimated peak metamorphic conditions are 850°C and 9 kbar (Kriegsman, 1993).

As in many other granulites from India and Sri Lanka, garnet contains FI (size range 5-75 μm) with one or several solids in a single F phase, and exceptionally two-phase (L/V) F at room T. Constant melting T (Tm=56.8±0.3°C), supplemented by Raman data, show that the F is (almost) pure CO_2 in all I (1-2 mol% N_2). Th (L) ranges from +8 to +11°C. These contain the following solids, identified by optical microscopy, Raman and SEM analyses as: magnesite, nahcolite, Al-silicate (probably sillimanite) and possibly diaspore. Magnesite is by far the most abundant solid, with a relatively constant volume ratio in most I (dm). This indicates that, at the time of trapping, the F was a homogeneous mixture of carbonate and CO_2, comparable to a CO_2 saturated carbonatite M; magnesite separated from the F upon cooling.

Representative isochores pass well below the peak P-T conditions, indicating a strong decrease of the F density during the retrograde evolution. Integration of the magnesite molar volume in the molar volume of the initial homogeneous F results in an "equivalent-CO_2" isochore lifted very close to peak-metamorphic conditions: the post peak-metamorphic F evolution has entirely taken place within the I, without significant leakage or exchange with the host mineral.

While carbonates very commonly occur in granulite CO_2 I, it can be calculated that, in general, they are not stable at granulite-facies P-T conditions (Lamb, 1996). They can either post-date or predate the CO_2 F. In most cases, carbonates inside I cavities are formed by interaction of former CO_2-rich I with later incoming ionic aq F. These carbonates (never associated with high-density, CO_2 F) are present in most granulites and they must be considered as S, retromorphic features.

The case presented here is fundamentally different: it corresponds to a CO_2-rich F introduced into the rock system as a saturated carbonate M at peak P-T conditions, which then has evolved, in situ, in the I cavity. Carbonate (mineral) is then contemporaneous with the CO_2 F, but carbonate (M) predates it. In the observed I, the CO_2 F solely is not representative of peak conditions, despite the P character of the cavity. Textural evidence for peak metamorphic I formation is not sufficient; it must always be supplemented by the information gained from the CO_2 density and mineral assemblage. (From authors' abstract by E.R.)

BOLOGNESI, Luca, 1997, A tentative correlation between seismic activity and changes in the composition of thermal waters on Vulcano Island, Italy: Geothermics, v. 26, no. 3, p. 379-392.

Indexed under FI (E.R.)

BONDARENKO, G.V. and GORBATY, Yu.E., 1997, In situ Raman spectroscopic study of sulfur-saturated water at 1000 bar between 200 and 500°C: Geochim. Cosmo. Acta, v. 61, no. 7, p. 1413-1420. Authors at Inst. of Experimental Mineral., RAS, 142432 Chernogolovka Moscow Region, Russia.

Raman spectra of a hydrothermal F, interacting with elementary sulfur, have been measured in the T range from 200 up to 500°C at a constant P of 1000 bar. The main products of the interaction are H_2S, SO_2, $[HSO_4]^-$, and S^0. The T dependencies of intensities for a characteristic Raman line of these species have been found. They show that concentrations of H_2S and SO_2 behave much alike, increasing in the whole T range studied, whereas the T trends for $[HSO_4]^-$ and S^0 show maxima at 350-400°C, so that these species practically disappear at higher T. The T dependencies for all the main components of the solution reveal features around the critical isotherm at isobaric heating or cooling. At low T, the presence of the $[SO_4]^{2-}$ ion may be suspected. The ion [HS] exists in the whole T range. Also, weak bands of the anion $[S_2O_3]^{2-}$ seem to occur in the spectra. (Authors' abstract)

BONEV, I.K., FALLICK, Anthony and BOYCE, Adrian, 1997, Isotopic composition of primary fluid inclusions in galena: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 48-49. First author at Geological Inst., Bulgarian Acad. of Sci., 1113 Sofia, Bulgaria; email (bonev@geology.acad.bg).

The presence of large P I (≤mm) located in undeformed large galena crystals from the Central Rhodopes, Bulgaria, provided a chance to extract original hydrothermal F and to measure its $\delta^{18}O$ and D/H isotope values simultaneously. It is noteworthy that the F trapped in galena had not been in any contact with other O and H containing phases.

Two techniques for extracting the F were applied: 1) decrepitation and crushing of crystal fragments, and 2) direct withdrawal of F from subsurface I. The procedure of Kishima and Sakai (1980) and Ohba (1986) for micro CO_2-water equilibration was generally followed for the separate determination of D/H and $\delta^{18}O$. H_2O was converted to H_2 with hot uranium.

Both methods for extractions of waters applied to galena samples give similar results: negative $\delta^{18}O$ values in the range of 0 to -10‰, and D/H values in the range -40 to -80‰, mean about -55‰. A criterion for the quality of isotope determinations is the difference in the $\delta^{13}C$ of the reference CO_2 gas before and after its equilibration with the F water, which usually is lower than 1-2%. When this difference was larger than 4-6%, due to various uncontrolled effects, the results, especially for $\delta^{18}O$, were highly deviant and uncertain and have been rejected. The lowest water amount still giving a reasonable $\delta^{18}O$ value was 0.40 ml [sic].

The methods applied here are not universal because the necessary large undeformed galena crystals are rare. Large crystals of sphalerite also sometimes contain macroinclusions but they are still rarely detectable.

Though having limitations and difficulties, this approach gives unique direct information about authentic conserved ore F. (From authors' abstract by E.R.)

BONEV, I.K. and KOUZMANOV, Kalin, 1997, Fluid inclusions in sphalerite as negative crystals: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 50-51. Authors at Geological Inst., Bulgarian Acad. of Sci., 1113 Sofia, Bulgaria; email (bonev@geology.acad.bg).

The shape, symmetry and crystallographic forms of FI in very light-colored sphalerite from Central Rhodope Mtns., Bulgaria, are described. Th (L) are ≈190-200°C, sal ~4-8% NaCl. On opening, xls of both NaCl and KCl form during evaporation. In spite of the low Th values, "Vapor bubbles of boiling solutions seem to have played an important role in the formation of the larger tube-like inclusions" (E.R.).

BONEV, I.K. and **RICE, C.M.,** 1997, Single crystal galena pillars as highly anisometric dissolution forms: Mineralogical Magazine, v. 61, p. 377-386. First author at Geological Inst., Bulgarian Acad. of Sci., 1113 Sofia, Bulgaria.

Remarkable single crystal galena formations in the unique form of cylindrical or steep conical 'pillars' with 'capitals' of small rhombododecahedral single crystals of sphalerite, are described. It is suggested that the pillars result from a highly specific process of anisotropic mineral dissolution controlled by a system of internal channels in the original skeletal crystals and represent a kind of dissolution whiskers. (Authors' abstract)

Of possible pertinence to the interpretation of FI in galena. (E.R.)

BONI, Maria, BECHSTÄDT, Thilo, LIU, Wenjun and **ZHENG, Rongcai,** 1997, Basin evolution and MVT ores in the Cambrian of western Hunan (China): GAEA 3, 18th IAS, Regional European Meeting of Sedimentology, Heidelberg, Sept. 2-4, 1997, Abstracts, p. 82. First author at Dipartimento di Scienze della Terra, Univ. di Napoli, Largo S. Marcellino 10, I-80138, Napoli, Italy.

Numerous base metal ore deposits, consisting of stratabound concentrations of Zn>Pb>Ba in Lower Cambrian carbonates, have been discovered in the last thirty years in the Huayuan district (border zone between Hunan and Guizhou provinces, southern China). Mining exploration was active mainly in the seventies, resulting in a series of small discoveries, economic only by local standards.

The belt of mineral deposits, situated in the Quinxudong Fm., is about 14 km long and 2 km wide. The main ores are confined to the upper part of the Fm. and are mostly contained in the microbial, partly stromatactis-bearing mounds and in oolitic limestones of the platform margin. The ore minerals are dominated by sphalerite, followed by galena, barite and fluorite. Among the gangue minerals, a few generations of calcite and dolomite (including saddle dolomite) occur. Bitumen, various organic compounds (present in black fluorites and calcites) and gaseous hydrocarbons (within FI) are extremely common. The T, measured in the FI of both ore and gangue minerals, range from 100 to 180°C, with average values of 138°C. Sal are high (up to 34 wt.% NaCl eq.), similar to those encountered in typical basinal brines. Preliminary Pb-isotope data of the galenas are heavily radiogenic, while S-isotopes of the barites ($\delta^{34}S$=34‰ CDT) have the same values like Cambrian sea water sulfur. The few existing values from the sulfides are very positive and seem to point to an isotopical equilibrium between the various sulfide phases.

The ores are filling various kinds of late porosity: They occur in mounds within stromatactis-like cavities (Dong Li, Lomichang), in small fractures and as cockade cements in larger veins and in dissolution/collapse breccias (Ma Chang, Laizibao). In the Dong Li area, at least two generations of ores occur, one related to an earlier event, with prevailing galena, and a second one, possibly related to a younger episode, resulting in the deposition of yellow sphalerite, bitumen and saddle dolomite. In the Ma Chang and Laizibao mines, several types of ore minerals occur, consisting of distinct generations of sphalerite and pyrite, with only minor galena.

The structure of the ores is clearly epigenetic: void filling and emplacement textures are very common and the main mineralization phase is in association with deep burial, hydrothermal cements. Summarizing, they are considered as Mississippi Valley Type ores, epigenetically deposited by hot, saline, metal-carrying brines. The emplacement of the mineralizations in the platform-marginal carbonates of the upper Quinxudong Fm. could have taken place through F migrating in connection with the "Caledonian" compressive movements (thrust sheet tectonics and uplift of the Jiangnan region). (From authors' abstract by E.R.)

BORISENKO, Alexander, BOROVIKOV, Andrey and **BABICH, Valeriy,** 1997, Specific compositional features of ore-forming fluids at Deputatskoe tin-ore deposit (Yakutia): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 52-53. Authors at United Inst. of Geol. Geophys. and Mineral., Univ. Precambrian Research, v. 82, no.. 3, Novosibirsk 90, 630090, Russia; email (obolensk@uiggm.nsc.ru).

FI in quartz and fluorite at the ore level of greisen stage of the Deputatskoe deposit have been studied using thermobarogeochemical technique (cryometry, Raman spectroscopy, homogenization, analysis of saline residue, etc.). The evolution of ore-forming F is traced on vertical–from ore to subore levels up to the depth of 1000-1100 m.

Ore-forming F are reduced highly-concentrated chloride solutions distinguished by high contents of Fe, Mn, Zn, Pb and other ore elements and carbonic-acid-nitrogen-methane gas phase. Multiphase I in quartz of cassiterite-fluorite-quartz and sulfide stages contain solutions of high concentration decreasing from deep horizons (58-60 wt.%–900 m) to the surface (37 wt.%–170 m). They are dominated by Cl, Na, K and Fe, and contain sulfur, As and Ca. High concentrations of ore elements Mn (6.5 wt.%), Zn (2 wt.%) and Ag are established. Gas phase of FI at the depth of >900 m consists mainly of methane with CO_2 and N_2 increasing upward. Sal ranges from 15.5 to 35.5%. Analyses ("microroentgen spectral") are presented for Cl, Na, K, Ca, Fe, Mn, Zn, Ag, S and As, made on "salt residue" (E.R.). (From authors' abstract by E.R.)

BORISENKO, A.S., KHOLMOGOROV, A.I., BOROVIKOV, A.A., SHEBANIN, A.P. and **BABICH, V.V.,** 1997, Composition and metallization of ore solutions of the Deputatskoe tin-ore deposit (Yakutia): Geol and Geophys., v. 38, p. 1830-1841 (in Russian; Engl. abst.).

Study of FI in minerals of the ores from the Deputatskoe tin-ore deposit by methods of thermobarogeochemistry (homogenization, freezing, Raman spectroscopy, analysis of salt remains on a microprobe) gave an insight into T, composition, and concentration of ore-forming solutions and contents of ore elements in them. The ore-forming solutions were distinguished by high concentrations of salt components (up to 60 wt.%), among which NaCl, KCl, and $FeCl_2$ were predominant. High concentrations of Mn, Zn, Pb, and Ag are established. The G phase of solutions varied from essentially methane (±N_2) at deep horizons of the deposit to carbon dioxide-nitrogen (± methane), in the top horizons. (Authors' abstract)

BORROK, David, KESLER, Stephen, ESSENE, Eric and **BOER, Rudolf,** 1997, Fluid inclusion evidence for a magmatic-hydrothermal model for massive iron oxide deposits (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-208. First author at Dept. of Geol., Univ. of Michigan, Ann Arbor, MI 48109.

Vergenoeg is a fluorite-bearing massive iron oxide deposit that is genetically related to granites of the Bushveld Complex. It consists of a pipe-shaped body of fayalite, fluorite, apatite, ilmenite, and magnetite that cuts Rooiberg rhyolites and is surrounded by stratiform bodies of felsite, and hematite-fluorite debris. With the exception of its abundant fluorite, Vergenoeg is similar to massive iron oxide deposits such as Kiruna, Pea Ridge, Cerro Mercado and El Laco. Although a hydrothermal (rather than magmatic) origin for deposits of this type has been advocated recently, most I-hosted F oberved in them so far are probably of low-T S origin. In contrast, P fluorite at Vergenoeg has I of a high-T (>500°C), high-sal (>67 eq. wt.% NaCl) F and/or a coexisting V phase rich in CO_2. Stable isotope analyses of fayalite and titanomagnetite that coexists with this fluorite yield calculated compositions that are typical of magmatic water. Fluorite associated with later alteration minerals at Vergenoeg contain I of F that homogenize at 150 to 500°C and have sal of 1 to 35 wt.% eq. NaCl. Stable isotope analyses of hematite and I waters in fluorite suggest that these F consist of a mixture of magmatic and meteoric water. F similar to the magmatic F at Vergenoeg have been reported from Pea Ridge and Cloncurry, and F typical of later alteration F have been reported from Olympic Dam and other deposits. These F form an almost continuous mixing (?) line between a highly saline, Fe-rich magmatic F and later meteoric water, providing strong support for a magmatic hydrothermal origin for these deposits. The variable amount of copper (and gold?) in these deposits, and their relation to magnetite-rich porphyry copper mineralization, appears to be a function of Cl:F ratio in the magmatic F. (Authors' abstract)

BORTNIKOV, N.S., 1997, Geology and characteristics of gold mineralization and geochemistry of fluids in the Charmitan and Nezhdaninskoye giant gold deposits, CIS (abst.): Implication for a behavior of gold in the mesothermal systems: Mineral Deposits Studies Group Ann. Gen. Meeting, Jan. 8-11, 1997, Glasgow Univ., Programme with Abstracts volume, p. 10-11.

The mesothermal vein and disseminated gold deposits hosted by terrigenous sequences began to play an important role in the gold production of the World. An understanding of processes which are responsible for formation of these gold mineralizations is needed from academic and industrial point of views. It is generally accepted that F phase separation of an H_2O-CO_2-CH_4-H_2S F is responsible for gold deposition. The results of study of mineralogy and geochemistry of two giant mesothermal gold deposits from the former USSR may change our knowledge on the gold behaviour in the hydrothermal processes.

The Charmitan gold quartz deposit has proved gold reserves of 400 t. The deposit Nezhdaninskoye is a vein- and veinlet-disseminated gold deposit in a low Permian terrigenous sequence. The proved gold reserves are 475 t.

A FI study indicates that minerals crystallized from F of various compositions: (a) H_2O-rich CO_2-and CH_4-bearing F with dissolved chlorides, (b) V-rich F composed of CO_2, CH_4, and N_2. Occurrence of syngenetic L-rich and V-rich I is an evidence of immiscibility of initial F into two F at the earliest auriferous stages. The sal of F range 1.5-15 wt.% eq. NaCl. The Th of FI are of 400 to 150°C. Deposits were formed under P of 2.7-0.9 kbar (Charmitan) and of 1.2-1.7 kbar (Nezhdaninskoye), from F with pH of 5±1. The oxygen fugacity varies near values equilibrated with pyrite-pyrrhotite-magnetite buffer.

The main conclusions drawn from our observations is that the F immiscibility, generally accepted an effective mechanism of gold deposition, could not play such an important role in the cases of deposits studied. Immiscibility induces a pH increase which cause minerals to precipitate. However, the loss of gaseous constituents such as CO_2, CH_4, H_2S, H_2, and NH_3 oxidizes the residual L phase. The arsenopyrite precipitation resulted rather from a F reduction. This phenomena may be caused by the redox reactions of a F with ferromagnesian minerals during wall rock alteration. Immiscibility is supposed to have been a process that has disequilibrated a F and host rocks and the interaction between them. The crystallization of earliest generations of native gold due to the metal adsorption from a gold-undersaturated F by sulfide surfaces is inferred. Further evolution of F and local boiling may result in T drop to saturate F with gold to precipitate this mineral at latest stages of formation of deposit.

The calculations revealed that high-T F (>400°C) transported gold mainly as chloride complexes. A T drop and pH increase caused gold to precipitate. Simultaneously, switchover of chloride complexes to bisulfide gold complexes could take place. The later may retain in a F and destabilise as a result of the drop of the H_2S activity due to sulfide crystallization. (From author's abstract by E.R.)

BÓRTNIKOV, N.S., GAMYÁNIN, G.N., BORISENKO, A.S., ANÍKINA, E.Yu., NOSIK, L.P. and **APLÁTOV, V.V.,** 1997, The role of fluid mixing in the formation of the Prognóz Ag-Pb-Zn deposit, Yakutia (fluid-inclusion and stable-isotope studies) (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 25-26, ISBN 5-88918-002-9 (in Russian; English translation courtesy Dr. D. B. Brown). First author at IGEM, RAS, Moskvá.

The Prognóz Ag-Pb-Zn deposit is the largest in the Verkhoyánsk argentiferous province (Gamyánin and Aplátov, 1996). Twelve orebodies (mineralized zones, affected by wrench-fault tectonic disturbances) have been found in this area. The main orebody has been traced along strike for more than 3.9 km and in depth down to 400 m. The mineralized zones strike in a sublatitudinal direction (110-080°) and dip steeply southwards (065-085°). The average amounts in the ores are Pb-8.4%, Zn-1.62%, and Ag-980 ppm. The deposit is located in the junction zone between the Sartáng Synclinorium and the Ádycha Brachyanticlinorium (Gamyánin and Aplátov, 1996). It is confined to the junction of three regional faults that intersect the crest of an anticlinal fold. The orebodies occur in Triassic siltstones and sandstones. Dikes of diorites (113±10 MY), quartz porphyries (96-108 MY), and lamprophyres, have been injected into the sedimentary rocks. The diorites are pre-ore in origin. The quartz-porphyries are regarded as intra-ore because they cut through the sphalerite-galena veinlets. As a result of observations of intersection in the mine workings and an analysis of the structural-textural relationships in bulk samples, the process of mineral formation has been subdivided into six phases: (1) quartz-pyrite-arsenopyrite; (2) siderite I-sulphide; (3) siderite II-galena-sphalerite; (4) quartz-sulphide-sulphosalt; (5) quartz-pyrite-sphalerite-ankerite-dolomite; and (6) gangue quartz-calcite.

The P FI, captured by the quartz and carbonates, consist of two phases (L+G) at room T (+22°C). Th L occurs at 225-100°C. The Te from -55°C to -52°C indicates that the L phase in the I is water with dissolved NaCl and $CaCl_2$ (Borisenko, 1977). Lowering of the Te to -64°C, revealed during cooling of some I, indicates a trace of KCl and $FeCl_2$ in the F. The content of NaCl and $CaCl_2$ varies from 29.0 to 8.0 wt.%. Preliminary data indicate that lowering of Th and the sal of the I takes place as the depth of occurrence of the minerals decreases. The Na:K ratio in the captured F varies from 0.5 to 2. According to Ramanovsky spectroscope data, the G phase in the FI consists of CO_2 (65.4-84.2%), N_2 (5-29.5%), and CH_4 (0.8-5.1%).

The $\delta^{13}C$ values for siderite I (n=16), siderite II (n=16), ankerite (n=9), and calcite (n=8) vary respectively from -3.2‰ to -12.1‰ (PDB), from -4.5‰ to -10.6‰, from -3.5‰ to 10.5‰, and from -8.0‰ to -9.9‰. There is significant predominance of $\delta^{13}C$ values ranging from -9.0‰ to -7.0‰. The data obtained point to the similarity of the carbon-isotope composition in carbonates of differing ages.

The $\delta^{18}O$ values of siderite I, siderite II, ankerite, and calcite vary respectively from +22.3‰ to +27.8‰ (SMOW), from +22.0‰ to +27.1‰, from +9.1‰ to +29.8‰, and from +9.6‰ to +26.1‰. An enrichment in the ^{16}O isotope has been found in the late ankerite and calcite.

The $\delta^{34}S$ values for pyrite, arsenopyrite, galena, sphalerite, and sulphosalts vary respectively from +13.9‰ to -1.8‰ (CDT), from 3.8‰ to -6.0‰, from +8.3‰ to -13.1‰, from +5.2‰ to -3.3‰, and from -3.4‰ to -7.9‰.

The substantial variations in the stable isotope (C, O, S) ratios in the minerals probably reflect significant changes in these ratios in the F during mineral-formation. These changes may be interpreted as a consequence of boiling of the F or mixing of the F and components, coming in from different sources (Ohmoto, 1986). Mixing, as a mechanism that controlled variations in the $\delta^{13}C$, $\delta^{18}O$, and $\delta^{34}S$ values, seems the more likely because the phenomenon of F ebullition has not been confirmed during a study of FI. The joint lowering of Th and sal of the F is regarded as a criterion for mixing of various F (Roedder, 1984). Thus, the data obtained on FI and stable-isotope ratios may be interpreted as a result of mixing of F which have entered the zone of mineral formation from different sources. We suggest that the concentrated F and the predominant role of CO_2 and sulphur came from a magmatic focus. The F, which formed as a result of interaction between meteoric waters and the country rocks and the sulphur, nitrogen, and methane extracted from them, played an important role during the formation of the deposit. (Authors' abstract)

BORTNIKOV, N.S., KRYLOVA, T.L., BOGDANOV, Yu.A., VIKENTYEV, I.V. and **NOSIK, L.P.,** 1997, The 14°45'N hydrothermal field, Mid-Atlantic Ridge: Fluid inclusion and sulfur isotope evidence for submarine phase separation: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 353-356. First author at IGEM, Russian Acad. of Sci., Moscow, Russia.

FI and sulfur isotopes in minerals from the 14°45'N hydrothermal field, Mid-Atlantic Ridge have been studied. The T and sal of a F entrapped in I [in gypsum] are 365 to 260°C and 16.2 to 4.2 wt.% NaCl-eq., respectively. The $\delta^{34}S$ value of chalcopyrite varies from +12.7‰ to +9.0‰ (CDT) towards a feeder channel. Phase separation is inferred to be responsible for a formation of brines and an enrichment in the ^{32}S isotope of late chalcopyrite. (Authors' abstract)

BORTNIKOV, N.S., VIKENTYEV, I.V., SAFONOV, Yu.G., KRINOV, D.I., ZVYAGINA, O.V., SAZONOV, V.N., MURZIN, V.V., NAUMOV., V.B. and **MIRONOVA, O.V.,** 1997, The Berezovsk giant gold quartz deposit, Urals, Russia: Fluid inclusion and stable isotope studies: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 157-160. First author at IGEM, Russian Acad. of Sci., Moscow, Russia.

FI studies indicate that the F responsible for formation of the Berezovsk gold-quartz veins was a mixture of $H_2O + CO_2 + N_2 + CH_4$ with minor F, CO and were of moderate sal. Entrapment of heterogeneous F indicates phase separation. T-P conditions are estimated to have ranged from 285 to 295°C and 0.9-1.8 kb. Wide variations of S, O, C isotopes in minerals are inferred to have occurred due to V phase escape. The chemistry and calculated isotopic composition of F are typical of those derived during metamorphism or exsolved from a granite magma. A preferable model suggests that intrusive rocks could have generated the mineralising F. (Authors' abstract)

BOUABDELLAH, M., BROWN, A.C. and **SANGSTER, D.F.,** 1997, Diagenetic versus hydrothermal dolomitization at the Beddiane Mississippi Valley-type lead-zinc deposit, northeastern Morocco (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A15. First author at Dept. of Mineral Engineering, Ecole Polytechnique, P.O. Box 6079, Sta. Centre Ville, Montreal, Quebec H3C 3A7.

The Mississippi Valley-type Beddiane lead-zinc deposit of northeastern Morocco consists of replacements and open-space fillings in a 25 m thick pene-horizontal Aalenobajocian (Middle Jurassic) dolomitic unit. The dolomitic host rocks are classified as 1) pene-horizontal stratiform host-rock dolostones exhibiting three generations of diagenetic dolomite recognized as fine, medium and coarse (FCD, MCD and CCD); and 2) pervasive hydrothermal dolomites of three generations: white hydrothermal dolomite (WHD), saddle dolomite (SD) and ferrodolomite (FD). WHD is a fine-grained replacement dolomite whereas the SD is a coarse-grained open-space filling dolomite with well-developed crystalline faces. The FD replaces both WHD and SD. The paragenetic sequence for the dolomites of the dolostones and the hydrothermal dolomites is FCD->MCD->CCD->WHD->SD->FD.

C, O and Sr isotopes and REEs indicate that FCD formed penecontemporaneously with Middle Jurassic seawater. MCD is interpreted to have formed either at shallow burial depths by F derived from basin compaction or from Middle Jurassic seawater soon after sedimentation. CCD may have formed during burial diagenesis. FI Th and sal and $\delta^{18}O$ analyses indicate that WHD and SD formed from warm brines (average 90°C, average 15 wt.% eq. NaCl). The origin of the FD remains uncertain. WHD and SD form large halos surrounding the numerous lead-zinc deposits of the Touissit-Bou Beker mining district (including the Beddiane deposit) and extending at least 2 km beyond the Beddiane deposit. Consequently, the distributions of WHD and SD are useful in outlining areas of possible hydrothermal lead-zinc mineralization in this important mining district. (From authors' abstract by E.R.)

BOUDREAU, A.E., STEWART, M.A. and **SPIVACK, A.J.,** 1997, Stable Cl isotopes and origin of high-Cl magmas of the Stillwater Complex, Montana: Geology, v. 25, no. 9., p. 791-794. First author at Dept. of Geol., Duke Univ., Box 90227, Durham, NC 27708.

We propose that the early M-extraction event depleted the mantle in F and Cl. Subsequent metasomatism by a Cl-rich agent with a crustal Cl isotopic signature, probably a F, produced a source rock with a high Cl/F ratio. In modern magmas, high Cl/F weight ratios are associated with high overall volatile contents, suggesting that the Stillwater Complex and other high-Cl layered intrusions crystallized from magmas that may have contained in excess of 1 wt.% water. (From authors' abstract by E.R.)

BOULLIER, A.-M., FIRDAOUS, Karima and **BOUDIER, Françoise,** 1997a, Fluid circulation related to deformation in the Zabargad gneisses (Red Sea rift): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 54-55. First author at LGIT-CNRS-BP 53X, F-38041 Grenoble cedex 9, France; email (boullier@obs.ujf-grenoble.fr).

A FI study in relation to textures has been performed on Pan-African granulite-facies gneisses from Zabargad Island (Red Sea rift, Egypt). The gneiss samples were collected at a maximum distance of 60 m above the contact with mantle peridotites with which they are co-structured by a high-T plastic deformation during an isothermal decompression starting from conditions estimated at 35 km depth and 850°C. A first metasomatism of the crustal section during decompression is represented by CO_2-FI trapped at minimum conditions 15 km depth and 800°C. The CO_2-FI planes are controlled in orientation by the high-T plastic flow structures, but have been subsequently deformed during medium-T plastic deformation in quartz.

The second metasomatism is represented by solid-rich aq FI which were trapped at minimum P-T conditions of 3.7 km depth and 450°C corresponding to a very high thermal gradient. They trace the introduction either of sea water or of F resulting from leaching of the Middle Miocene evaporites, within the gneisses during their residence at a shallow depth below sea-floor. These data are discussed in connection with two models proposed in the literature in order to reconstruct the geodynamic history of the Zabargad Island. (From authors' abstract by E.R.)

BOULLIER, A.-M., FIRDAOUS, Karima and **BOUDIER, Françoise,** 1997b, Fluid circulation related to deformation in the Zabargad gneisses (Red Sea Rift): Tectonophysics, v. 279, p. 281-302. First author at Laboratoire de Géophysique Interne et Tectonophysique, C.N.R.S., B.P. 53X, F-38041 Grenoble Cedex, France.

A FI study in relation to textures has been performed on Pan-African granulite-facies gneisses from Zabargad Island (Red Sea rift, Egypt). A first metasomatism of the crustal section during decompression is represented by CO_2-FI trapped at minimum conditions of 15 km depth and 800°C. The second metasomatism is represented by solid-rich aq FI which were trapped at minimum P-T conditions of 3.7 km depth and 450°C corresponding to a very high thermal gradient. They trace the introduction either of seawater or of F resulting from leaching of the Middle Miocene evaporites within the gneisses during their residence at a shallow depth below the seafloor. Two models are proposed in the literature in order to reconstruct the geodynamic history of Zabargad Island. Although it is impossible to date trapping of FI and to know with certainty the origin of the F, our preference is for the second model but slightly modified. The high-T decompression path traced by CO_2-FI, relayed by solid-rich aq I, traces a continuous process of crustal thinning. (From authors' abstract by E.R.)

BOULLIER, A.-M., FIRDAOUS, Karima and **ROBERT, François,** 1997, On the significance of aqueous fluid inclusions in gold-quartz vein deposits in Abitibi (Canada): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 56-57. First author at LGIT-CNRS-BP 53X, F-38041 Grenoble cedex 9, France; email (boullier@obs.ujf-grenoble.fr).

It is now well established that Archean gold-quartz vein deposits have formed from CO_2-bearing, low to moderate sal F. This is reflected by an abundance of CO_2-rich and H_2O-CO_2 FI in the veins. Controversy exists as to the significance of such FI and their link with gold mineralization. They have been regarded as either the product of unmixing from a parent H_2O-CO_2 F of low sal, or as representing late basement brines that have percolated through existing veins. The purpose of this note is to present new FI data that may shed some light on this important problem. We examined FI in a quartz vein within a Proterozoic diabase dyke cross-cutting a gold-quartz veins at the Donalda deposit in the Noranda district in Southern Abitibi belt. This Proterozoic quartz vein provides a sample of the post-ore F that may have overprinted gold-quartz vein deposits.

Only aq F have been found in the late quartz vein and two types of FI have been distinguished. The first type (type 1) is represented by two-phase (L+V) FI characterized by low Te (<-45°C), variable ice melting T (-5 to -33°C) and high Th (>200°C). The second type is represented by two or three-phase (L+V±solid, types 2a and 2b) FI characterized by low Te (<-45°C), highly variable ice melting T (-2.4 to -52.8°C), and low Th by V bubble (type 2a, <130°C) or halite (type 2b, <200°C) disappearance. Using microthermometric data (eutectic, ice melting and halite disappearance) the saturated type 2b I indicate a Ca:Na wt.% ratio around 2.3.

The first group of FI is interpreted as resulting from trapping of hot aq F convecting around the cooling diabase dike immediately after its emplacement. The second type of FI is similar to the low Th aq FI with variable sal encountered in many gold-quartz deposits in Abitibi (references). Considering the Proterozoic age of the studied quartz vein, this type of saline aq F cannot be related to gold deposition in the Donalda deposit and, consequently, in the other gold-quartz deposits in Abitibi. They are rather related to a general phenomena affecting the Archaean Superior Province. They have a chemical composition (Ca-Na-Cl solutions with variable sal) compared to that of brines and groundwaters found in the Canadian Shield (Frape and Fritz, 1987). Consequently, it is proposed that they result from trapping of a melange in variable proportions of cratonic brines which have equilibrated with surrounding rocks for a long time, plus downward percolating fresh waters. (From authors' abstract by E.R.)

BOUZENOUNE, A. and LÉCOLLE, P, 1997, Petrographic and geochemical arguments for hydrothermal formation of the Ouenza siderite deposit (NE Algeria): Mineralium Deposita, v. 32, p. 189-196. First author at Laboratoire de Géologie Appliquée, UPMC, F-75252 Paris Cedex 05, France.

The Ouenza siderite- Pb, Zn, Cu, Ba and F deposit is located proximal to evaporitic diapirs of Triassic age. Stable isotope compositions ($\delta^{18}O$ and $\delta^{13}C$) of iron carbonates and limestones allow estimation of the isotopic composition of the mineralizing F and precipitation T: $\delta^{18}O$=7.5‰ SMOW, T=100-120°C. FI studies of quartz yield sal of 18-22 wt.% eq. NaCl and Th between 150 and 180°C. These values are similar to those of Mississippi Valley type deposits which are associated with basinal brines. (From authors' abstract by E.R.)

BOYCE, Adrian, FALLICK, Tony, WILKINSON, Jamie, EARLS, Garth, CAREY, Paul, MOLES, Norman, PARNELL, John, HUTTON, Donnie, JOHNSTON, Dave and LEGG, Iain, 1997, The identification and role of three fluids in the genesis of a mesozonal gold deposit at Curraghinalt, Northern Ireland: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 161-163. First author at SURRC, East Kilbride, Glasgow, UK.

The origin of structurally controlled, mesozonal gold deposits hosted in quartz veins within metamorphic terrains remains controversial, centering on whether they are related to magmatic or metamorphic events. Using petrographic and geochemical techniques, we have unravelled a complex history of F flow and vein formation during development of the quartz-electrum-polymetallic sulphide vein deposit at Curraghinalt in Ireland. Our results reveal three F to be involved, two of which are related to gold transport. The first F (FI) transports gold and has the geochemical characteristics of a magmatic F. Gold deposition is triggered by mixing with a local pore water of surface derivation (F2). Significantly, the third F (F3) also transports gold, and has geochemical characteristics typical of basin-derived brines. We consider this F to have been introduced during Variscan tectonism, when it was responsible for remobilisation of gold within the deposit. (Authors' abstract)

BRANNON, J.C., LEACH, D.L., GOLDHABER, M.B., TAYLOR, C.D. and LIVINGSTON, Eric, 1997, Radiometric dating of ore-stage calcite from Knight vein, Il-Ky-Fluorspar district, yields 195 MA for both U-Pb and Th-Pb systems (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-209. First author at EPSC Dept., Washington Univ., One Brookings Dr., St. Louis, MO 63130.

Fluorite in the Il-Ky-Fluorspar district occurs as bedded replacement deposits and vein deposits. Blocky white to cream color calcite from Knight Vein, Il-Ky-Fluorspar district is crosscut by clear-gray fluorite establishing that this calcite is paragenetically older than vein fluorite. Although P FI were not observed within the calcite, S FI have sal (~20 wt.%) and Th ranging from 110-140°C. These FI characteristics are consistent with those of P FI found in fluorite in the bedded replacement ore and vein ore within the district.

The ore-stage calcite has been radiometrically dated using two independent isotopic systems. The age obtained from ^{232}Th-^{208}Pb is 194±13 Ma (MSWD-2.3) with an initial $^{208}Pb/^{204}Pb$=39.6±0.2. The age obtained from ^{238}U-^{206}Pb is 195±23 Ma (MSWD=24) with an initial $^{206}Pb/^{204}Pb$=19.9±0.2. This age does not agree with previously determined ages. Chesley et al. (1994) obtained a $^{147}Sm/^{144}Nd$ age of 277±16 Ma for fluorite in bedded replacement deposits. Symons (1994) obtained a paleomagnetic age of 155±10 Ma using bedded replacement fluorite, vein fluorite, near-ore limestone and caprock standstone.

The age of vein mineralization is robustly established by two independent isotopic systems. Although it has been assumed that vein deposits formed at the same time as bedded replacement deposits, the paragenetic relationships between banded fluorite in bedded replacement deposits, the paragenetic relationships between banded fluorite in bedded replacement deposits and non-banded fluorite in the vein deposits has not been clearly established. The discrepancy in ages for mineralization in the district may be consistent with multiple mineralization events or protracted duration of mineralization. (Authors' abstract)

BRATUS', M.D., ZINCHUK, N.N., SVOREN', I.M. and ARGUNOV, K.P., 1997, Gases from Yakutian polycrystalline diamonds: Dok. Akad Nauk, v. 355, no. 1, p. 85-87, (in Russian, translated in Transactions (Doklady) of the RAS/Earth Sci. Sections, v. 355, no. 5, p. 757-759). First author at Inst. of the Geol. and Geochem. of Fossil Fuels, Nat'l. Acad. of Sci. of Ukraine, ul. Naukova 3-A, Lvov, 290053 Ukraine.

The extraction of contents from I was performed by the crushing in the inlet system of an MX-1303 mass spectrometer under high vacuum and normal conditions. After the analysis of extracted G, the crushed rock was vacuumized and heated, and the released gaseous components were analyzed. The composition of G extracted by heating to 1300°C and by crushing, both show major CO_2, CO, N_2, and H_2O and variable but minor CH_4, C_2H_6 and C_3H_8. It should be noted that the crushing of crystals promotes the release of components occurring in a molecular form in tiny vacuoles within grains and interstices. The heating provokes the desorption of separate atoms and radicals (from lattice defects), which react with each other on the outer surface of crystal to form free molecules. Thus, the total sum of G released during heating includes not only free molecules from vacuoles, but also newly formed molecules. (From authors' abstract by E.R.)

BRAUER, N.A., BODNAR, R.J. and LAW, R.D., The PT conditions of solid-state deformation of the Papoose Flat pluton, eastern California: A fluid inclusion and microstructural study: Eos Trans. AGU v. 78 (17), Spring Meet. Suppl., p. S319. First author at Dept. of Geological Sci., Virginia Tech, Blacksburg, VA 24061-0420; email (nbrauer@vt.edu)

Analyses of the FI and microstructures of the Papoose Flat pluton were used to investigate the P/T conditions associated with the transition from magmatic to solid-state deformation. The granodioritic pluton intruded the southwestern limb of the Inyo Mountains in the late Cretaceous. The pluton interior has been divided by previous microstructural analyses into three domains: i) a central core characterized by magmatic microstructures, ii) a middle domain of high T (>500°C) solid-state deformation, and iii) an outermost domain characterized by relatively low T (<500°C) solid-state deformation.

Microstructural analysis of samples from the three domains confirmed the transition from magmatic (core) to solid-state deformation at the pluton's margin. However, weakly developed solid-state microstructures overprint the dominant magmatic microstructures in samples from the magmatic domain. The existence of solid-state microstructures in all three domains indicates that deformation continued during and after crystallization of the pluton's interior. Throughout the pluton, the majority of FI are hosted by deformed grains and have been classified as recrystallization-primary (RP) I. The original P I were either destroyed or modified by several episodes of recrystallization of the quartz and feldspar hosts. Two phase, low sal (<23 wt.% eq. NaCl), L-rich RP aq FI predominate in all samples. Microthermometry yielded wide Th ranges which overlap for all three domains. Coexisting andalusite and cordierite in the contact aureole and the modal composition of the pluton indicate trapping P of 3 to 4.5 kb. The majority of the calculated Tt at P of 3 to 4.5 kb are below the granodiorite solidus of 680°C (300 to 600°C at 4 kb). The low Tt argue for post-crystallization deformation, consistent with microstructural observations.

Two mechanisms are proposed to explain the low Tt. The RP I may have re-equilibrated as the pluton cooled along an isobaric PT path. Re-equilibration from isobaric cooling increases I densities which lowers Th and calculated Tt. All samples yielded wide Th ranges, which argue strongly for re-equilibration throughout the pluton. Modification of I from recrystallization may also account for the low calculated Tt. The combination of these two mechanisms best explains the deformational microstructures and wide range of low Tt of the Papoose Flat pluton. (From authors' abstract by E.R.)

BREITER, Karel, FRYDA, Jiří, SELTMANN, Reimar and THOMAS, Rainer, 1997, Mineralogical evidence for two magmatic stages in the evolution of an extremely fractionated P-rich rare-metal granite: The Podlesi Stock, Krusné Hory, Czech Republic: J. of Petrol., v. 38, no. 12, p. 1723-1739. First author at Czech Geological Survey Praha, Geologická 6, CZ-15200 Praha, Czech Republic.

The Podlesí granite stock in the western Krusné Hory (Erzgebirge) Mountains, Czech Republic, represents an extremely fractionated, strongly peraluminous, F- and P-rich, rare-metal granite system of Late Variscan age. The stock, studied in drill core of 300 m length, is formed by albite-protolithionite-topaz granite ('stock granite', depth 50-300 m) and shows geochemical and textural zoning. The stock granite is rich in P (~0.5 wt.%), F (0.5-1.2 wt.%), Rb (~1000 ppm), Li (500-1000 ppm) and Cs (100-150 ppm), and poor in Ti, Mg, Fe, Ca, Sr, Ba, Zr and rare earth elements (REE). Within the uppermost part of the stock (depth 57-115 m), the stock granite is intercalated with albite-zinnwaldite-topaz 'dyke granite' layers of 0.5-7 m thickness and a few thin flat dykes of pegmatite. The dyke granite and pegmatite are even more enriched in P (~1 wt.% P_2O_5), F (1.0-1.5 wt.%) and Rb (up to 3000 ppm), and are also rich in Nb (up to 100 ppm), and Ta (up to 50 ppm). The chemical data for the rock-forming minerals show distinct differences between the stock granite and the dyke granite and pegmatite. No chemical zoning of the rock-forming minerals, either from the upper, rapidly cooled, or from the lower, slowly cooled parts of the stock granite was observed. These rock-forming minerals formed during only one stage of crystallization from a parental M with moderate contents of P, F, and Li (0.5 wt.% P_2O_5 in K-feldspar, 5-7 wt.% F and 3 wt.% Li_2O in Li-mica). In contrast, alkali feldspars and zinnwaldite from the dyke granite and pegmatite show well-developed chemical zoning. The rims of K-feldspars are strongly enriched in phosphorus (up to 2 wt.% P_2O_5), and rims of zinnwaldite grains are enriched in fluorine (8-9 wt.% F). Both zinnwaldite and topaz from the dyke granite have the OH-F sites fully occuped by fluorine. Also, accessory phosphates were formed during the late magmatic crystallization of the strongly P, F-enriched residual M. Thus, the mineralogical data reflect the presence of two crystallization events within the dyke granite and pegmatite. The presence of two M, parental and residual, the later strongly enriched in phosphorus, has been also confirmed by study of MI in quartz from samples of the stock granite in its dyke-bearing uppermost part. Mineral, MI and whole-rock chemical data from all rock types provide evidence for two stages of granite evolution, namely crystallization from parental and residual M. This means that, in addition to the granites in Beauvoir (France) and Argemela (Portugal), the Podlesí stock is another well-documented example of a two-stage evolution of a P-rich granite system. (Authors' abstract)

BROWN, P.E. and HAGEMANN, S.G., 1997, New data and ideas on Archean gold-bearing paleohydrothermal systems: Geological Society of Australia, Abstracts No. 44, p. 16. First author at Univ. of Wisconsin-Madison, Dept. of Geol. and Geophys., 1215 W. Dayton St., Madison, WI 53706, USA.

Recent detailed investigations of Archean lode-gold deposits suggest that examples of this ore type formed throughout the crust from nearly the surface to the root zone of greenstone belts. Consequently, the gold-bearing paleohydrothermal systems developed under a wide range of P-T conditions from epizonal to mesozonal to hypozonal levels in the crust. Here we examine F sources and possible depositional processes at shallow and deep crustal levels using constraints from: (i) the recently developed Univ. of Wisconsin-Madison laser-based oxygen isotope facility, (ii) combined gas- and ion-chromatography of FI in silicates and sulfides using techniques developed at the Univ. of Toronto, and (iii) experimental studies that show significant H_2O and H_2 diffusion at amphibolite- to granulite-facies conditions.

Laser-based oxygen isotope micro-analysis on quartz-comb crystals from gold-rich ore shoots of the Wiluna lode-gold deposits allow us, for the first time, to map out $\delta^{18}O$ distribution in single (e.g. 1.0 x 0.5 cm) quartz comb-crystals. The light $\delta^{18}O$ F values (as low as -4 per mil) and the large range (up to 6 per mil difference within a single crystal) suggest an important surface water component in the F but also indicate that the comb crystals formed through complex processes such as boiling and/or F mixing. The precise spatial analyses of ^{18}O distribution in growth zones of the quartz combs further allow the interpretation that these processes occurred during the final stages of the complex evolution of the Wiluna paleohydrothermal system. There is no indication that the boiling or mixing of the F induced rapid and widespread precipitation of gold as is known to happen in lower P geothermal environments.

Gas- and ion-chromatography (GC-IC) of FI trapped in pyrite, arsenopyrite and stibnite from the Wiluna deposits provide constraints on the precise G and ion content of the F responsible for the formation of these sulfides. In addition, GC-IC data on I in quartz that is in apparent textural equilibrium with these sulfides show that there is locally a distinct F disequilibrium between silicate and sulfide assemblages. The halogen geochemistry of FI documents an evolution of Br/Cl ratios in the Wiluna paleohydrothermal system and allows comparisons of halogen signatures of Wiluna FI with present day and Archean ocean waters.

New FI data on hypozonal lode-gold deposits such as the Three Mile Hill, Griffins Find and Marvel Loch deposits in the Yilgarn Craton document the widespread occurrence of apparently P methane-rich I. Isochores for these I project to P values as little as half of the P inferred for the mineralization on petrological grounds. Comparison with new experimental data suggests that post-mineralization modification such as hydrogen and/or H_2O diffusion may have selectively effected FI populations.

New analytical techniques such as laser-based stable isotope analysis or GC-IC, in addition to new experimental data on synthetic FI as well as the possibility of analyzing in situ or ultra-small samples (<10 micromole G), reveal a much higher complexity in the evolution of paleohydrothermal F than previously thought. Given the intricacy of processes and probable multiple F sources that supply hydrothermal F in a metal-bearing hydrothermal system, it remains questionable whether unifying genetic models that call on one particular F source (e.g. magmatic or metamorphic F) or process, are able to explain the genesis of Archean lode-gold deposits that occur throughout the entire upper crust of the earth. (Authors' abstract)

BURNARD, Pete, GRAHAM, David and **TURNER, Grenville,** 1997a, Vesicle-specific noble gas analyses of "Popping Rock": Implications for primordial noble gases in Earth: Science, v. 276, p. 568-571. First author at Dept. of Earth Sci., Univ. of Manchester, Manchester M13 9PL, UK.

G trapped in individual vesicles in the volatile-rich basaltic glass "popping rock" were found to have the same CO_2, ^4He, and ^{40}Ar composition, but a variable $^{40}Ar/^{36}Ar$ ratio (~4000 to ≥40,000). The ^{36}Ar is probably surface-adsorbed atmospheric argon; any mantle ^{36}Ar trapped in the vesicles cannot be distinguished from an atmospheric contaminant. Consequently, the $^{40}Ar/^{36}Ar$ ratios and $^3He/^{36}Ar$ ratios (1.45) determined are minimum estimates of the upper mantle composition. Heavy noble G relative abundances in the mantle resemble solar noble G abundance patterns, and a solar origin may be common to all primordial mantle noble G. (Authors' abstract)

BURNARD, P.G., GRAHAM, D.W. and **TURNER, G.,** 1997b, Argon in the mantle: Resolving atmospheric contaminants by laser probe: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 38-39, Lunar and Planetary Inst., Houston. First author at Dept. of Earth Sci., Manchester Univ., Manchester M139PL, U.K.; email (peteb@man.ac.uk)

The isotopic composition of Ar in the Earth's mantle remains poorly constrained. The $^{40}Ar/^{36}Ar$ ratio most commonly used for the upper mantle (UM) is 30,000, based on analyses of volatile-rich basalts. However, due to contamination by atmosphere-derived Ar with a $^{40}Ar/^{36}Ar$ ratio of ~300, these analyses are lower limits to the actual MORB value. The Ar isotopic composition in the lower mantle (LM) is even more contentious because the basalts may have been contaminated by upper mantle volatiles, as well as by atmospheric Ar. Current estimates for $^{40}Ar/^{36}Ar_{LM}$ range between <3,000 and >12,000, although these are largely based on geochemical modeling. The maximum (i.e., least air-contaminated) $^{40}Ar/^{36}Ar$ ratios analyzed in basalts and xenoliths erupted at high- $^3He/^4He$ hotspots are between 2,000 (Loihi) and 20,000 (Samoa).

It has been established that He and Ne abundances and isotopes in the mantle resemble "solar" noble gases that have been implanted into meteorites. It is possible nonradiogenic mantle Ar (i.e., ^{36}Ar and ^{38}Ar) is also "solar" in origin. "Solar" and atmospheric $^{38}Ar/^{36}Ar$ ratios are very similar (0.188 and 0.182 respectively) and it will not be possible to identify nonatmospheric $^{38}Ar/^{36}Ar$ ratios in mantle materials with the present levels of atmospheric contamination. However, $^3He/^{36}Ar$ ratios of "solar" and "planetary" noble gases are distinct (~12 and <0.001 respectively) and can be used to discriminate "solar" and "planetary" abundance patterns.

Like the $^{40}Ar/^{36}Ar$ ratio, $^3He/^{36}Ar$ ratios in mantle samples are also lower limits to the mantle value. $^3He/^{36}Ar$ values suggest that "solar" Ar may be present in the mantle. (From authors' abstract by E.R.)

BUSECK, P.R., GALDOBINA, L.P., KOVALEVSKI, V.V., ROZHKOVA, N.N., VALLEY, J.W. and **ZAIDENBERG, A.Z.,** 1997, Shungites: The C-rich rocks of Karelia, Russia: The Canadian Mineralogist, v. 35, p. 1363-1378. First author at Dept. of Geol. and Chem., Arizona State Univ., Tempe, AZ 85287-1404.

The Lower Proterozoic rocks of the Shunga district near Lake Onega, Karelia, Russia contain large amounts of elemental carbon-about 25 x 10^{10} T in an area of roughly 9,000 square kilometers. Biogenic, metasomatic, and volcanogenic origins have variously been proposed for the carbon in these rocks. Most rocks in a 1200 to 2000 m stratigraphic sequence contain at least several wt.% carbon, and localized areas contain up to 98 wt.% glassy carbon, a most unusual natural form. The authors differ regarding the implications of the carbon-isotopic data. JWV and PRB interpret them as indicating a biogenic origin, either in situ or remobilized during low-grade metamorphism, whereas LPG interprets the field and isotopic data as indicating an abiogenic, volcanic origin. (From authors' abstract by E.R.)

BUSHEV, A.G., KUZ'MIN, V.I., PEN'KOV, V.F., NOVGORODOVA, M.I., BUSLAEVA, E.Yu. and **LOBZIN, E.V.,** 1997, Organic compounds in minerals of the Pamir pegmatites: Geokhimiya, 1997, no. 3, p. 348-352 (in Russian; translated in Geochemistry Internat'l., v. 35, no. 3, p. 299-303). First author at All-Russia Research Inst. of Mineral Resources (VIMS), Staromonetnyi per. 31, Moscow, 109017 Russia.

Elevated contents of highly volatile organic compounds have been established at a number of pegmatite deposits in the Pamir Mountains. The escape of gaseous products with a pungent noxious odor has been noted during sampling of two rare-metal pegmatite veins.

Approximately 70 organic compounds have been identified in minerals of the pegmatite veins and country rock at these deposits. The compounds belong to three groups: aliphatic, aromatic, and heterocyclic hydrocarbons (HCs). The Kukhi-Lal pegmatites with dravite, occurring in magnesian marbles, have the most varied composition of organic admixtures. The Kukkurt pegmatites with topaz and beryl have lower contents of HCs, which are not of such varied types. (From authors' text by E.R.)

CABRI, L.J., 1997, Micro-analytical techniques useful in the evaluation of precious metal ores (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 221-222 (in English), ISBN 5-88918-002-9. Author at Canada Centre for Mineral and Energy Technology, 555 Booth St., Ottawa, Canada K1A 0G1.

A review with 15 references. (E.R.)

CALAGARI, A.A., PATTRICK, R.A.D., BOYCE, A.J., POLYA, D.A., FALLICK, A.E. and **BURNARD, P.G.**, 1997, Stable isotope studies of the porphyry copper deposit in Sungun, East Azarbaidjan, Iran (abst.): Mineral Deposits Study Group Annual General Meeting, Glasgow Univ., 1997, Programme and Abstracts Volume, p. xxx. First author at Dept. of Geol., Tabriz Univ., Tabriz, Iran.

The Sungun porphyry copper prospect involves intrusions into dacite. The Sungun porphyries are cut and displaced by many, mainly normal, faults. The majority of them postdate alteration and mineralization, and hence are barren. Three distinct types of hydrothermal alteration and mineralization are found, (a) hypogene, (b) metasomatic (skarn), (c) supergene.

Hypogene. Four distinct types of hydrothermal alteration assemblages have been recognized: (1) potassic, (2) potassic-phyllic, (3) phyllic, (4) propylitic. Mineralization occurs primarily as disseminations and as fracture and micro-fracture fillings. Pyrite is the most abundant sulfide and chalcopyrite is the most dominant copper ore. There are also minor amounts of molybdenite, bornite, tetrahedrite, and hypogene chalcocite.

Metasomatic (skarn). Alteration and mineralization occurs at the contact of porphyry with limestone. Appreciable amounts of Si, Fe, Mg and S were introduced into the limestone by hydrothermal F resulting in a metasomatic halo in the limestone in which anhydrous (garnet, diopside) and hydrous (actinolite, epidote) calc-silicates along with sulfides (pyrite, chalcopyrite, galena, sphalerite) and oxides (magnetite, hematite) were developed.

FI investigations showed that the incipient F involved in the formation of quartz-sulfide and quartz-molybdenite veinlets and micro-veinlets, in which the quartz crystals are intimately associated with sulfides were very hot (~600°C) and moderately saline (10-15 wt.% NaCl eq.). Boiling caused the residual F to become increasingly saline (up to 50 wt.% NaCl eq.). Multiple boiling events are characterized by the coexistence of G-rich and L-rich I homogenizing at the same T over a wide range. The sal of the F gradually decreased with decreasing T. At T>370°C, the F, upon boiling, did not become saturated with respect to NaCl. However at lower T the boiling caused the residual F to become saturated.

Stable isotopes: S, O, H and C isotope analyses suggest a magmatic sulfur source, $\delta^{18}O$ and δD [from FI] values lie within the range for magmatic water, the $\delta^{13}C$ values suggest that there was almost no magmatic carbon in the hydrothermal system, and the isotopic ratio of helium is relatively high, suggesting a mantle signature, whereas the isotopic ratios of Ar is very low close to the meteoric values. (From authors' abstract by E.R.)

CALVACHE, V.M.L. and **WILLIAMS, S.N.**, 1997, Emplacement and petrological evolution of the andesitic dome of Galeras Volcano, 1990-1992: J. of Volcanology and Geothermal Research, v. 77, no. 1-4, p. 57-69.

Since the reactivation of Galeras volcano in 1988, the emplacement of a lava dome in the main crater of the volcano has been its most significant magmatic activity. The chemical composition of the dome ranges from 59.4 to 61.1 wt.% SiO_2 (anhydrous). The presence of (1) large plagioclase phenocrysts with strongly inversely zoned rims and (2) small euhedral plagioclase crystals with normal zoning and Ca-rich cores indicates that a magma mixing event occurred early in the history of dome emplacement. Large amounts of crystal fractionation then took place. About 70% fractionation can explain the mineral suite and the major- and trace-element compositions of the glasses. The uppermost part of the dome, degassing freely at the surface for ten months, was able to isolate the magmatic system, producing a highly evolved M in the dome interior. The July 1992 eruption tapped not only the uppermost part of the dome but also a deeper H_2O-saturated magma. Analyses from these samples show that most of the H_2O was degassed while Cl and B contents were higher than in the uppermost part of the dome. However, the F content is lower in this deeper part of the conduit, while it increases in the matrix glass of the degassed upper part of the dome. (From authors' abstract by E.R.)

CAMERON, G.H., WALSHE, J.L., HEINRICH, C.A. and **WALL, V.J.**, 1997, Decompression and reconcentration of gold at Porgera: Some general implications for gold deposits: Geological Society of Australia, Abstracts No. 44, p. 17. First author at Australian Nat'l. Univ., Canberra ACT 0200, Australia.

Recent work on the Porgera gold deposit has revealed some rather interesting aspects of the ore forming processes which we feel may be relevant to the general understanding of certain types of gold mineralization.

High grade Au mineralization at Porgera appears to be the result of two spatially and temporally distinct mineralization events referred to as stages I and II. Stage I mineralization resulted in the formation of pyrite, Fe-rich sphalerite, galena and minor pyrrhotite rich vein sets, spatially associated with intrusions, and hosted in intrusions, the surrounding altered sediment and calcareous black shale. The veins carry 10 to 20 g Au/tonne but due to their scattered nature generally do not constitute high grade ore. The F responsible for this mineralization contained about 1 molal NaCl (corrected for CO_2 after Richards and Kerrich, 1993), a minimum of 2 molal CO_2, yields an average Th of about 280°C (Richards et al., op. cit.) and was relatively reduced. Stage II mineralization, which constitutes the bulk of the high grade ore, consists of Au ore hosted in banded quartz and quartz-roscoelite-pyrite-barite breccia veins, which are spatially associated with the mineralization. FI data from stage II quartz yields a bimodal sal at 4.2 and 7.8 wt.% NaCl eq., and an average Th of 145°C (Richards et al., op. cit.). The CO_2 content of these F is extremely variable ranging up to at least 2 molal. High grade ore shoots occur at the intersection of stage I and II veins sets. Quartz and carbonate are intimately intergrown with sulphide but are rarely observed in textural equilibrium with sulphide. We infer that sulphides formed early in stage I and were dissolved during stage II quartz and carbonate precipitation. Munroe and Cox (1996) suggest that the Roamane Fault was not active during stage I, but was the main spatial control upon development of stage II mineralization.

We propose that Porgera evolved initially during stage I within the Pb-Zn rich, moderately distal reaches of a porphyry hydrothermal system, within relatively impermeable host rocks, and under moderately high P. Both Au and base metals were complexed as chloride and deposited through passive boiling of a CO_2-rich moderately saline F at about 280°C. Rupture of the Roamane Fault resulted in P drop and associated throttling and adiabatic decompression of the F, which prematurely ended the stage I hydrothermal system. F that originally deposited base metal sulphide and Au in the early veins, immediately began dissolving both, and simultaneously deposited quartz and carbonate as the F flowed into low P zones along the Roamane Fault. Here the same F further decompressed and continued to deposit barren quartz and lesser carbonate. Decompression also permitted deeper sourced, fresh, oxidized magmatic F to quickly achieve similar levels within the Roamane Fault and mix with the reduced pregnant ore-bearing F. Mixing of the two F at the confluence of stage I and II structures resulted in oxidation of the reduced Au-bearing F and precipitation of the high grade Au-rich quartz-roscoelite layers. That Au was carried in the reduced (rather than the oxidized) F is evidence by the replacement of pyrite by Au within the assemblage quartz-roscoelite-pyrite-barite.

Key elements of this model are the CO_2-rich (high F P) composition of the early F, the impermeable nature of the host black shale (to maintain F P) and its calcareous composition (buffer capacity). Decompression resulted in loss of CO_2 to the V phase which under normal conditions would lead to sulphide deposition due to pH increase. However, stage I F was internally buffered with respect to pH (due to dissolved HCO_3^-, Ca, Fe and Mg) and therefore loss of H_2S and H_2 to V resulted in the dissolution of sulphides and Au respectively. Together, these factors resulted in the remobilization of a significant proportion of the widely distributed stage I Au and its subsequent redeposition (through mixing induced oxidation) in a more concentrated form within a much smaller area.

We propose that the physical parameters necessary for decompression-induced reconcentration of Au are commonly achieved in hydrothermal systems. Many of the Carlin Type deposits have similar characteristics (to those at Porgera) which include calcareous shale host rocks, early widely dispersed disseminated/veinlet-hosted mineralization deposited by early CO_2-rich F and later overprinting more spatially restricted Au-rich mineralization associated with arsenical pyrite within a relatively oxidized assemblage. Other examples might be the large Ashanti Gold mine in Ghana (Mumin et al., 1994) and Kelian in Indonesia. (Authors' abstract)

CAMPRUBÍ, Antoni, CANALS, Àngels, CARDELLACH, Esteve and PROL-LEDESMA, R.M., 1997, Low-sulphidation epithermal Ag-Au deposits of La Guitarra (Temascaltepec, Mexico): in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 165-168. First author at Departamento de Cristalografía, Mineralogia i Dipòsits Minerals, Universitat de Barcelona, Spain.

La Guitarra is a polymetallic and multi-stage, low-sulphidation epithermal vein system belonging to the Taxco-Guanajuato silver belt. Stage-I F show the following compositional ranges: sal from 5 to 14 wt.% NaCl eq.; T from 162 to 212°C; $\delta^{18}O_{water}$ from +1.2 to +5.2‰. Stage-II (Ag-bearing stage): sal from 4 to 5 wt.% NaCl eq.; T from 164 to 210°C; $\delta^{18}O_{water}$ from +0.4 to +5.4‰. These data point to a mixing process between F of meteoric and magmatic origin as the main mechanism of vein formation. (Authors' abstract)

CANALS, A., CARDELLACH, E. and MARTINEZ, F.J., 1997, Fluids associated to the Vivero fault (NW Spain): Microthermometric and Raman data: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 58-59. First author at Dept. de Cristal.lografia, Mineralogia i Dipòsits Minerals, Univ. de Barcelona, Spain; email (angels@natura.geo.ub.es).

A microthermometric and Raman spectroscopic study in FI has been undertaken in some selected quartz veins in order to determine: 1. The P-T conditions of the trapping of F and to compare them with the P-T recorded by the mineral assemblages of the metamorphic host rocks, and 2. The bulk composition of the F in order to know the possible link between it and the host rock lithology.

Four types and a wide range of compositions of FI were found: 100% CO_2., 100% N_2, 90% CH_4 and intermediates; sal 3-24%, Th 100-500°C, mainly 250-300°C. (From authors' abstract by E.R.)

CANDELA, P.A., 1997, A review of shallow, ore-related granites: textures, volatiles, and ore metals: J. of Petrology, v. 38, no. 12, p. 1619-1633. Author at Laboratory for Mineral Deposits Research, Dept. of Geol., Univ. of Maryland at College Park, College Park, Mineralium Deposita, v. 20742-4211.

A review. (E.R.)

CAO, R.-L. and ZHU, S.-H., 1997, The mantle fluid and metallogeny of super-giant mineral deposits (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 86 (in English), ISBN 5-88918-002-9. Authors at Guangzhou Inst. of Geochem., Chinese Acad. of Sci., Guangzhou, China 510640.

[In] recent years a mantle F metasomatic ore deposit was discovered in China by the authors. The Bayan Obo in Inner Mongolia, northern China, is the world's largest known rare earth elements (REE) ore deposit. In view of the overall low Sr isotopic ratios of REE minerals, the metallogenetic elements, REE and Nb, etc., are thought to be derived from mantle source. The carbon and oxygen within the REE fluorocarbonate minerals are composed of mantle C and O; meanwhile, the sulphur in the associated sulphide belongs to meteorite S, suggesting that the ore-forming solution was not the hydrothermal brine from crustal source, but would be the mantle F that has never been documented in the classical works of economic geology and traditional metallogeny.

The W-Sn-polymetallic super-giant ore deposits in southern China have been usually considered as mineralization in relation to granitoids. However, the characteristics of abnormal enrichment in F and Li, as well as multi-members of source bed for the metallogenetic elements have shown the information about deep-source F activities. It is suggested that the mantle F would be responsible for the metallogeny of such type super-giant ore deposits in two folds. It could remobilize the so-called "crustal source metallogenetic elements," such as U, Sn, Au, W, Mo, Pb and Zn, etc. from various source beds. On the other hand, the mantle F would enrich the diverse crustal rocks in volatile and fusible components, triggering granite magmatism. (From authors' abstract by E.R.)

CAPASSO, Giorgio, FAVARA, Rocco and **INGUAGGIATO, Salvatore,** 1997, Chemical features and isotopic composition of gaseous manifestations on Vulcano Island, Aeolian Islands, Italy: An interpretative model of fluid circulation: Geochim. Cosmo. Acta, v. 61, no. 16, p. 3425-3440.

CARIGNAN, J., GARIÉPY, C. and **HILLAIRE-MARCEL, C.,** 1997, Hydrothermal fluids during Mesozoic reactivation of the St. Lawrence rift system, Canada: C, O, Sr and Pb isotopic characterization: Chemical Geol., v. 137, p. 1-21. Authors at GEOTOP and Dépt. des Sciences de la Terre, Univ. du Québec à Montréal, P.O. Box 8888, Sta. Centre-ville, Montréal, Qué.

The mineral assemblages, paragenesis and precipitation T of the veins resemble the Mississippi Valley deposits, but the data exclude the basin brine model of formation for the vein deposits. The veins rather formed in the Mesozoic, in response to the rifting of northeastern North America and the reactivation of the St. Lawrence rift. (From authors' abstract by E.R.)

CARPENTER, R.L., 1997, Significance of partial melt textures in mantle xenoliths: An example from the Hessian Depression, Germany (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A23. Author at WMC Internat'l. Ltd. (Americas Div.), 22 Gurdwara Rd., Nepean, ON, K2E 8A2.

Partial M textures of clinopyroxene and Cr-Spinel are well developed in anhydrous Fe-Ti metasomatisized Group 1 mantle xenoliths from the Hessian Depression, Germany. Melting has produced a spongy/porous, FI rich structure optically continuous with unmelted host grains. The FI rich spongy M textures are interpreted as a modal metasomatic feature formed in the mantle due to interaction with a proximal magma conduit or rising silicate M. Heat and volatile rich F derived from the magma promoted partial melting of clinopyroxene and Cr-spinel. Experimental studies have shown that such F can substantially leach Na and Al from the mantle and also reduce the solidus T and facilitate partial melting under mantle conditions. Xenoliths from the Hessian Depression less affected by Fe-Ti metasomatism show only weak development of spongy M texture and are interpreted to represent mantle wall rocks comparatively distal from magma conduits or silica M. (From author's abstract by E.R.)

CARTIGNY, P., BOYD, S.R., HARRIS, J.W. and **JAVOY, M.,** 1997, Nitrogen isotopes in peridotitic diamonds from Fuxian, China: The mantle signature: Terra Nova, v. 9, no. 4, p. 175-179.

CARTWRIGHT, Ian, BUICK, I.S. and **HARLEY, S.L.,** 1997, Timing and mechanisms of carbon isotope exchange in granulite-facies calc-silicate boudins, Rauer Group, East Antarctica: Amer. Mineral., v. 82, p. 392-404. First author at Victorian Inst. of Earth and Planetary Sci., Dept. of Earth Sci., Monash Univ., Clayton, Victoria 3168, Australia.

Diffusion of carbon isotopes probably occurred synchronous with the post-peak metamorphic mineral reactions. At that time, centimeter-scale diffusion would have been facilitated by the presence of the F, while isotopic exchange between the minerals and the F would have been promoted by recrystallization. The calculated timescales may reflect the time over which metamorphic recrystallization occurred and a reaction-enhanced porosity was present. (From authors' abstract by E.R.)

CASSIDY, K.F. and **HAGEMANN, S.G.,** 1997, The granitoid-hosted Westonia gold deposit, Yilgarn Craton, Western Australia: Evidence for Archean lode gold mineralisation synchronous with the final stages of cratonisation: Geological Society of Australia, Abstracts No. 44, p. 20. First author at Australian Geological Survey Organisation, Canberra, 2601, Australia.

Gold mineralisation is localised in a series of quartz-rich veins within a broad shear zone in the Edna May Gneiss and its contact zones with mafic-ultramafic amphibolites. The ore zones comprise (1) Type 1a 'foliation-parallel' veins: narrow variably deformed quartz-bearing veins and zones of intense metasomatism oriented parallel to the dominant gneiss fabric, and characterised by recrystallised granoblastic textures; (2) Type 1b 'foliation parallel' veins: narrow quartz-diopside-bearing veins typically (sub-) parallel to the gneissic fabric and characterised by unstrained textures; and (3) Type 2 Quartz Reefs: laminated to massive thick quartz-rich reefs that form broad antiformal structures which cross-cut the foliation and have a pseudo-pegmatitic texture. Textural relationships suggest Type 1a veins formed early in the deformation sequence, whereas Type 1b veins and Quartz Reefs developed syn- to post-peak metamorphism and late in the deformation sequence.

Metasomatic assemblages associated with Type 1a veins are typically of low-variance and comprise one or more of the following minerals: quartz, K-feldspar, plagioclase, biotite, muscovite, sillimanite, cordierite, amphibole, diopside. Hydrothermal alteration associated with Type 1b veins in the Edna May Gneiss and mafic amphibolites comprise a dominant quartz-diopside-titanite ±K-feldspar-rich assemblage in veins, a diopside-hornblende ±plagioclase ±K-feldspar assemblage on vein margins, and plagioclase-biotite-hornblende ±K-feldspar assemblage in the wallrock. The Quartz Reefs are composed of quartz with subordinate K-feldspar, plagioclase, biotite, diopside, hornblende, and minor muscovite. Hydrothermal wallrock alteration associated with the high-grade Quartz Reefs in the Edna May Gneiss is limited to development of biotite and pyrrhotite. All vein types and wallrock contain pyrrhotite and ilmenite, minor pyrite, chalcopyrite, galena, and trace scheelite, wolframite and molybdenite.

Preliminary microthermometric investigations on FI hosted in Type 1b 'foliation-parallel' veins and Type 2 Quartz Reefs, and spatially related to gold mineralisation, are of three P types: (1)H_2O-NaCl±halite I of moderate sal (mean 15.2±5.1 [1σ] eq. wt.%NaCl), containing a mean of 31±18 (1σ) mol.% CO_2, and molar volumes with a mean of 32±10 (1σ) cm^3, (2b) CO_2-CH_4 I with minor amounts of CH_4 (mean 13±5 [1σ] mol.%), and molar volumes with a mean of 52±2 [1σ] cm^3, and (3) CH_4 I containing minor amounts of CO_2 (<10 mol.% CO_2). Mass balance calculations indicate the addition of Si, K, Rb and S from the ore F, and an ore element association of Au, Ag, W, Mo, Cu, Pb±Bi. Mineral equilibria studies on low-variance Type 1a vein and high variance Type 1b and Type 2 vein assemblages indicate P-T conditions of formation of 650°±50°C at ≈4 kbar, respectively. Quartz-diopside oxygen-isotope geothermometry gives T from 590 to 615°C for Type 1b veins in mafic amphibolites. Using the mineralisation T of 600°C and isochores calculated from Type 2 I, P of about 4±2 kbar are obtained. Ore and alteration assemblages poorly constrain $X(CO_2)$ to within the broad range of $0.05<X(CO_2)<0.50$, but importantly indicate a value of fO_2 such that CO_2 would be the dominant carbonic phase in the F. A magmatic and/or metamorphic origin for the ore F is suggested by stable isotope analyses on quartz, diopside, hornblende and biotite which indicate a $\delta^{18}O$ ore F composition of 7.3 to 8.9‰ (n=19) and a δD ore F composition in the range from -63 to -29‰ (n=8).

In combination, structural, mineralogical, textural, FI, stable isotope and thermodynamic studies indicate that mineralisation was synchronous with peak to slightly post-peak metamorphism and likely has a mixture of magmatic and metamorphic F. Preliminary interpretations suggest that the major crustal F flow responsible for gold mineralisation at Westonia was related to partial melting and intrusion of granitoids and high-grade metamorphism within the more deeply exposed segments of the Yilgarn Craton at ca. 2640 Ma. (From authors' abstract by H.E.B.)

CASTLEBERRY, Laura and **HEUMANN, Rebecca,** 1997, Late Proterozoic or Paleozoic (?) hydrothermal veins in the Adirondack Highlands, NY.; fluid inclusion and mineralogical assessment (abst.): Geological Society of America, Abstracts with Programs v. 29, no. 1, p. 36.

CATHELINEAU, Michel, BANKS, David, AYT OUGOUGDAL, Mohammed, PIRONON, Jacques, BOIRON, M.-C., DUBESSY, Jean and **YARDLEY, Bruce,** 1997, Fluid mixing during brine and oil migration in the Rhine Graben (Soultz deep drilling) at the basement-sedimentary cover contact: New fluid chemistry data: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 60-61. First author at CREGU and EP 578, BP 23, 54501, Vandœuvre-lès-Nancy Cedex, France; email (cathelin@cregu.cnrs-nancy.fr).

The Triassic sandstones and their underlying granitic basement of the Rhine continental rift basin near Soultz, France, drilled as part of the European HDR project, have experienced extensive F migration since the Oligocene. Thus, a detailed microthermometric and crush-leach analysis of I F has been carried out on the most recent vein fillings cross-cutting the silicified sandstones, and the granite.

The sequence of F trapping is the following:

i) P aq I in quartz overgrowths, which display sal around 7-10 wt.% eq. NaCl and Th in the 120-130°C range; ii) S aq I in FIP cross-cutting the quartz overgrowth veinlets. F observed in healed microcracks have a sal in the 17-20 wt.% eq. NaCl range and Th between 150 and 190°C. Hydrocarbon compounds are sometimes detected; iii) P and PS FI in barite veins cross-cutting the cemented sandstones. In the barite both aq FI and hydrocarbon rich I are found. Their textural relationships (heterogeneous HC/water ratios) could indicate the trapping of a two phase F. Aq FI display a rather wide range in Tm ice from -1 to -8°C, and Th similar to the present day T (115-130°C).

Hydrocarbon I are scattered in barite crystal among the aq P FI. They have been distinguished thanks to observations under UV illumination. They are biphase I and sometimes contain bitumen. The V phase is highly variable in the 40-80 vol.% range. The Tm of hydrocarbon phase is around -70°C which indicate that hydrocarbons are mostly nonane-octane equivalent species. Infrared spectroscopy has been carried out on the different FI phases (L, V and solid). Analyses of L and V phases confirm the presence of aliphatic hydrocarbons containing 6 to 8 carbons. This estimation has been obtained by calculation of the CH_2/CH_3 area ratio. Traces of CH_4 have been detected in V phase. IR spectra of the solid phase show the presence of aliphatic CH (corresponding to alkyl chains with 8 to 16 carbons), aromatic CH and OH groups. CO_2 is detected in all I phases.

The overall examination of the data obtained on the late barites (devoided of hydrocarbon I) in the basement and its sedimentary cover shows that they contain aq FI displaying a rather narrow range of sal around 9-12 wt.% eq. NaCl, and are trapped under T similar to the present day T. Investigation of the F chemistry has been done on the late barites using crush-leach techniques. Results show

–a regular increase of the Na/K ratio with depth, e.g. with increasing T. The values range from 8 to 25 and bracket the ratio of the present day F;

–a relatively wide range of Br/Cl ratios from 0.003 to 0.008 indicating the contribution of a Br enriched end-member in F percolating the sediments. Such values are higher than those of the present day reservoir F;

and –Na/Li ratios around 25/40, slightly lower than those of present day F.

The large variations in Cl contents among the studied F suggest a mixing process between convected low sal F (<5 wt.% eq. NaCl) and brines resulting from the dissolution of salts in Triassic formations. This is indicative of active F movement between the sedimentary formation, the basement, and the surface, and incomplete or heterogeneous mixing processes.

The fracture system in the Soultz granite and its cover rocks have acted as a pathway for flows of different sal F at different times, evolving toward compositions similar to those present at depth today. However, the Tt of the dilute F is not significantly lower than that of the higher sal F, suggesting that the different F types enter the flow system at an early stage, on the downflow path from sediments into granite. The diversity of F compositions is not the result of mixing of deep, saline waters with shallow, dilute ones. (From authors' abstract by E.R.)

CENDÓN, D.I., AYORA, Carlos and **PUEYO, J.-J.,** 1997, The origin of barren bodies in the Subiza potash deposit, Navarra, Spain: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 62-63. First author at Inst. de Ciencies de la Terra (Jaume Almera), CSIC, Barcelona, Spain.

Sylvite-depleted bodies are commonly found when mining potash deposits. Most of them have been interpreted as being formed by selective dissolution of sylvite by the circulation of diagenetic or later F (Korenevskii, 1989). Contrary to the commonly favored post-depositional interpretation, the barren bodies of the Subiza mine have been interpreted as being formed by synsedimentary processes. This genetic idea is also strongly supported by the study of FI trapped in halite from different locations in the Barren Bodies, Lower Halite Unit and Sylvite Member. All FI studied are found in cloudy halite, form bands parallel to the cube faces, and have been considered as P.

The major solutes in individual FI have been determined by means of X-ray microanalysis. A description of the analytical method is found in Ayora et al. (1994). Regardless of the location of the sample, the analyses are very close to sylvite saturation in all cases. This concurs with the presence of trapped crystals of sylvite in some FI from different locations. The I have a Mg-K-Cl-rich composition, which perfectly matches the solute content expected from the evaportion of a brine in a basin with major seawater recharge. Both the trapped sylvite crystals and the solute content in FI correspond to a P brine and differ greatly from the Na-Cl rich brines expected from a post-depositional replacement process. (From authors' abstract by E.R.)

CEPEDAL, A., MARTIN-IZARD, A., FUERTES, M. and **PEVIDA, L.R.,** 1997, Fluid inclusions on quartz, garnet and pyroxene from the "El Valle" copper-gold deposits (Asturias): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 64-65. First author at Dept. of Geol., Univ. of Oviedo, 33005 Oviedo, Spain.

The deposit is associated with skarns from a post-orogenic calc-alkaline igneous body which intruded U. Cambrian carbonates. The calcic skarn consists of wollastonite in contact with marble, and grossular-andradite garnet. The magnesic skarn consists of forsterite and diopside pyroxene, frequently rich in organic matter (black skarn).

The study was undertaken on more than 330 FI in the garnet and pyroxene of the calcic and magnesic skarn and in quartz from veins cutting the granodiorite and skarns. Five different types of I were found:

–Type I: FI rich in dm in garnet and pyroxene. The solid phases are KCl>NaCl>probably anhydrite±calcite>probably a sulfide mineral. These occupy between 60 and 80%, distorting the V phase which occupies between 10 and 20%. The aq phase is scarce and the ice melting T could not be measured. The sal, based on the dissolution T of dm, is about 40 wt.% KCl and 45 wt.% NaCl; Th=580-610°C.

–Type II: H_2O-CO_2-NaCl PFI in quarz. Tm ice, where measurable, was generally close to Te for the NaCl-H_2O system. The sal measurements, based on final clathrate melting, range between 1.02 and 3.15 wt.% eq. NaCl, and Th vary from 240 to 358°C.

–Type III: H_2O+NaCl+$MgCl_2$ I in quartz which cuts a magnesic skarn altering the pyroxene to amphibole. Tm ice lies between -30.0 and -33.0°C, near Te for the H_2O+$MgCl_2$ system, and sal=62-9.2 wt.%. The most frequent sal measurements range from 6.2 to 9.2 wt.% eq. NaCl. Two subtypes have been distinguished. The first subtype (presumably P) has Th between 345 and 369°C. The second subtype has Th between 150 and 165°C, and is interpreted as PS or S.

–Type IV: H_2O+NaCl FI in quartz. This is the most abundant type of I found and may be P or S. Sal=3.25 to 4.5 wt.% NaCl eq.; Th=180 to 195°C or 120 to 165°C. These I often show metastability during freezing studies, and the final ice melting T were sometimes measured above +0°C.

–Type V: Mixed S salt FI in quartz. Tm ice=-50 to -70°C; Th=53 to 1091°C.

The microthermometric data show the evolution at least of two hydrothermal events. The first is a metasomatic process related to a magmatic F which was trapped at minimum T of 580 and 620°C. This F evolved into two unmiscible F: one CO_2-rich which emigrated toward the upper areas, and the other aq low sal F. The most frequent Th of both F range from 270 to 360°C. Other I show Th lying between 180 and 195°C, and between 120 and 165°C, suggesting a late epithermal event overprinting skarn mineralization. Type V is believed to represent later meteoric F. (From authors' abstract by E.R.)

CESARE, B., SALVIOLI MARIANI, E. and **VENTURELLI, G.,** 1997, Crustal anatexis and melt extraction in the restitic xenoliths at El Hoyazo (SE Spain): Min. Mag., v. 61, p. 15-27. First author at Dipto. di Mineralogia e Petrologia, Univ. di Padova, Corso Garibaldi 37, 1-35137 Padova, Italy; email (bernardo@dmp.unipd.it).

The dacite of El Joyazo contains abundant metapelitic xenoliths. these can be divided in two main types: garnet-biotite-sillimanite, and spinel-cordierite. In the xenoliths, the widespread occurrence of rhyolitic glass as interstitial films, foliation-parallel layers and PMI in all mineral phases indicates that these mineral assemblages developed in the presence of a M phase, i.e. during anatexis. The composition of interstitial glass is comparable to that of the MI, suggesting that M was locally produced. Phase equilibria indicate that anatexis occurred at P-T conditions of 850±50°C and 5-7 kbar.

Mass balance calculations based on the chemical composition of the interstitial glass and MI in minerals, the bulk xenoliths and representative samples of potential pelitic sources support a model wherein the xenoliths represent restites after the extraction of 30/50 wt.% M from graphitic metapelite protoliths. (Authors' abstract)

CESARETTI, N.N. and **DOMINGUEZ, E.,** 1997, Fluid inclusions and porosity in Pozo Escondido, Yacoraite formation: Diagenetic and oleogenetic indicators: Revista de la Asociación Geológica Argentina, v. 52, no. 3, p. 361-378 (in Spanish, Engl. abst.). Authors at Dpto. de Geología, Univ. Nacional del Sur, San Juan 670, 8000 Bahía Blanca, Argentina; email (ghcesar@criba.edu.ar).

Hydrocarbon and saline FI were studied in quartz and anhydrite cements and overgrowths in the upper chalk and sandstone sections of the Yacoraite Formation, Lomas de Olmedo second order basin. The analyzed samples were taken from the drill holes in Pozo Escondido oil field: PE x-1, e-2, e-4 and PEE x-1. Lomas de Olmedo basin starts with a rift emplacement in the Early Jurassic. In late Jurassic-Early Cretaceous, the basin grows recording fluvial deposits associated with minor volcanics in a environment of extensional faulting. The main basin subsidence occurs during Cretaceous; at this time, the rocks of the Yacoraite Formation were deposited. Clastic continental and evaporitic sediments were formed at the end of this basin history. Tertiary and Quaternary folding, faulting and uplift are also recorded. Sandstone and carbonate porosity evolution was studied. Primary, intergranular, moldic and vuggy porosity was reduced by authigenic quartz overgrowths and cementations of anhydrite and bitumen. Porosity was increased by dolomitic re-emplacement and fracturing. High selective porosity conservation was caused by the amount of pore F in some sandstones layers. A mature mesogenesis was reached according to the textures and 10 to 20% selective porosity values. A direct ratio was found between actual porosity, FI abundance and extractable organic matter. Paraphinic and asphalt hydrocarbon FI were recognized by their light blue and yellow-greenish fluorescence colours. Reddish asphalt FI with low cloudy points predominate in the stratigraphically lower levels; by contrast light hydrocarbons with high cloudy points, propane, ethane and methane are found in the FI coming from upper levels. A brine composed by NaCl- $MgCl_2$ -Na_2SO_4- $NaHCO_3$ and Na_2CO_3 was the diagenetic formation water (17% NaCl eq. sal). Based on FI, 121-137°C, with an anomalous value of 154°C was the interval of T reached during diagenesis. The analyzed samples fall in the oil and gas generation window. The amounts of TOC (total organic carbon) and EOM (extractable organic matter) define a source and reservoir rock in the upper chalk section and a reservoir rock in the upper sandstone section. The diagenetic evolution indicates that a hydrocarbon (oil) was present from an early diagenetic stage and persists today. An increase in burial depth is correlated with an increase in the T and P in the pore F. This fact produces maturation of organic matter in the carbonatic section, generating CO_2 and carboxyl which in turn caused carbonate dissolution and anhydrite and dolomite precipitation. In the upper sandstone section the fractionated maturation resulted in bitumen filling the pores and S fluorescent asphalt FI in microfractures of quartz. These microfractures were the hydrocarbon migration pathways. (Authors' abstract)

CHABIRON, Aliouka, ALECHINE, Alexei, CUNEY, Michel, GOLUBEV, Viatcheslav, VELICHKIN, V.I. and **POTY, Bernard,** 1997, Composition of melt inclusions in the rhyolites of the Streltsovka uranium ore field (eastern Transbaikalia, Russia) as indicators of magma specialization: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 66-67. First author at Centre de Recherche sur la Géologie des Matières Premières Minérales et Energétiques & EP-CNR-CREGU 0578, BP 23, 54501 Vandœuvre lès Nancy, Cedex, France.

The Mo-U deposits of Streltsovka caldera are the largest uranium field associated with volcanics in the world. About 20 U-Mo deposits have been discovered. They were formed immediately after volcanic activity. All the rocks, volcanics and granites, are deeply altered by hydrothermal F and their original chemistry is strongly modified, especially the P uranium concentrations.

Several samples of rhyolites from Tulukuiev and Krasny Kamen open pits were investigated. Magmatic I compositions have been studied before and after rehomogenization. Non-homogenized M I trapped in quartz phenocrysts of rhyolites were investigated by scanning electron microscopy and electron-microprobe. Specific analytical conditions were used to avoid alkali loss during microprobe analysis. Four types of trapped minerals were identified by electron-microprobe: quartz, Li- and F-rich mica (zinnwaldite to polylithionite), fluorite, and a REE fluo-carbonate (probably parisite). The Tulukuiev glass before rehomogenization showed SiO_2 69.79±1.70, F 1.96±0.20, and Cl 0.20±0.05. The average composition of Krasny Kamen glasses before rehomogenization was very similar except for F 0.61±0.40. Subsequently, the magmatic I have been rehomogenized in an oven about 850°C±15°C and at 1 bar. After rehomogenization both glasses show more Si, Ca and F, from dissolution of dms (F now 2.40±0.50 and 1.54±0.70, respectively). U-content of the silicate M has been determined by fission track analysis using glass standards for calibration. U-concentrations varies from 13.4 ppm to 23.6 ppm with an average of 17 ppm (±4) in the Tulukuiev glasses and present rather constant compositions (22 ppm±2) in the Krasny Kamen glasses. (From authors' abstract by E.R.)

CHALOKWU, C.I., GHAZI, M.A. and **FOORD, E.E.,** 1997, Geochemical characteristics and K-Ar ages of rare-metal bearing pegmatites from the Birimian of southeastern Ghana: J. of African Earth Sci., v. 24, no. 1-2, p. 1-9. See FIR v. 27, p. 21 (E.R.). See FIR v. 27, p. 21 (E.R.).
Indexed under FI (E.R.)

CHANG, Hailiang, 1997, The characteristics of fluid inclusions in the Ashele No. 1 copper-zinc deposit, Xinjiang, China: J. of Geol. and Mineral Resources of South China, 1997, no. 3, p. 23-32. Author at Yichang Inst. of Geol. and Mineral Resources, Yichang Hebei province, China 443003.

Ashele deposit is one of the biggest volcanic rock hosted massive sulfide deposits (VHMS) in China. After the deposition of the sulfide, later metamorphism overprinted the region. The FI from these two geological events have been distinguished. From the hydrothermal sedimentation stage, there are L I and one-phase L I with Te range from -48 to -28.3, sal from 6.0 to 6.9 wt.% NaCl, and Th ranges from 142 to 212°C. FI in the later metamorphic stage are CO_2-H_2O, L I, with Te, about 57.0°C, sal of 9.5 to 12.6 wt.% NaCl, and Th ranges from 170 to 270°C. The composition of these two F is different; the F in metamorphic stage is more rich on CO_2 and higher sal. (Abstract courtesy of H.-Z. Lu)

CHANG, Hailiang and **HUANG, Huilan,** 1997, Characteristics and origin of melt-fluid inclusions: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 3 (in English). Authors at Yichang Inst. of Geol. and Mineral Resources, Yichang, 443003.

There exists a mix-up in the terminology of "melt-fluid inclusion." In this paper the authors discuss the connotation of M-FI and demarcate that only the anomalous I simultaneously captured which the silica M and F (H_2O, CO_2, etc.) in an immiscible M-F system may be called "melt-fluid inclusion;" and those should be called MI which consist presently of silica M and F but only a M phase was captured during the I were trapped [sic]. Taking the I in topaz from the Jianfengling pegmatoid for an example, the authors describe in this paper the characteristics of the M-FI. (Authors' abstract)

CHANNER, D.M.DeR., de RONDE, C.E.J. and **SPOONER, E.T.C.,** 1997, The Cl^-–Br^-–I^- composition of ~3.23 Ga modified seawater: implications for the geological evolution of ocean halide chemistry:

Earth and Planetary Sci. Letters, v. 150, p. 325-335. First author at Dept. of Geol., Earth Sci. Centre, Univ. of Toronto, 22 Russell St., Toronto, Ont., M5S 3B1 Canada.

FI leachates obtained from vug and vein quartz samples from an Archean (~3.23 Ga) Fe-oxide hydrothermal deposit in the west-central part of the Barberton greenstone belt, South Africa, were analyzed by ion chromatography for chloride, bromide, and iodide. The deposit, known as the ironstone pods, formed by seafloor hydrothermal activity and F discharge. Quartz is dominated by type I L-V, aq I with a bimodal sal distribution (0-0.25 M_{Cl^-} and 0.9-1.8 M_{Cl^-}). Bulk analytical sal range from 0.45 to 0.99 M_{Cl^-} and represent averages of type I inclusions. Bulk FI bromide and iodide concentrations are 1.44-3.32 μM and 0.01-0.12 μM, respectively. For comparison, modern seawater has halogen contents of 590 μM chloride, 0.9 μM bromide, and 0.5 μM total iodine. In the F from the ironstone pods, bromide and iodide are enriched relative to chloride, when compared with modern seawater.

Approximate Br^-/Cl^- and I^-/Cl^- ratios of 3.2 Ga Barberton seawater are 2.5×10^{-3} and 40×10^{-6}, respectively. Dispersion to higher values was caused principally by reaction with organic sediments whose trends are similar to those seen for modern vent F at unsedimented and sedimented ridges, relative to modern seawater. These halide ratios are greater than those of modern seawater, suggesting a change in the halide ratios of seawater over geological time. The analytical data are consistent with a model in which marine organic sedimentation has fractionated bromine and iodine out of seawater relative to chloride, thereby causing the halide ratios of seawater to decrease from high early and mid-Archean values toward their present day values. (Authors' abstract)

CHAREF, Abdelkrim, SHEPPARD, S.M.F. and ABBES, Ali, 1997, Halite, anhydrite and barite from the Triassic salt domes of north Tunisia: Nature of fluid inclusions and genetic implications: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 68-69. First author at INRST, BP 95, 2050 Hammam-Lif, Tunisia.

In 1995, ≥20 m of halite and more than 40 m of anhydrite were cored (using saturated salt solution drilling F) in the diapir at Fedj-el-Adoum. From optical and microthermometric studies, several different generations of FI have been identified in halite, massive anhydrite and barite. FI are moderately abundant in halite and anhydrite, and very abundant in barite. Because these minerals and their I are easily modified, step heating and cooling data were only accepted as probably being valid [and] the value did not change with time and no changes were observed on returning to room T, and the dispersion of the measurements was limited. For Th measurements, samples were not heated to higher values to avoid deformtion. No problems were observed with I of monophase L CO_2 or CO_2-H_2O-NaCl with $V_{H_2O}/V_t \leq 0.3$. For other types of I, about 10% gave both reproducible results and no metastability problems. About 20% of the halite samples showed evidence for leakage, necking down and/or metastability but these processes were very rare in anhydrite and barite.

FI in halite, anhydrite, and barite show a wide range of compositions, including monophase CO_2L, various CO_2-H_2O-NaCl, hydrocarbons, and halite and sylvite dxls. Th ranged from 190-260 (halite) 121-210 (anhydrite), and 187 to >337 (barite). The CO_2 has N_2, CH_4 or H_2S present. The FI in halite are believed to be from recrystallization.

Based on the relative chronology of the neoformed minerals and their P and S I, and the P and S I in halite and its cap rocks, several pulses of hot (≈365°, ≈260°, ≈160°, ≈145°, ≈105°, and ≈65°C) F of quite variable composition (dominated by one or more of the constituents H_2O, CO_2, N_2, NaCl, KCl, hydrocarbons) circulated within the salt formation and its subsequent diapir and cap rock system. Because the I in halite, anhydrite and barite are later than the P I in the neoformed minerals, the T of the pulsations initially decreased to at least 145°C and then increased to 200 to 250°C during the late high P event. Thermal events at 110° and 70°C associated with the two major Zn-Pb mineralizations are considered to be later than the high P event. (From authors' abstract by E.R.)

CHAZALLON, B., CHAMPAGNON, B., PANCZER, G., PAUER, F. and KUHS, W.F., 1997, Micro-Raman analysis of air-inclusions in ice cores: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 70-71. First author at Laboratoire de Physico-Chimie des Materiaux Luminescents, UMR 5620, Univ. Claude Bernard LYON1,43 Boulevard du 11 novembre 1918, 69622 Villeurbanne Cedex, France; email (chazallon@silly.uni-mki.gwdg.de)

During the densification process of snow into ice, air bubbles are captured in polar glacier ice. Due to the high hydrostatic P at several hundred meters depth, these air I are converted in air hydrate crystals (clathrate) which are recovered from the ice cores. The analysis of the gas trapped in the ice can in principle be used to reconstruct the earth's paleoatmospohere over the last 100,000-300,000 years. In fact the occurrence of air hydrate crystals in the ice cores hampers a straightforward determination of the air I composition as the clathrate composition is not necessarily representative of the trapped air (e.g. some fractionation effects of the different gases or other diffusion or dissolvation process in certain proportion of the gases may take place in the ice matrix during the clathrate formation).

Raman microspectrometry is a unique tool to detect the stretching modes of the included molecules in air hydrates with practically no interference with the matrix. This allows differentiation of the gases and determines the ratio of N_2 and O_2 from the integrated stretching mode intensities. As expected, the inelastic Raman frequencies of the N_2 and O_2 stretching modes of the molecules in the clathrate structure (2328 cm^{-1} and 1552 cm^{-1} respectively) are slightly different from the free nitrogen and oxygen molecules (2334 cm^{-1} and 1558 cm^{-1} respectively) in air.

To investigate if climatically-induced variations of the clathrate gas composition are present or if other complex processes (such as fractionation) occur, we started micro Raman measurements on synthetic clathrate samples, prepared at high P and low T. Raman measurements using a triple-dispersed monochromator system (XY-DILOR) spectrometer) equipped with a nitrogen-cooled CCD detector, were undertaken, using a Linkam TMS600 stage cell allowing to work at very low T (typically -160°C). The microscope allows observation of very small quantities (about 10 μm^3) and only a few seconds accumulation are necessary to obtain a signal/background ratio good enough to avoid any smoothing or noise substraction.

The study of synthetic samples is designed to complement the microscopic and Raman spectroscopic observations on natural samples, which are at present far from being fully understood. (From authors' abstract by E.R.)

CHAZOT, Gilles, LOWRY, David, MENZIES, Martin and **MATTEY, David,** 1997, Oxygen isotopic composition of hydrous and anhydrous mantle peridotites: Geochim. Cosmo. Acta, v. 61, no. 1, p. 161-169. Authors at Dept. of Geol., Royal Holloway, Univ. of London, Egham, Surrey, TW20 0EX, UK.

Oxygen isotope ratios, determined using the laser fluorination technique, are reported for minerals from anhydrous and hydrous (i.e. amphibole-bearing) spinel lherzolites from Yemen, as well as from hydrous spinel lherzolites and amphibole megacrysts from Nunivak Island, Alaska. The only isotopic disequilibria are observed in minerals which have grown in M-pockets formed by partial melting of amphibole. The homogeneity of the oxygen isotopic ratios of mantle minerals in this study indicate that the F circulating in the mantle and precipitating amphibole or mica had the same oxygen isotopic compositions as the mantle protolith or that the F had been buffered by the isotopic composition of the olivine, the most abundant mineral, during percolation through the peridotites. (From authors' abstract by E.R.)

CHEN, Haoshou and **XU, Butai,** 1997a, Isotope tracing and prospecting assessment for gold-silver deposits in Zhejiang, China: Acta Geologica Sinica (Dizhixue Bao), v. 71, no. 1, p. 54-63.

In order to determine the metallogenic epoch of the gold-silver deposits in Zhejiang Province, the FI in quartz from the Huangshan gold deposit, Zhilingtou gold-silver deposit and Haoshi silver deposit were dated by Rb-Sr isochron method. The results show that the Rb-Sr isochron age for the Huangshan deposit is 396.9±34.5 Ma with ^{87}Sr/^{87}Sr)i [sic] =0.70404±0.0003. This age is consistent with the time (330-339 Ma) of formation for the Huangshan ductile shear zone. It is considered that the mineralization of the Huangshan gold deposit was related to the Variscan mylonitization of this region. The initial Sr isotope ratio (0.70404) for the Huangshan deposit is the lowest in the three studied deposits. It falls in the mantle (basalt) source field, suggesting that the ore F came for the upper mantle. The ore-forming materials were derived mainly from the mixed source area of the upper crust and upper mantle or the lower crust. The mineralizations for different ore types and magnitudes or grades have different Pb isotopic compositions, which may serve as an indicator for ore prospecting and assessment. (Authors' abstract)

CHEN, Haoshou and **XU, Butai,** 1997b, Isotope tracing and prospecting assessment of gold-silver deposits in Zhejiang Province: Acta Geologica Sinica (English Edition), v. 71, no. 3, p. 293-304.

See previous abstract. (E.R.)

CHEN, Kaixu, YANG, Zhenqiang, JIN, Guangfu and **XIE, Fapeng,** 1997, A preliminary discussion on silver enrichment mechanism in the diagenetic process of the Baiguoyuan silver-vanadium deposit, Hubei Province: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 1, p. 53-60 (in Chinese; Engl. abst.). First author at Yichang Inst. of Geol. and Mineral Deposits, Chinese Acad. of Geological Sci., Yichang 443003.

The Baiguoyuan silver-vanadium deposit is of black shale type rarely seen both in China and abroad, with pyrite in the ore bed serving as the main carrier mineral. Based on studying pyrite of different shapes and stages, the authors have found that the enrichment of silver was intimately related to diagenetic pyrite. Spatially, the grade of silver is obviously conditioned by the content of silver-high pyrite (spear-shaped, spherical and cubic pyrite) in the ore bed; temporally, the migration and enrichment of silver were consistent with the evolution of diagenetic pyrite. [The stages are:] (1) The sedimentary and syngenetic period: in a hot water enviroment, silver was scattered in sediments together with the deposition of colloidal pyrite and carbonaceous-siliceous-pelitic sediments. (2) The early diagenetic period: under a certain T and P condition (t=165°C±, p=550 x 10^5 [to] ~580 x 10^5Pa), connate water evolved into hot brine solution characterized by low oxygen fugacity (f_{O_2}≈$10^{-46.49\sim-47.7}$ x 10^5Pa), slightly acid nature (pH≈4.29~4.40) and rich [in] activated ions (Na^+, Ca^{2+}, Cl^-, SO_4^{2-}, etc.), which caused the mobilization and migration of silver in the form of $[AgCl_2]^-$. (3) The late diagenetic stage: The drop in T (t<152°C), the increase in sulfur fugacity, the rising of alkalinity and the intensification of reduction resulted in the decomposition of the silver complex, and the silver was concentrated in pyrite formed at the late diagenetic stage, thus exhibiting the macroscopic unity of the rich silver orebody and the silver-bearing pyrite bed. (Authors' abstract)

Includes analyses (Table 2, p. 52) of 5 samples of FI from barite for K, Na, Ca, Mg, Li, F, Cl, HCO_3, SO_4^{2-} CO_2, CO, CH_4, H_2 and H_2O.

CHEN, Peirong, LIU, Changshi, HAO, Yanli and **SHEN, Weizhou,** 1997, The tin-bearing topaz-quartz porphyry, Yangbin area, Taishun County, Zhejiang Province; A fluid inclusion study: Chinese J. of Geochem. (Zhongguo Diqiu Huaxue Xuebao), v. 16, no. 2, p. 97-104. First author at Dept. of Earth Sci., Nanjing Univ., Nanjing, 210093.

The tin-bearing topaz-quartz porphyry Yangbin area is subvolcanic in origin, derived from granitic residual magma through strong crystallization differentiation. The rock contains various types of I (hydroxyl-melt, V-rich, halite-bearing multiphase, and L-rich), which permits us to trace the evolutionary path of the F. It is suggested that immiscibility took place in a pulsating manner between M and F during the rock-forming process with the Th ranging from 580 to 180°C and the sal varying from low through high to low (5.1-10.5→6.9-21.4→30-48→16-22→2-10 wt.% eq. NaCl). The hydroxyl-M I are considered as evidence of magma-hydrothermal transition. (Authors' abstract)

CHEN, Peirong, XU, Shijin, WANG, Rucheng, CHEN, Xiaoming, SHEN, Weizhou and **NI, Pei,** 1997, Physico-chemical characteristics and genesis of highly copper-rich fluid in the Xifanping porphyry copper deposit, Yanyuan County, Sichuan Province: Geochimica (in Chinese; Engl. abst.), v. 26, no. 5. Author at Dept. of Earth Sci., Nanjing Univ., Nanjing 210093.

Ore-forming source rock of the Xifanping porphyry copper deposits is the biotite adamellite. The polyphase FI in the deposit commonly contain dm of chalcopyrite. Ore-forming F is a kind of H_2O-NaCl system characterized by high copper content (about 20,000 X 10^{-6} [sic])

and high T (470-590°C), high sal [55%-65% (NaCl)], and boiling F. A minimum trap P of polyphase FI is about 51 MPa. The oxygen isotopic composition of the ore-forming solution is consistent with that of magmatic water. Pb and S isotopes of pyrite show that the ore-forming materials were mainly derived from deep source magma. All the characteristics suggest that the deposit is of the genesis of orthomagmatic model. In the area where polyphase FI developed, the F of high sal and high ore-forming element actived [sic]. Therefore, such a kind of polyphase FI can be considered as a good sign of exploring porphyry copper deposits. (Authors' abstract)

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

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

CHENG, Dajin and **YANG, Mingshou,** 1997, Geochemistry of fluid inclusions in Carlin gold deposits in western Jiangxi province: Mineral Resources and Geol. (Kuangchan Yu Dizhi), v. 11, no. 6, p. 406-412 (in Chinese; English abst.). Authors at Research Inst. of Geol. for Mineral Resources, CNNC, Guilin 541004.

Studies on geochemistry of I in Carlin [-type] gold deposits in western Jiangxi province suggest that the major mineralization T of the gold deposits are 100~200°C with average about 150°C. The sal for mineralization is 1.9~8.6 wt.% NaCl. The P for mineralization is 247 x 10^5 Pa~608 x 10^5 Pa. The mineralization F solution is the type of K^+–Ca^{2+} –SO_4^{2-}–(F^-)–CO_2, with pH value 3.6~4.1, mainly from meteoric water, mixed by formation water and a little magmatic water. It is considered that the gold in the area is mainly transported as a form of gold-sulfur complex, at a higher T (220 ~300°C), and under a condition of reduction in the system. The gold was precipitated and enriched to form gold deposits when the T decreased to 150°C±, with lower fS_2 and coexisting pyrite and As-rich pyrite. The deposition was at a suitable structural space with low P and better oxidation. (Authors' abstract)

CHENG, Zhongfu and **RUI, Xingjian,** 1997, Ore-forming geochemical environments of Saidu gold deposit in Habahe, Xinjiang: Volcanology & Mineral Resources, v. 18, no. 1, p. 25-36 (in Chinese; English abst.). Authors at IGMR, Nanjing 210016.

Saidu mylonite-type gold deposit is an important gold deposit in Altai area. In this paper, the ore-forming geochemical environments, such as source background of ore-forming material, geochemistry of ore-forming F and stable isotope geochemistry during ore-forming process, are systematically discussed. Based on isotopic age determination and geological condition, the metallogenic epoch is deduced to be 294-316 Ma.

Extensive FI data are presented. (H.E.B.)

CHEVYCHELOV, V.Yu. and **CHEVYCHELOVA, T.K.,** 1997, Partitioning of Pb, Zn, W, Mo, Cl, and major elements between aqueous fluid and melt in the systems granodiorite (granite, leucogranite)-H_2O-NaCl-HCl: N.Jb. Miner. Abh., v. 172, no. 1, p. 101-115. Authors at Chernogolovka, Russia.

The partition coefficients $K_D = c_{fluid}/c_{melt}$ of Pb, Zn, W, and Mo between aq F and M were measured in the systems granodiorite-H_2O-NaCl-HCl, granite-H_2O-NaCl-HCl and leucogranite-H_2O-NaCl-HCl at 1 and 5 kbars, 800-1000°C and starting solution of 1 m NaCl+0.1 m HCl, with many reversed runs. We also determined the concentrations of SiO_2, Al_2O_3, CaO, K_2O, and Na_2O in both phases of the systems studied and the concentrations of Cl in the M. The silica concentration in the solution increases considerably with increasing C_{SiO_2} in the coexisting M. The concentrations of calcium, potassium and sodium in the solutions also correlate with the concentrations in the glasses. At 1 kbar, chlorine is most soluble in granodioritic M at 1000°C (0.8-0.9 wt.%). C_{Cl} decreases considerably in the granitic and leucogranitic M. It also decreases with reduction of T to 850-800°C or with increasing P to 5 kbar. At 1 kbar, $K_D^{fluid/melt}$ of Pb and Zn can differ by a factor of 2-4 for different granitoid compositions and 1-2 orders of magnitude due to larger changes of M composition from basaltic to granitic. Our data show very low contents (to n x 100 ppm) of tungsten and molybdenum in the granitoid M studied. At 1 kbar, $K_D^{fluid/melt}$ of W and Mo increase 2-3 times due to the change of the M composition from granodioritic to granitic and leucogranitic. (Authors' abstract)

CHI, Guoxiang, RHÉAUME, Pierre and **SCHRIJVER, Kees,** 1997, The Largentiére sandstone Pb-Zn-Ag deposit, Ardèche, France: Fluid inclusion and geologic evidence for an epigenetic origin: Econ. Geol., v. 92, p. 108-113. First author at Centre Géoscientifique de Québec, 2535 Blvd. Laurier, C.P. 7500, Sainte-Foy, Québec, Canada G1V 4C7.

PFI in sphalerite [and barite] show T first melting -66 to -40°C; sal 6.4 to 24.9%; Th 62 to 154°C. NaCl/(NaCl+$CaCl_2$) weight ratio 0.18 to 0.82. Conclusion–deposit formed from warm basinal brines (E.R.).

CHI, Guoxiang and **SAVARD, M.M.,** 1997a, Origin of basinal brines related to MVT mineralization along the southern margin of the Maritimes basin – Approach from major solute composition (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A60. Authors at Geological Survey of Canada, Quebec Div., 2535 Boulevard Laurier, Sainte-Foy, QC G1V 4C7.

A group of carbonate-hosted base-metal deposits occurs in the lower Windsor Group (Viséan) along the southern margin of the Maritimes Basin. Previous studies indicated that these deposits formed from saline basinal F. The high sal (mainly 15-30 wt.% NaCl eq.) may have been derived from evaporated sea water or dissolution of halite; both may be related to the thick layer of evaporites on top of the host carbonates. In this study, we tentatively use the Ca_{excess}-$Na_{deficit}$ (with reference to sea water) diagram, recently proposed by Davisson and Criss (Geoch. Cosmo Acta, v. 60, p. 2743, 1996), to discuss the origin of the solutes in the ore F. FI decrepitates in ore-stage minerals from two deposits (the Gays River and Jubilee deposits) were analyzed by the SEM/EDS method. The analyzed elements are Na, Ca, Mg, K, and Cl. Cl^- is deficient relative to cations, and is adjusted to satisfy valence balance. The concentration of each element in the F is reconstructed by using the average sal value of FI in the host mineral. Our data plot slightly to the left of the Basinal F Line (BFL) of Davisson and Criss (1996) on the Ca_{excess}-$Na_{deficit}$ diagram, and form linear trends parallel to the BFL, with a slope near 1. According to the principle of the diagram, these F likely originated from dissolution of halite and followed by F-rock interaction with 1 Ca for 2 Na exchange. F which originated from evaporated sea water would plot to the right of the BFL. However, it is noticed that in some other MVT deposits, IF which have evaporated sea water Na-Cl-Br systematics also plot close to the BFL. It is not unlikely that part of the ore F of the Gays River and Jubilee deposits originated from evaporated sea water, and mixed with halite dissolution-related F. The linear covariation of Ca_{excess} and $Na_{deficit}$ probably reflects variable degrees of F-rock interaction. (Authors' abstract)

CHI, Guoxiang and **SAVARD, M.M.,** 1997b, Sources of basinal and Mississippi Valley-type mineralizing brines: mixing of evaporated seawater and halite-dissolution brine: Chemical Geol., v. 143, p. 121-125. Authors at Geological Survey of Canada-Quebec Geosci. Centre, 2535 boul. Laurier, Ste-Fy, QC G1V 4C7, Canada.

Origins of basinal brines and Mississippi Valley-Type (MVT) mineralizing F have been separately attributed to evaporation of seawater or dissolution of halite, although brines originating from the two processes are not mutually exclusive in basins. This study shows that the Na/Br-Cl/Br diagram cannot distinguish between evaporated seawater and halite-dissolution F. Using the $Na_{deficit}$-Ca_{excess} diagram which was previously proposed to characterize fluid-rock interactions of basinal brines, it is shown that most basinal brines including MVT mineralizing F of the Viburnum Trend deposits were probably initially a mixture of halite-dissolution F and evaporated seawater. Using the same diagram, we suggest that the mineralizing brines of the Gays River MVT deposit were derived from an aquifer of clastics underlying a thick succession of evaporites, where halite-dissolution F and evaporated seawater could have mixed. (Authors' abstract)

CHOU, I.-M., 1997, The use and misuse of the f_{H_2} sensors: A discussion of the paper by Dachs (1994): Contrib. Mineral. Petrol., 1997, no. 128, p. 302-305.

CHRISTENSON, B.W., MROCZEK, E.K., WOOD, C.P. and **AREHART, G.B.,** 1997, Magma-ambient production environments: PTX constraints for paleo-fluids associated with the Ngatamariki diorite intrusion: Proceedings 19th NZ Geothermal Workshop 1997, p. 87-xx. Authors at Inst. of Geological and Nuclear Sci., Taupo, NZ.

A study of the alteration halo surrounding a diorite intrusion in the Ngatamariki geothermal system is being conducted to ascertain the nature of the reservoir F extant at the time of diorite emplacement. Preliminary results show that hot, highly saline (>30 wt.% NaCl) F were in equilibrium with a low density, volatile-rich phase within, and immediately adjacent to the diorite, and that these F interacted with convecting meteoric F during formation of the extensive alteration halo. T in this system range from 250°C in the alteration halo to >500°C in the diorite, and evidence points to the existence of repeated P transients across the brittle-plastic transition during subsolidus cooling of the intrusion. (Authors' abstract)

CHU, H.-T., WANG, Yunshuen and **YU, B.-S.,** 1997, Lead-zinc quartz veins of the Chinmienshan, Toucheng, Northeastern Taiwan: J. of the Geological Soc. of China, v. 40, no. 1, p. 225-242. Authors at Central Geological Survey, MOEA, Taipei, Taiwan, R.O.C.

Sulphide quartz veins were discovered unexpectedly during the construction of the Taipei-Ilan Expressway. The principal metallic minerals in the veins are galena, sphalerite, wurtzite, pyrite, chalcopyrite and pyrrhotite. Detailed petrographic observations indicate that this lead-zinc vein is closely associated with quartz, calcite and chlorite. Fluorite veins are also present.

FI in quartz veins demonstrate an evolving H_2O-CO_2-NaCl-CH_4-N_2 system. Coexisting three-phase (aq L+CO_2-L+V) FI with different CO_2 contents, homogenizing between 310 and 330°C, were trapped during the F unmixing of a homogeneous aq CO_2-bearing hydrothermal F. Aq two-phase (L+V) I normally homogenize between 220 and 260°C, which accounts for the successive loss of CO_2, CH_4 and N_2 during F vaporization. This coincides with increasing sal and decreasing T resulting from high enthalpy steam loss. (From authors' abstract by E.R.)

CHUPIN, Serguei, CHUPIN, Vladimir, BARTON, Jay and **BARTON, Erika,** 1997, Melt inclusions in detrital zircons from Archean pararocks of South Africa: Magma compositions and probably sources of protoliths: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 72-73. First author at Inst. of Mineral. and Petrog., SB RAS, 630090, Novosibirsk, Russia; email (chupin@uiggm.nsc.ru).

Detrital zircons from South African pararocks contain P MI. MI were found in all morphological types of zircons. They did not homogenize even at 1250°C. Heated and quenched I were studied by X-ray microprobe. Compositions of I located at different distances from the center of the crystal allowed us to determine the compositions of parent M, as well as their evolution.

Zircons from quartzites of the lower horizon of the Witwatersrand deposit (age of zircons is 2.98 to 3.33 Ga) crystallized from at least two types of M. The Type 1 (rounded) zircons crystallized from potassium-sodium trachyrhyodacite-rhyolite magmas with high chlorine content (up to 0.83 wt.%). The Type 2 (less rounded) zircons crystallized from tonalite-trondjemite M with low chlorine content. In terms of the chlorine content, these M differ drastically from potassium-sodium acidic M, characteristic of the Type 1 zircons. Thus, the potassium-sodium M with high chlorine content cannot be considered as the differentiates of tonalitic magmas. It is important that the central parts of the less rounded Type 2 zircons (which reflects the shorter distance of transport during sedimentation) crystallized from tonalite-trondjemite magmas, while I in zircons of Type 1 typically contain potassium-sodium acidic M. This suggest that the Type 2 zircons derived from some tonalite-trondjemite source rocks, located fairly close to the deposit. Presumably, subalkaline (potassium-rich) acidic magmatic rocks, located far from the deposit, served as one of the sources for rounded zircons.

Study of MI in zircons from paragneiss Singelele and from quartzites of the central part of the Limpopo belt (older than 3 Ga) revealed similar differences in magma sources, and hence were supplied by erosion of different acidic igneous rocks.

The data obtained can be applied to the problem of the origin and of the time of appearance of old, essentially potassium acidic magmas. It has been shown that for the continental crust of South Africa, such magmas have formed at more than 3 Ga ago. (From authors' abstract by E.R.)

CHUPIN, S.V., CHUPIN, V.P. and **POSPELOVA, L.N.**, 1997, Chemical composition of melt inclusions in zircon from Archean metasedimentary rocks of South Africa: Dok. Akad Nauk, v. 356, no. 1, p. 97-101, (in Russian, translated in Transactions (Doklady) of the RAS/Earth Sci. Sections, v. 356, no. 7, p. 1017-1021). Authors at Joint Inst. of Geol., Geophys. and Mineral., (UIGGM), Siberian Div., RAS, Univ. pr. 3, Novosibirsk, 630090 Russia.

I of mineral-forming media in detrital zircons from metasedimentary rocks of South Africa were investigated. The zircon-bearing rocks studied include the OGQ quartzite from the lower horizon of the largest Au-U deposit of Witwatersrand, the Singelele paragneiss, and the quartzite from the central Limpopo Belt. From a theoretical and a practical standpoint, it is important to determine the composition of the source rocks, the erosion of which resulted in the formation of sediments at the Witwatersrand deposit. M I in zircon represent the microvacuoles of ancient solidified magmas.

Fifty-eight analyses are presented for the normal nine constituents plus Cl, that give direct evidence that tonalitic-trondhjemitic rocks were one of the sources for the Witwatersrand sediments, and this conclusion is consistent with isotopic geochemical and geochronological data. (From authors' text by E.R.)

CHUPIN, Vladimir, KUZMIN, Dmitri and **TOURET, J.L.R.**, 1997, Melt and fluid inclusions in minerals from garnet granulites/eclogites (eastern Pamir): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 74-75. First author at Inst. of Mineral. and Petrog., SB RAS, 6300909 Novosibirsk, Russia; email (chupin@uiggm.nsc.ru).

Explosion pipes of alkaline basaltoids occur, emplaced during the Neogene. They contain a wide range of xenoliths: eclogites, pyroxenites and granulites. Garnet granulites, notably, are believed to be transported by the basaltoid magma from the lower crust.

All major as well as accessory (apatite, monazite, zircon) minerals of the kyanite granulites contain P MI, a fact which implies their magmatic origin. These I contain glass + heterogeneous bubble + several microcrystallites. Almost all I in garnet are partly decrepitated. The gas bubble looks at first sight like the shrinkage bubble commonly observed in MI, but freezing data and Raman analysis reveal that, in most cases, it is filled with high density CO_2, containing minor N_2. This typical granulite F has notably been observed in I from garnet, quartz, feldspar, and apatite. In I occurring in quartz from massive granulites, which provide the best conditions of observation, the CO_2 content of trapped M was estimated to be roughly 1.5-1.8 wt.%.

The M trapped in garnet from eclogitoids after heating to 1000-1050°C corresponds to a K-Na dacite, and that of M trapped in garnet and other minerals from kyanite granulites to K-rich dacite and rhyodacite. I glass in garnet from eclogite-like rock and in garnet and other minerals from massive granulites is enriched in chlorine (up to 0.24 and 0.33 wt.% respectively), whereas I glass in gneissic granulites does not contain detectable chlorine. This finding is in line with other data on granulite F, showing concentrated, NaCl-rich aq F (brines) to be a very common F besides CO_2 (Touret, 1995).

MI in quartz from massive granulite homogenize at 1050-1020°C and in garnet from eclogite-like rock at 1020°C. These values can be considered as a maximum limit of the formation T, both because of kinetic problems during high T microthermometry and volatile loss during initial cooling. Other mineral thermobarometric estimates are scarce and imprecise.

CO_2-rich I in PM/FI from garnet cores in gneissic granulites are partly decrepitated, but they still contain F of a CO_2-equivalent density of ca 0.8 g/cm^3. This would correspond to a P of about 5 kb for a reference T of 1050°C, namely a depth of about 15 km (possibly the depth of the last magma chamber of the basaltoids before eruption). Syngenetic M and FI imply that the early stages of granulite crystallization occurred in presence of CO_2-saturated M.

In conclusion, this preliminary study show that lower crustal xenoliths in Eastern Pamir may provide interesting data bearing on the evolution of the Pamir-Himalayas collisional orogen. (From authors' abstract by E.R.)

CIOFLICA, G., JUDE, R., LUPULESCU, M. and **SARU, Denisa**, 1997, Neogene volcanic-hosted epithermal gold-silver mineralizations from the Apuseni Mts., Romania: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 169-172. First author at Mineral. Dept., Bucharest Univ., Romania.

In the Neogene volcanic arc of the Apuseni Mts., gold mineralizations are related to shallow intrusions. They belong to the epithermal-type and are represented by various associations as Au-Ag, Te-Au-Ag, Pb-Zn (± Au, Ag) of low sulfidation type and Cu-As (Au) of high sulfidation-type. The epithermal mineralizations are developed in the upper part of the Cu-Au (Mo) porphyry systems and cross cut them. The main features of the epithermal mineralizations and relationships with porphyry systems will be pointed out in this paper. (Authors' abstract)

COETZEE, D.S., WATSON, M.D. and **SCHOCH, A.E.**, 1997, Fluid inclusions, cathodoluminescence and decrepetometry of shear zone restricted vein-quartz and undeformed quartzite in the main reef formation, Witwatersrand basin, South Africa: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 76-77. First author at Dept. of Materials Tech., Technikon Pretori, South Africa; email (faan@natsci.ns.techpta.ac.za).

The Witwatersrand basin is a late Archaean to early Proterozoic sedimentary basin with a complex tectonometamorphic history including four major pre-Ventersdorp deformational events from the onset of basin formation 3100 my ago until the formation of the Vredefort structure some 2000 my ago.

Decrepetrometry conducted on hand-picked quartz particles from undeformed quartzite outside the shear zones show peaks at 380 and 400°C, but those from vein-quartz selvages withn the shear zones show 400 and 500°C. The differences are considered to be representative of different F populations.

FI in vein-quartz associated with pyrophyllite and kyanite occur in irregular three-dimensional clusters (P) and along healed cracks forming a network of intersecting trails (S and PS). L to V homogenization of I [sic] along trails cluster around 200°C, while homogenization for I in three-dimensional clusters range between 145 and 170°C. PI have ±13 [~13%?] wt. % NaCl eq., while S/PS I have 6 to 14 wt.% NaCl.

FI in vein-quartz associated with pyrophylite, but without visible kyanite occur at random throughout the sample, have 6 to 8 wt.% NaCl and show peak homogenization at around 200°C.

FI associated with undeformed quartzite outside the shear zone occur in colonies (undecided origin) or along trails across grain boundaries (S). The salt contents of the colonies are 8 to 9 wt.% NaCl eq., and homogenize to the L phase between 190 and 210°C.

In conclusion, F associated with peak metamorphic condition and which are considered to be responsible for gold remobilization clearly have higher salt contents (±13 wt.% NaCl eq.) than FI associated with undeformed and retrograde conditions. An integration of petrogenetic and FI data suggest peak metamorphic condition of ±390°C and 3 kbar P. (From authors' abstract by E.R.)

COLE, Andrew, WILKINSON, Jamie, SERENKO, Tom and HALLS, Chris, 1997, Structural, petrogenetic and fluid controls of gold-quartz stockwork mineralisation, Jilau gold deposit, Tajikistan (abst.): Mineral Deposits Study Group Annual General Meeting, Glasgow Univ., 1997, Programme and Abstracts Volume, p. xxx. Authors at Dept. of Geol., Imperial College, Prince Consort Rd., London SW7 2BP.

Jilau is a large tonnage, low grade gold mesozonal stockwork deposit, hosted within granodiorite. At least five quartz generations form the orebody, but so far only two have yielded FI of a size suitable for study. Preliminary results show that both P and S I are present. P I in the main third generation of quartz veining appear to have formed under constant P-T conditions while I of the later sulphide-rich fourth generation indicate a range of P-T conditions. Both populations indicate the importance of low sal H_2O-CO_2 F in mineralisation.

The continuing study will involve fieldwork to determine local field relationships; mineralogical and geochemical analysis of vein and host rocks utilising a range of techniques including SEM-microprobe, ICP-AES and laser ablation; geochronological studies of host rocks and alteration phases; textural analysis by conventional optical microscopy and CL petrography; FI studies to constrain F resources, T and depth of mineralisation and to evaluate controls of ore deposition. (From authors' abstract by E.R.)

CONRAD, M.E., THOMAS, D.M., FLEXSER, Steven and VENNEMANN, T.W., 1997, Fluid flow and water-rock interaction in the East Rift Zone of Kilauea Volcano, Hawaii: J. of Geophys. Research, B, Solid Earth and Planets, v. 107, no. 7, p. 15,021-15,037.

Indexed under FI (E.R.)

COOKE, D.R., 1997, Superposition of low sulfidation epithermal Au and porphyry Cu-Au mineralisation at Acupan, Philippines, by transpressional uplift and erosion (abst.): Geological Society of Australia Abstracts No. 44, p. 21. Author at Special Research Centre for Ore Deposit Studies (CODES), Univ. of Tasmania, GPO Box 252-79, Hobart 7001.

In the Philippines, both low sulfidation (e.g., Baguio district; Acupan, Antamok, etc.) and high sulfidation epithermal deposits (e.g., Mankayan district; Lepanto) are superimposed onto porphyry systems. Recent research (e.g. Arribas et al., 1995) has shown that high sulfidation epithermal Au-Cu-As systems can be genetically related to the formtion of porphyry-style mineralisation, and can form above or immediately adjacent to some porphyry systems (e.g. Lepanto/Far South East).

The Acupan low sulfidation epithermal gold mineralisation has overprinted porphyry Cu-Au mineralisation. FI and stable isotope studies have shown that there was no direct input of magmatic-hydrothermal F from the porphyry system into the low sal epithermal vein system. (From author's abstract by E.R.)

COOPER, S.P. and LISENBEE, A.L., 1997, Gas/fluid evolution and the formation of rhyolite dike-associated breccia margins at the Homestake gold mine, Lead, SD (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 2, p. 7. Authors at Dept. of Geol. and Geological Engineering, South Dakota School of Mines and Tech., 501 E. St. Joseph St., Rapid City, SD 57701; email (spc2417@silver.sdsmt.edu).

A north-trending swarm of 6-10 early-Tertiary rhyolite dikes and associated breccia dikes extends from the surface in the Open Cut to the 7400 ft. level in underground workings of the Homestake mine. The breccias consist of angular-to-rounded, clast supported xenoliths of Precambrian black schist and rhyolite in a black matrix of fine-grained disarticulated Precambrian schist fragments.

Regional stratigraphic reconstructions show that about 1 km of Phanerozoic strata covered the mine area at the time of dike emplacement. Therefore, the maximum depth of explosive release of F from the magma occurred at a depth of 3.3 km. FI in veins associated with the dikes indicate CO_2 was evolved at approximately the present 3000 ft. mine level (Uzunlar, 1993). Therefore, CO_2 evolution could only have contributed to breccia development at original depths of about 1.9 km, if at all. (From authors' abstract by H.E.B.).

COSTAGLIOLA, P., BENVENUTI, M., LATTANZI, P. and TANELLI, G., 1997, Metamorphogenic barite-pyrite (Pb-Zn-Ag) veins at Pollone, Apuane Alps, Tuscany: Vein geometry, geothermobarometry, fluid inclusions and geochemistry: Mineral. and Petrol., v. 62, p. 29-60. First author at Museo di Mineralogia e Litologia dell'Università, Firenze, Italy.

The barite-pyrite-(Pb-Zn-Ag) deposit of Pollone is located in the Apuane Alps metamorphic core complex. The southern sector mainly consists of stratiform, supposedly syngenetic, barite-pyrite orebodies, whereas the northern area is characterized by a barite-pyrite-(Pb-Zn-Ag) vein system. FI data and mineral equilibria suggest that the mineralizing F were initially hotter than the country rocks (about 450°C at 3.5-4.0 kbar). Rocks in direct contact with the orebodies are depleted in Rb and enriched in Sr in comparison to similar rocks elsewhere in the area. Remobilization of syngenetic orebodies was conceivably of minor importance in the production of metamorphogenic veins. F cooling along a major tectonic lineament is thought to be responsible for barite deposition. (From authors' abstract by E.R.)

COX, S.C., CRAW, Dave and CHAMBERLAIN, C.P., 1997, Structure and fluid migration in a late Cenozoic duplex system forming the Main Divide in the central Southern Alps, New Zealand: New Zealand J. of Geol. and Geophys., v. 40, p. 359-373. First author at Geol. Dept., Univ. of Otago, P.O. Box 56, Dunedin, NZ.

Four generations of postmetamorphic veins, some with ≤ 850 ppb Au, cut rock slabs of the duplex system. This gold mineralisation occurred within c. 1 km of the surface and had epithermal affinities. Hydrothermal F mineralising the various fractures range in T between 350°C and near ambient T. The quartz-adularia-calcite veins formed at 0.5-2.5 km depth before duplex formation, and veins formed at shallower levels after duplex formation. Vein carbonates have $\delta^{18}O_{(SMOW)}$ between 11.4 and 26.1‰, and $\delta^{13}C_{(PDB)}$ between -0.6 and -11.4‰. Calculated isotopic ratios for the mineralising F show little evidence for meteoric origin. The F may be meteoric water which has undergone isotopic exchange with host rocks, metamorphic water, or a mixture of these, and mineralization occurred during rise of the F from depth. (From authors' abstract by E.R.)

CRAW, D., 1997, Fluid inclusion evidence for geothermal structure beneath the Southern Alps, New Zealand: New Zealand J. of Geol. and Geophys., v. 40, p. 43-52. Author at Geol. Dept., Univ.of Otago, P.O. Box 56, Dunedin, NZ.

Fissure veins containing adularia, bladed calcite, quartz, and chlorite occur in fractures in schist immediately west of the mountain crest in the Southern Alps, an active collisional mountain range. The vein minerals contain P FI which homogenise between 240 and 260°C. The F have low dissolved salt content (<2 wt.% NaCl eq.) and low CO$_2$ content (<1 wt.%). FI in adularia show physical (co-existing L and V) and chemical (variable CO$_2$ contents) evidence for boiling during entrapment. The mineral assemblage is similar to that seen in boiling zones of modern geothermal systems. Boiling occurred at 500±150 m below topographic surface, or c. 1 km above sea level, and F T was higher than rock T. In contrast, F trapped in the same rock sequence at 300-350°C at 6-10 km under lithostatic and hydrostatic F P were approximately the same T as host rock and define part of a conductive thermal anomaly. The boiling zone developed due to topography-driven two-dimensional circulation of meteoric water into the uplift-induced conductive anomaly, followed by rapid buoyant rise of heated and partially isotopically exchanged water to shallow levels under hydrostatic F P.

Farther west, near the Alpine Fault, the conductive thermal anomaly has resulted in F and rock T of 300-350°C at <5-8 km under lithostatic and hydrostatic F P. The F is mainly meteoric in origin, but has partially exchanged isotopically with the host rock. Minor buoyant rise of F has resulted in penetration of hot (200°C) F into relatively cool rock at shallow levels (<2 km). Hot springs emanate from the surface above this portion of the hydrothermal system, but these springs are fed by topographically-driven meteoric water, which penetrates to only shallow levels in the crust and is isotopically distinct from the deeper F. (Author's abstract)

CRAW, D., CHAMBERLAIN, C.P., ZEITLER, P.K. and KOONS, P.O., 1997, Geochemistry of a dry steam geothermal zone formed during rapid uplift of Nanga Parbat, northern Pakistan: Chemical Geol., v. 142, no. 1-2, p. 11-22.

Natural dry steam zones (V only) are relatively rare; most geothermal systems contain both L and V and typically follow a boiling point-depth (BPD) relationship. The Nanga Parbat uplift-driven conductive thermal anomaly results in a geothermal system which follows a BPD relationship at shallow levels, but below about 3 km FI show that the hydrothermal F is dry steam with F densities from 0.36 to as low as 0.07 g/cm^3. This dry steam zone may persist down to the brittle-ductile transition. The dry steam has sal up to 5 wt.% dissolved salts, and up to 22 mole% dissolved CO$_2$. The dry steam originated as meteoric water high on the slopes of Nanga Parbat, with $\delta^{18}O$ as low as -16 per mil. Oxygen isotopic exchange with the host rock was facilitated by high T (340 to 450°C) and low F densities so that the F meteoric isotopic signature was completely obliterated. Hence, quartz veins formed by the migrating dry steam have $\delta^{18}O$ between +9 and +15 per mil, a range which is indistinguishable from quartz in the host rocks. Quartz vein precipitation from dry steam requires 3 to 5 orders of magnitude greater volume of F than typical hydrothermal F. The dry steam zone at Nanga Parbat has formed due to near-isothermal depressurization of very hot F during rapid tectonic uplift at rates >3-6 mm/year. (Authors' abstract)

CROWLEY, S.F., BOTTRELL, S.H., McCARTHY, M.D.B., WARD, J. and YOUNG, B., 1997, $\delta^{34}S$ of Lower Carboniferous anhydrite, Cumbria and its implications for barite mineralization in the northern Pennines: J. of the Geological Soc. of London, v. 154, part 4, p. 597-600.

Sulfur data support a Lower Carboniferous marine sulphate source for mineralization at these sites. Identification of extensive evaporite deposits in the Solway Basin resolves several longstanding problems associated with mineralization in the Northern Pennines including the source of barite sulphate and the origin of hypersaline mineralizing F. (From authors' abstract by E.R.)

CRUMMY, J., HALL, A.J., BOY, A.E. and FALLICK, A.E., 1993, The Caledonian Appinite Suite as gold exploration target, and possible clues from sulphur isotope geochemistry (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). First author at Dept. of Geol., Univ. of Manchester, Manchester M13 9PL, UK.

The appinite suite was targeted for reconnaissance level gold exploration in Scotland and Ireland on account of their close relationship to lamprophyres (known carriers of gold) and the occurrence of explosive brecciation during their emplacement which intuitively provides an efficient gold precipitation mechanism via F devolatisation. One cluster of breccia pipes at Cruachan Cruinn, near Ardlui in the Southern Highlands of Scotland, returned gold grades of nearly 1 ppm, but all others sampled proved to be barren. FI work on quartz gangue from the Cruachan Cruinn pipes indicated that hydrothermal F were hot (230-290°C), saline (9-14 wt.% NaCl), CO_2-bearing and effervescing at the time of quartz deposition. The exploration model was therefore partly vindicated by these results. (From authors' abstract by E.R.)

CRUMMY, J., HALL, A.J., HASZELDINE, R.S. and **ANDERSON, I.K.**, 1997, Potential for epithermal gold mineralization in east and central Sutherland, Scotland: Indications from River Brora headwaters: Trans. Instn. Min. Metall. (Sect. B: Appl. Earth Sci.), v. 106, Jan-Apr 1997, p. B9-B14.

Mineralization is dominantly in the form of open, matrix-supported breccias comprising pyritic quartz/sericite clasts in a vuggy cherty, chalcedonic and crystalline quartz matrix. FI in pyritic clasts within these breccias indicate Tt for gold-mineralizing hydrothermal F of 170-240°C. These textures and the indicated T of the hydrothermal F suggest that the mineralization represents the upper part of the feeder zone to an exhalative hydrothermal system.

The possibility exists that other high-level feeder zones to such hydrothermal systems could be preserved elsewhere in this terrain, and the potential for further bedrock gold occurrences in this terrain [should not] be overlooked. (From authors' abstract by E.R.)

CUNNINGHAM, C.G., RYE, R.O., BETHKE, P.M. and **LOGAN, M.A.**, 1997, Vein alunite formed by episodic degassing of an epizonal pluton: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F746. First author at U.S. Geological Survey, 954 Nat'l. Center, Reston, VA 20192; email (cunningham@usgs.gov)

On Alunite Ridge, the alunite veins cut small pyrite- and alunite-bearing rhyolite dikes which are interpreted to be apophyses of the stock. The alunite veins are surrounded by alunitized wall rock containing minor pyrite that grades laterally to propylitically altered rocks. The alunite veins are the uppermost part of a large magmatic/hydrothermal system that includes ore deposits. Gold and silver veins surround the area of altered rocks and lead-zinc manto deposits, associated with 14 Ma sericite, replace limestones under Deer Trail Mountain. 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 FI that resulted from the entrapment of steam that transported the components of the alunite in the V-dominated geothermal system. Reconnaissance gas studies indicate the presence of H_2 in the FI. The $\delta^{34}S$ of the alunite, near zero per mil, is essentially identical to values from the base-metal mantos and wallrock pyrite which represent the bulk sulfur of the magmatic system. The average δD value of -70 from the alunite is consistent with a magmatic origin. $\delta^{18}O_{SO_4}$ values are about 9 per mil and $\delta^{18}O_{OH}$ values are about 3 per mil indicating oxygen isotopic disequilibrium. Microprobe analyses perpendicular to the alunite layers show a sawtooth pattern of P_2O_5 and SrO increasing within each layer, which may record the degassing and subsequent crystallization of newly exposed magma. Preliminary $\delta^{34}S$ values across the layers show no variation indicating disproportionation did not occur and suggesting complete S isotopoic disequilibrium. The oxygen and sulfur isotopic data are consistent with rapid degassing, on the order of minutes to days, and crystal growth at high T and low P. (From authors' abstract by E.R.)

D'ALESSANDRO, W., GIAMMANCO, S., PARELLO and **VALENZA, M.**, 1997, CO_2 output and $\delta^{13}C(CO_2)$ from Mount Etna as indicators of degassing of shallow asthenosphere: Bull. Volcanol., v. 58, p. 455-458.

DAI, Chuanshan, 1997, Thermal analysis of indirect geothermal district heating systems: Geothermics, v. 26, no. 3, p. 351-364.

Indexed under FI (E.R.)

DAMARUPURSHAD, A., HART, R.J., SELLSCHOP, J.P.F. and **MEYER, H.O.**, 1997, The application of INAA to the geochemical analysis of single diamonds: J. of Radioanalytical and Nuclear Chem., v. 219, no. 1, p. 33-39.

Indexed under FI (E.R.)

DANYUSHEVSKY, L.V., 1997, High-Ca boninites: A result of the interference of mantle plumes into the affairs of subduction zones? (abst): MAEGS, 10th Meeting Association of European Geological Societies, Sept. 1-5, 1997, Carlsbad, Abstracts: J. Czech Geol. Soc., v. 42, no. 3, p. 7. Author at Dept. of Geol., Univ. of Tasmania, GPO Box 252-79, Hobart, Tasmania, 7001, Australia.

Boninites, a subduction-related magmatic suite, are characterized by relatively high SiO_2, H_2O, and low TiO_2 contents compared to tholeiitic suites, and by the presence of very magnesian olivine phenocrysts. It is generally accepted that these rocks originated from mantle which has been variably depleted in the basaltic component compared to a typical mid-ocean ridge basalt source, but is always extremely depleted in incompatible elements. Variations in the degree of depletion of the boninite sources in the basaltic component are reflected by a wide range of CaO/Al_2O_3 (0.4-0.85) in primitive boninites, which is negatively correlated with the degree of depletion. Variations in CaO/Al_2O_3 values recorded in several boninite suites have been explained as a result of progressive source depletion during boninite magma genesis. It is widely accepted that boninite petrogenesis requires mantle T of 1200-1350°C and depths below 10 kbar.

Experimental studies of MI in olivine phenocrysts from Tongan and Troodos boninites have demonstrated that their P M had high MgO (21-24 wt.%) and moderate H_2O (around 2 wt.%), and crystallization T of 1350-1389°C at about 1 kbar. A high-P experimental study has demonstrated that such M are in equilibrium with a harzburgite mantle residue at 15-17 kbar and 1430-1470°C.

The high T of the high-Ca boninite P M is explained by their derivation from hot mantle plumes. The transition from subduction to transform tectonics is proposed as a major factor in allowing the intrusion of hot mantle plume in the mantle wedge above the slab, as such transition forms a window connecting the wedge with the astenosphere under the subducting plate. The mantle source for high-Ca boninites was a mantle plume previously depleted by the extraction of OIB-type magmas. Intrusion of this hot mantle triggers extensive degassing of the slab, and the derived F cause the "second-stage" melting of the depleted plume, producing high-Ca boninites. (From author's abstract by H.E.B.)

DANYUSHEVSKY, L.V., CARROLL, M.R. and **FALLOON, T.J.**, 1997, Origin of high-An plagioclase in Tongan high-Ca boninites: Implications for plagioclase-melt equilibria at low P (H_2O): The Canadian Mineralogist, v. 35, p. 313-326. First author at Dept. of Geol., Univ. of Tasmania, GPO Box 252-79,. Hobart, Tasmania 7001, Australia.

Detailed petrological, mineralogical and M-I studies of an unusual plagioclase-phyric high-Ca boninite from the Tongan forearc demonstrate that phenocrysts of high-An plagioclase ($An_{>90}$) crystallized at the latest stages of M evolution from H_2O-saturated dacitic M (64-67 wt.% SiO_2, ~2 wt.% MgO) at ~1050°C and low P (<1 kbar). These M contained ~1.5 wt.% H_2O and had low CaO/Na_2O (~3, in wt.%). Our results suggest that the presence of high-Ca ($An_{>90}$) plagioclase phenocrysts in arc lavas does not necessarily imply either high H_2O-contents of the M (>6 wt.%), or involvement of refractory M ($CaO/Na_2O>8$) in magma genesis, as was previously suggested. Established conditions of crystallization [P, T, X, X(H_2O)] during evolution of the Tongan boninite contradict those predicted by available models of plagioclase-M equilibria. The effect of H_2O on the activities of plagioclase components in hydrous M is strongly nonlinear. Extrapolation of experimental results on the effect of H_2O on plagioclase-M equilibria from M H_2O contents of >4 wt.% to the low H_2O contents (<2 wt.%) of the evolved Tongan boninite predicts a less calcic plagioclase than observed, or higher H_2O contents than measured in plagioclase-hosted M I. These observations are in accord with the well-known large effect of small amounts of H_2O on mineral melting T, and also with recent results on the effect of H_2O on M viscosities at low H_2O contents. Better predictions require new experimental data at low P(H_2O) (<1 kbar). (Authors' abstract)

DARLING, R.S., CHOU, I.-M. and **BODNAR, R.J.**, 1997a, Cristobalite in granulite facies garnet from Gore Mtn., NY (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 1, p. 39. First author at Dept. of Geol., St. Univ. College at Cortland, Cortland, NY 13045; email (darlingr@snycorva.cortland.edu).

See next abstract (E.R.).

DARLING, R.S., CHOU, I.-M. and **BODNAR, R.J.**, 1997b, An occurrence of metastable cristobalite in high-pressure garnet granulite: Science, v. 276, p. 91-93. First author at Dept. of Geol., State Univ. of New York College at Cortland, Cortland, NY 13045.

High-P (0.8 gigapascals) granulite facies garnet from Gore Mountain, New York, hosts multiple solid I containing the low-P silica polymorph cristobalite along with albite and minor ilmenite. Identification of cristobalite is based on Raman spectra, electron microprobe analysis, and microthermometric measurements on the α/β phase transformation. The cristobalite plus albite I may have originated as small, trapped samples of hydrous sodium-aluminum-siliceous M. Diffusive loss of water from these I under isothermal, isochoric conditions may have resulted in a large enough internal P decrease to promote the metatastable crystallization of cristobalite. (Authors' abstract)

See also Liou, et al.

DARROZES, José, GAILLOT, Philippe and **MUNOZ, Margot**, 1997, Multi-scale fluid inclusion analysis: The normalised optimised anisotropic wavelet coefficient (NOAWC) method: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 78-79. Authors at UMR 5563 CNRS, 38 rue des 36 ponts, F-31400 Toulouse, France; email (darrozes@lucid.ups-tlse.fr).

Investigation of complex spatial organisations, such as FI, necessitates recognition and understanding of a number of physical processes acting simultaneously at different scales. Finding out the part taken by each spatial organisation, according to its characteristic scale, is an effective way to analyse such systems. Our purpose is to promote the NOAWC method which allows to decipher signals where information of different scales are combined.

The anisotropic wavelet transform is an efficient mathematical tool for multi-scale analysis of multi-dimensional signals. Multi-scale FI analysis using the NOAWC method leads to recognise and quantify the different levels of structural organisations. These levels are from the finest scale to the largest scale: from the individual FI itself to alignments, or clusters, of I.

An example illustrates the effectiveness of the NOAWC method:

The geometry (shape and orientation) of the individual FI has been characterised: an heterogeneous size distribution ranging from 2 to 16.5 µm, and a well-defined orientation at -28°±2°C (in the direct trigonometric repair).

Two perpendicular FI alignments (≈-30° and +60°C) have been evidenced.

This configuration has not been previously evidenced, as the microthermometric data are homogeneous. This is a new parameter which could lead to information about small scale mineral deformation (work in progress). [sic] (From authors' abstract by E.R.)

DASGUPTA, Somnath, GUHA, Dipayan, SENGUPTA, Pulak, MIURA, Hiroyuki and **EHL, Jürgen**, 1997, Pressure-temperature-fluid evolutionary history of the polymetamorphic Sandmata granulite complex, Northwestern India: Precambrian Research, v. 83, p. 267-290. First author at Dept. of Geological Sci., Jadavpur Univ., Calcutta-700 032, India.

The granulite facies rocks are intruded by enderbite and metanorite. Reaction textures, geothermobarometric data and phase equilibria considerations that (a) the granulite facies rocks were metamorphosed at ca. 8 kbar, 820°C, (b) enderbite and metanorite were emplaced, (c) all the rocks were subsequently metamorphosed at ca. 6.5-7 kbar, 650-700°C, and (d) the rocks were affected by non-pervasive hydrous F flux either prior to or during the later metamorphism. (From authors' abstract by E.R.)

de GROOT, P.A., 1997, The uses of stable isotopes in mineral exploration: An overview: Economic Geol. Research Unit Information Circular No. 310, Univ. of the Witwatersrand, Johannesburg, 36 pp. Author at Economic Geol. Research Unit, Dept. of Geol., Univ. of the Witwatersrand, P/Bag 3, WITS 2050, South Africa.

Briefly discusses the use of FI to the topic. (H.E.B.)

de RONDE, C.E.J., CHANNER, D.M. DeR. and **SPOONER, E.T.C.**, 1997, Archaean fluids: Oxford Monographs on Geol. and Geophys., v. 35, p. 309-335.

Indexed under FI (E.R.)

de RONDE, C.E.J., CHANNER, D.M.DeR., FAURE, Kevin, BRAY, C.J. and **SPOONER, E.T.C.**, 1997, Fluid chemistry of Archean seafloor hydrothermal vents: Implications for the composition of circa 3.2 Ga seawater: Geochim. Cosmo. Acta, v. 61, no. 19, p. 4025-4042. First author at Earth and Ocean Sci. Research, Univ. of Otago Campus, P.O. Box 56, Dunedin, NZ.

Seafloor hydrothermal vents of mid-Archean age (ca. 3230 Ma) have been identified and mapped in the Barberton greenstone belt, South Africa, and are known as the Ironstone Pods. FI Th data, when combined with G chromatographic data, provide a minimum calculated water depth for the pods of 982 m.

Ironstone Pod hydrothermal F endmember concentrations (Mg = 0) of various dissolved components derived from bulk FI crush-leach experiments, include: Cl (730 mmol/L), Br (2.59), I (0.058), Na (822), NH_4 (11.4), K (21.5), Ca (42.6), and Sr (0.15). This hydrothermal F also contains up to 1.07 mol% CO_2, 0.03 mol% N_2, 0.02 mol% CH_4, 262 ppm COS, and minor amounts or C_2-C_4 hydrocarbons. Hydrothermal endmember Ca, Sr, and NH_4, in particular, and to a lesser degree K, I, and CO_2, commonly plot on, or very close to, modern vent F trends. By contrast, endmember Na and Br concentrations are distinct (higher) from modern vent F. High I and NH_4 concentrations are consistent with contributions from sediments and/or organic matter. Calculated $\delta^{18}O_{H_2O}$ values for the pod hydrothermal endmember F define a narrow range from 0.9 to 1.6‰, very similar to that of modern vent F values (0.4-2.1‰).

A best estimate for the Ironstone Pod seawater endmember composition is Cl (920 mmol.L), Br (2.25), SO_4 (2.3), I (0.037), Na (789), NH_4 (5.1), K (18.9), Mg (50.9), Ca (232), and Sr (4.52). Barberton seawater components are commonly within an order of magnitude of modern seawater values, with the exception of significantly higher I, NH_4, Ca, and Sr in the I. Sulfate concentrations are minimum estimates for Barberton seawater. FI samples containing the greatest amount of seawater component have higher N_2 (up to 0.1 mol%) and low CO_2, when compared to samples dominated by the hydrothermal endmember F. Barberton ambient seawater is considered to have been an evaporative brine of NaCl-$CaCl_2$ composition during the time of pod deposition.

Ironstone Pod FI seawater endmember (Br/Cl and I/Cl values of 2.45 x 10^{-3} and 40.2 x 10^{-6}, respectively, are within error of bulk Earth (2.38 x 10^{-3} and 190 x 10^{-6}) and are consistent with the chemistry of 3.23 Ga Barberton seawater being buffered by the mantle. (Authors' abstract)

DeSCHUTTER, G., JAMES, R., GOFF, S. and McDONALD, A., 1997, Gold mineralization and associated alteration in Algoma-type banded iron formation, Snow Goose Grid, Meliadine Trend, Rankin Inlet Area, NWT (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A37. First author at Falconbridge Ltd. Exploration, P.O. Box 1140, 517 Moneta Ave., Timmins, P4N 7H9.

Gold mineralization in altered ca. 2.6 Ga Algoma-type banded iron formation (BIF) occurs discontinuously along the Meliadine Trend, 20 km north of Rankin Inlet, NWT.

FI in quartz veins intimately associated with auriferous sulphides are H_2O-rich and have low sal. (approximately 5 wt.% NaCl eq.). Those from relatively gold-barren drill holes have significant CO_2 contents and moderate to very high sal.

FI data, the association of gold with sulphides, and the composition of minerals formed through reaction(s) between original BIF components and auriferous hydrothermal F, suggest that gold was transported as a reduced bisulphide complex (Au(HS)2-). Oxidation of the hydrothermal F due to amphibole-forming reactions and a reduction in sulphur fugacity via sulphidation of magnetite in the BIF are probable mechanisms responsible for the precipitation of free gold in the Snow Goose Grid hydrothermal system. (From authors' abstract by H.E.B.)

de VIVO, Benedetto, AYUSO, R.A., BELKIN, H.E., BLACK, Stuart, MACDONALD, Ray, McGEEHIN, J.P., PAONE, Angelo, ROLANDI, Giuseppe, RUBIN, Meyer, TOROK, Kalman and WEBSTER, J.D., 1997, Geochemical and isotopic (Nd-Pb-Sr-O and U-Th series) variations, fluid-melt inclusion studies and ^{14}C dating bearing on the genesis and evolution of volcanic rocks from Mt. Somma-Vesuvius, Italy: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 84-85. First author at Univ. di Napoli "Federico II", Italy; email (devivo@biol.dgbm.unina.it).

Silicate-melt I have been studied by microthermometry, electron microprobe and ion microprobe (SIMS) analytical techniques in lava phenocrysts (cpx, olivine, leucite and plagioclase) from activity >25,000 yBP, between 17,000 and 14,000 yBP, and between 472 and 1631 AD, in order to examine pre-eruptive volatile contents and magma evolution. Petrographically, the I fit into three general types: (1) transparent glass, bubble + a small opaque phase; (2) transparent glass, dxls (cpx and oxide), bubble, and (3) I containing a variety of accidentally trapped solid crystals (apatite or oxide). Some I appear to be completely devitrified. Cpx hosted I yield Th from 1170 to 1260°C with the majority between 1220 and 1240°C. Plagioclase-hosted I have Th from 1210 to 1230°C. I hosted by olivine darkened during heating, obscuring Th at >1000°C, and those in leucite decrepitated and/or stretched. The included bubble(s) is usually larger than that resulting from pure shrinkage and indicates the presence of volatiles. Electron microprobe and SIMS analyses indicate that SO_3, Cl, B, Li, Sr and Th show a systematic increase from older to younger products (i.e. from >25,000 yBP to 1631 AD); Zr and Y show opposite behavior. Chondrite-normalized REE patterns (Ce, Sm, Dy, Yb) show moderate light-rare earth enrichment (CeN/YbN ranges from 5 to 20) with minor differences among different age samples. SIMS determined H_2O content varies between 0.6 and 2.7 wt.%, Cl between 0 and 1 wt.%, F between 0 and 0.63 wt.% and SO_3 between 0 and 0.5 wt.%. (From authors' abstract by E.R.)

DECITRE, Sylvie, MARIGNAC, Christian and GASQUET, Dominique, 1997, Magmatic fluids in the La Clarté orbicular granite (Ploumanac'h granite complex, N. Brittany, France): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 80-81. Authors at CRPG-CNRS BP 20 54 501 Vandœuvre Cedex France; email (decitre@crpg.cnrs-nancy.fr).

In the Late Carboniferous Ploumanac'h magmatic complex (N. Brittany), a 600 m^3 orbicular granite body displays huge orbicules (c. 10 cm), with a Kfs nucleus and a radiating shell of micropegmatitic plumose Kfs megacrysts; and a matrix of fine-grained granite, with pegmatitic patches. The latter are thought to have evolved from an unmixed magmatic F, late in the crystallization of the orbicular magma.

Six quartz samples from the [host] La Clarté granite and from the pegmatite patches in the orbicular facies were studied for FI.

Five types of FI were recognized: (i) aq two-phase FI, homogenizing in the L phase (Lw), occurring in sealed microcracks (FIP); (ii) aq three-phase FI, with a halite cube (LwSh), either isolated or in short FIP; (iii) aq multi-phase FI with two solids (LwS2), a halite cube and an unidentified birefringent crystal, prismatic in shape (Kfs is suspected); they occur isolated or in FIP; (iv) carbonic two-phase FI, homogenizing in the L phase (Lc), mainly found isolated; (v) three-phase carbonic FI, homogenizing in the carbonic L phase (Lc-w), with a water to CO_2 ratio between 20 and 50%; they sometimes contain in addition a halite cube (Lc-wSh); occurring either in FIP or as aggregates, they are consistently associated with the LwS2 FI.

Type (ii) FI are restricted to the La Clarté granite, whereas types (iii), (iv) and (v) are only found within the pegmatite quartz from the orbicular granite.

(The results of the microthermometric measurements are summarized in a table.) The first melting T (Te) are generally low (-50 to -65°C), in all types of FI. The Lw FI appear to exhibit some differences according to their setting either in the La Clarté granite or in the orbicular granite. The L-V homogenization in LwSh, LwS2 and Lc-wSh FI occurs always before the melting of solids, which could not be achieved by hearing up to 450°C.

Two distinct F were present at the pegmatitic stage in the orbicular granite: a dense NaCl brine (W1), containing other cation chlorides, and a carbonic F (C1), close to pure CO_2.

It is known that the La Clarté granite was emplaced under a confining P of 2 kbar. At such a P, aq and cabonic F are totally miscible, even for high saline contents of the aq F (Bowers and Helgeon, 1983). Indeed, the Lc-w and Lc-wSh types of FI are convincing evidence that the C1 F was able to mix in various proportions with W1 (or the pristine W0 F, see below). Therefore, the coeval W1 and C1 F cannot be taken as the result of the unmixing of an earlier F of the C-O-H salts system, unless an unrealistic transient drop of P is called for.

Due to the absence of any aq V, the W1 F cannot be derived from the unmixing of an earlier salt-undersaturated aq F. Thus, it must be concluded that W1 evolved from a very saline undersaturated brine (W0), due to a T decrease at constant P. Modeling the F in the H_2O-NaCl system with the data of Bodnar (1994), it is found that the W1 isochores (Th c. 400°C) are consistent with the homogenous trapping of a W0 brine (c. 60 wt.% NaCl) at ≥2 kbar and T >500°C. The constructed isochores for the Lc FI intersect the 2 kbar isobar at T in the 475-650°C range; therefore, it is likely that the C1 and W0 F coexisted at such high T. However, the Lc-w isochores intersect the 2 kbar line at lower T (375-425°C).

Thus, magmatic F, represented by the W0 brine, were unmixed from the crystallizing orbicular magma and were collected in more or less coalescent patches, leading to the crystallization of pegmatites at T close to 650°C. Residual magmatic brines were still present in the crystallized orbicular rocks, down to c. 375°C; they eventually became oversaturated in halite (W1 brine).

Since the late magmatic stage, a carbonic F (C1) was simultaneously present in the orbicular body, and was able to mix with the magmatic F. The origin of C1 is not clear; it may be tentatively ascribed to the degassing of coeval mafic magmas. Indeed, mafic magmas are present as huge I in the Ploumanac'h complex; and minute rounded mafic I were present in the orbicular magma, acting as nucleus for some orbicules. (From authors' abstract by E.R.)

DEINES, Peter, HARRIS, J.W. and GURNEY, J.J., 1997, Carbon isotope ratios, nitrogen content and aggregation state, and inclusion chemistry of diamonds from Jwaneng, Botswana: Geochim. Cosmo. Acta, v. 61, no. 18, p. 3993-4005. First author at Dept. of Geosci., Pennsylvania State Univ., University Park, PA 16802.

A detailed study of diamonds from the Jwaneng kimberlite leads to the conclusion that diamonds formed in at least seven physically or chemically distinct environments and over an extended time interval which may have lasted as long as 3 Ga.

The work revealed a $\delta^{13}C$ range for P-type (peridotitic) diamonds from -3 to -14‰; E-type (eclogitic) diamonds have a $\delta^{13}C$ range from -4 to -19‰ and more $\delta^{13}C$ values lower than -10‰. The nitrogen content of P-type diamonds tends to be lower than that of the E-type, but the degree of nitrogen aggregation of the two types is indistinguishable. Among those E-type diamonds for which a nitrogen aggregation age could be computed, low $\delta^{13}C$ diamonds tend to show older ages.

P-type diamonds are more often octahedral and green coated or brown and deformed than E-type diamonds. The latter are more often colorless, partially resorbed, and of irregular shape. It is postulated that diamonds containing olivines formed in at least three different environments based on their nitrogen content, $\delta^{13}C$ value, and the chemical composition of the I. The Jwaneng peridotitic minerals I suite (ol, gt, chr) is enriched in Fe compared to similar suites from other southern African kimberlites. Considering these suites together one observes that the Fe content of olivine I is negatively correlated with the $\delta^{13}C$ of their hosts.

In the suite of E-type diamonds no compositional subgroups could be identified, but, the Mg content of the E-type mineral suite tends to be lower than that of E-type I in diamonds from other southern African kimberlites. It is suggested that as many as four distinct time/T histories for E-type diamonds can be discerned based on coexisting garnet/clinopyroxene equilibration T, the nitrogen content, and the state of nitrogen aggregation in the host diamonds. (Authors' abstract)

DELLA-PASQUA, F.N., 1997, Primitive ankaramitic melts in island arcs: Evidence from melt inclusions: PhD dissertation, Univ. of Tasmania, Hobart, xxx pp.

Chapter titles:

1. Characteristics of ankaramite rocks
2. Ankaramite samples from Indonesia and Vanuatu
3. Primitive ankaramitic melts in island arcs: Evidence from melt inclusions
4. "Fe-loss" in melt inclusions hosted in olivine
5. Dry, hydrous, and CO_2-bearing phase relations for ankaramite composition based on melt inclusion compositions
6. The formation of Al-spl in melt inclusions
7. Synthesis

References

Appendix 1-Analyses of rocks

Appendix 2.1-Analytical details

Appendix 2.2-Electron microprobe analyses of olivine phenocrysts

Appendix 2.3-Electron microprobe analyses of clinopyroxene

Appendix 2.4-Electron microprobe analyses of olivine-spinel inclusions pairs

Appendix 2.5-Electron microprobe analyses of Ca, Mn, Ni and Cr in olivine.

PFI were found adjacent to chromian spinel I in olivine phenocrysts from ankaramites of the Rinjani volcano and elsewhere. They contained some CO_2.

See also next item (E.R.)

DELLA-PASQUA, F.N. and **VARNE, Rick,** 1997, Primitive ankaramitic magmas in volcanic arcs: A melt-inclusion approach: The Canadian Mineralogist, v. 35, p. 291-312. Authors at Dept. of Geol., Univ. of Tasmania, GPO Box 252-79, Hobart, Tasmania 7001, Australia.

Ankaramite is more mafic than basalt, commonly porphyritic, and generally interpreted as a variety of picrite or olivine basalt that has been enriched in clinopyroxene crystals rather than a product of crystallization of an ankaramitic magma. Samples of ankaramite from the Ulakan Formation, Bali, and Rinjani volcano, Lombok, both in the Sunda arc, and from Merelava and Epi, in the Vanuatu arc, contain olivine and clinopyroxene phenocrysts with vitreous and crystalline I. Heated and homogenized silicate M I hosted by olivine with $Fo_{>90}$ have CaO/Al_2O_3 (wt.%) values >1, and are rich in Mg (>14 wt.% Mg) and Ca (>13 wt.% CaO), and therefore have ankaramitic affinities and are quite unlike picrites. Although the composition of the I provides evidence that primitive ankaramitic M exist, they are consistently more silica-undersaturated than the ankaramitic bulk-rock compositions. Primitive ankaramitic M are substantially higher in their normative diopside contents than the compositions of experimental M of dry lherzolite at all P up to 4 GPa, which typically are picritic. Olivine fractionation of P komatiite-like M with CaO/Al_2O_3 (wt.%) values >1, derived by partial melting of lherzolite at high P (>5 GPa), could produce compositions similar to primitive ankaramitic samples. Such M would be likely to react with mantle during ascent to become less silica-undersaturated and more like ankaramitic bulk-compositions. (Authors' abstract)

DEMÉNY, Attila, GATTER, István and **KÁZMER, Miklós,** 1997, The genesis of Mesozoic red calcite dikes of the Transdanubian range (Hungary): Fluid inclusion thermometry and stable isotope compositions: Geologica Carpathica, v. 48, no. 5, p. 315-323. First author at Laboratory for Geochem. Research, Hungarian Acad. of Sci., Budaörsi út, H-1112 Budapest, Hungary.

Red calcite dikes with widths of 1-3 m were formed during the middle and upper Cretaceous within Mesozoic sedimentary carbonate rocks in the Transdanubian range of Hungary. The dikes frequently develop a complex zonation with fine-grained dark red calcite at their margins and purer and more coarsely crystalline calcite toward their centres. The staining material responsible for their colour is amorphous Fe-oxide-hydroxide whose amount remains below 1%. The FI of carbonates contain rather dilute (<3.5 NaCl eq. wt.%) solutions and frequently show boiling phenomena. The evidence of boiling makes use of Th data (100-190°C) as estimates of formation T possible. The Th-sal plot of the microthermometric data reveals that boiling, cooling and dilution processes were operating during calcite precipitation. The stable carbon and oxygen isotope compositions of calcites and hydrogen isotope compositions of I waters indicate that the formation of red calcite dikes was induced by the ascent of magmatic H_2O-CO_2 F which suffered degassing prior to and during dike formation and was contaminated by meteoric waters originating from the neighbouring rocks. The assumed movements of the magmatic F fit well into the results of earlier studies which have shown direct effects of magmatic F around lamprophyre dikes and influences of magmatic F in the formation of manganese oxide ores during the Cretaceous in the area of the Transdanubian Range. (Authors' abstract)

DEMOUSTIER, Axelle and **CASTROVIEJO, Ricardo,** 1997, Fluid inclusion characterization of the Carneros epithermal ores (Cabo de Gata, Almería, SE Spain): Preliminary results: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 82-83. Authors at ETSIMinas, Ríos Rosas, 21, E-28003 Madrid, Spain; email (rcastro@dinge.upm.es).

This paper deals with the Carneros low-sulphidation, (adularia-sericite) Au-Ag epithermal deposits, in altered andesites of the Cabo de Gata area (Almería).

The samples selected for FI study belong mainly to the main sulphide phase. The complex chronology of the hydrothermal infill is supported by the study of quartz generations. The original textures are freqeuntly overprinted by recrystallization.

FI study was begun by detailed FI petrography on the various quartz types from different samples of the Carneros vein field, aiming at the characterization of the different families present and at the identification of P FI to establish the conditions of vein quartz formation. P FI are ubiquitous, although frequently very small (to <1µm). Boiling is suggested by the coexistence in the same growth zone of: -primary biphase aq I with vapour FI. Preliminary observations point to Th in the range 200-250°C. The FI are water-rich, undersaturated, and suggest the involvement of meteoric waters. (From authors' abstract by E.R.)

DIETRICH, A., LEHMANN, B., WALLIANOS, A. and **TRAXEL, K., 1997,** The Lower Miocene tin porphyry system of Llallagua, Bolivia: Bulk rock and melt inclusion geochemistry: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 625-628. First author at TU Clausthal, Institut für Mineralogie und Mineralische Rohstoffe, Clausthal-Zellerfeld, Germany.

The tin porphyry system of Llallagua, Bolivia, consists of a 1.6 km^2 large subvolcanic stock intruded in a Lower Paleozoic clastic sequence. The intrusion is composed of a rhyodacitic porphyry core, an igneous breccia near the margins, and rhyodacitic dikes. Cassiterite-tourmaline mineralization is directly related to pervasive hydrothermal overprint. Sericitization is dominant near the surface, tourmalinization increases towards depth. Pipe- and dikelike bodies of hydrothermal breccias crosscut the stock.

Bulk rock geochemistry of the porphyry defines a rhyodacitic to dacitic composition with moderate degree of fractionation. The hydrothermal overprint has resulted in strong enrichment of B, Bi and Sn (>100x upper crust), and in moderate enrichment of Sb, Pb, Ag, As, Au, W (10-100 X upper crust). The geochemistry of M I in quartz phenocrysts is distinctly different from the bulk rock geochemistry. Electron and proton microprobe data indicate a fairly fractionated M with TiO_2 ± 1 wt.% Zr 20-80 ppm, Ta ± 8 ppm and Rb/Sr up to 20. The M I data align with the general fractionation trend of Tertiary igneous rocks of the Andean tin belt. The Llallagua porphyry system appears to be related to a larger and partly rhyolitic magma chamber not fully represented by the exposed rock. (Authors' abstract)

DILL, H.G., PERTOLD, Z. and RIERA KILIBARDA, C., 1997, Sediment-hosted and volcanic-hosted Sb vein mineralization in the Potosi region, central Bolivia: Economic Geol., v. 92, p. 623-632. First author at Federal Inst. for Geosci. and Natural Resources, P.O. Box 510153, D-30631 Hannover, Germany.

Includes study of CO_2 FI in barite and quartz, and aq FI with 0-12% sal and (one mine) 15-21%. Th = 100-270°C. (E.R.)

DINGWELL, D.B., HOLTZ, F. and BEHRENS, H., 1997, The solubility of H_2O in peralkaline and peraluminous granitic M: Amer. Mineral., v. 82, p. 434-437.

DINTER, D.A., SELVERSTONE, Jane and BARTLEY, J.M., 1997, Fluid inclusion data concerning kinematics of core complex unroofing, Raft River Mountains, Utah (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-233–A-234. First author at Dept. of Geol. and Geophys., Univ. of Utah, Salt Lake City, UT 84112; email (dadinter@mines.utah.edu).

Microthermometric analyses of FI in mylonites in the Raft River metamorphic core complex, northwestern Utah, limit P-T conditions of deformation. Determining the P-T conditions under which postmylonitic structures formed permits a rigorous assessment of their origins (cf. Selverstone et al., 1995, Tectonics). (From authors' abstract by E.R.)

DIXON, J.E., 1997, Degassing of alkalic basalts: Amer. Mineral., v. 82, p. 368-378. Author at Div. of Marine Geol. and Geophys., Rosenstiel School of Marine and Atmos. Sci., Univ. of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149.

In order to model quantitatively exsolution of volatiles over the range of basaltic M compositions found on oceanic islands, I present compositional parameterizations of H_2O and CO_2 solubilities and use these parameterizations to develop V saturation and degassing models for alkalic basaltic L. V-saturation diagrams generated as a function of M composition are used to determine the P at which the M was last in equilibrium with a V and the composition of the V phase based on measured H_2O and CO_2 contents in basaltic glasses. These models allow the calculation of the P at which a magma of known initial volatile content reaches V saturation and begins to exsolve a V phase. Partitioning of H_2O and CO_2 into the V during volatile exsolution is controlled by the difference between H_2O and CO_2 solubilities. As M become more alkalic, the relative difference between H_2O and CO_2 solubilities decreases, thus diminishing the preferential partitioning of CO_2 into the V. Exsolution of volatiles from tholeiites is characterized by strong partitioning of CO_2 into the V such that most or all CO_2 is lost before any significant loss of H_2O. In contrast, the combination of higher CO_2 solubility and higher volatile contents (and perhaps higher CO_2/H_2O ratio) in alkalic M results in less fractionation between CO_2 and H_2O during volatile exsolution. (From author's abstract by E.R.)

DIXON, J.E., CLAGUE, D.A., WALLACE, Paul and POREDA, Robert, 1997, Volatiles in alkalic basalts from the North Arch volcanic field, Hawaii: Extensive degassing of deep submarine-erupted alkalic series lavas: J. of Petrol., v. 38, no. 7, p. 911-939. First author at Div. of Marine Geol. and Geophys., Rosenstiel School of Marine and Atmos. Sci., Univ. of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149.

Glasses from these lavas were analyzed for H_2O, CO_2, Cl, S, $Fe^{3+}/\Sigma Fe$, and noble G to investigate the role of volatiles in the generation, evolution, and degassing of these alkalic series lavas. (From authors' abstract by E.R.)

DOBES, P. and DURISOVÁ, J., 1997, Character of palaeofluids in the western part of the Bohemian massif: A fluid inclusion record: (abst): MAEGS, 10th Meeting Association of European Geological Societies, Sept. 1-5, 1997, Carlsbad, Abstracts: J. Czech Geol. Soc., v. 42, no. 3, p. 51. Authors at Czech Geological Survey, Klárov 3, 11821 Prague 1, Czech Republic.

New data on palaeofluids from mineral associations of several geological units of the Western Bohemian Massif were obtained within the framework of the project "Geological model of Western Bohemia in relation to the deep borehole KTB in the FRG". A combination of optical microthermometry and micro-Raman spectrometry (carried out in CREGU, Nancy) was applied on FI from rocks of several units: HP-HT granulites, quartz veins (partly Au-bearing), LP-LT Upper Proterozoic volcano-sedimentary rocks, and Pb-Zn vein epithermal mineralization in the Bohemicum (the Stribro ore district).

The content of H_2O, CO_2 and $CH_4 + N_2$ phases is very variable in metamorphic minerals. The amount of CO_2 in F increased with the metamorphic grade. The I of water-free L CO_2 are typical of minerals from granulites. The F with predominance of CH_4 and/or N_2 belong to relatively late generations of I, which originated under lower T (<350°C) and P (<100 MPa). The presence of CH_4-rich F in minerals from the inter-pillow matrix metavolcanic rocks is connected with basalt-sediment-seawater interaction.

The Late Variscan palaeofluids of the Pb-Zn mineralizations (the Stribro type) are characterized by mixing of chloride solutions of variable Na-K-Mg-Ca composition. Ion chromatographic technique (carried out in USGS, Denver) also revealed elevated bromide and ammonium concentrations suggesting that the F reacted with organic-rich lithologies.

FI in granulites formed during their retrograde development under the amphibolite-grade and lower metamorphic conditions (down from about 650°C and 400-450 MPa).

The study of FI in the products of basalt-sediment-seawater interaction from the volcano-sedimentary complex showed that H_2O-rich I (Th to 315°C) probably represent an initial stage of interaction, whereas later H_2O-CH_4 I were trapped during the subsequent F circulation under lower T of about 200°C and P not exceeding 100 MPa.

Th of I in minerals from the Stribro ore district vary from 130°C to about 100°C for quartz, fluorite, dolomite-ankerite and sulphidic minerals. For late barite and calcite, these were <100°C. The hydrothermal veins represent low-T F circulation through open tensional fault zones in the consolidated and relatively cold crust. (From authors' abstract by E.R.)

DOBES, Petr, SUCHY, Václav, SEDLÁCKOVÁ, Vladimíra and **STANISOVÁ, Nikol,** 1997, Hydrocarbon fluid inclusions from fissure quartz: A case study from the Barrandian basin (Lower Paleozoic), Czech Republic: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 86-87. First author at Czech Geological Survey, Klárov 3, 118 21 Prague 1, Czech Republic.

Hydrocarbon-I bearing authigenic quartz crystals are commonly found in fractures and veins that cross-cut Silurian and Devonian carbonate rocks of the Barrandian Lower Paleozoic Basin.

Euhedral quartz isolated from extension veins bears abundant I of both solid and L organic materials. Irregular blebs of a dark opaque substance up to 1 mm in diameter, thought to represent bitumens, were found randomly dispersed in many quartz crystals. These solid I do not exhibit any visible fluorescence which may point to relatively highly matured bituminous substance.

Quartz contains a number of two-phase P hydrocarbon I of negative crystal shape, from 10 to 200 mm [µm?] in size, with consistent L to V ratios (of about 10 vol.% of V phase). Larger I occur rarely, mostly with variable LVR, some containing immiscible yellowish waxy substances. No aq I have been found in this quartz type.

At room T, most hydrocarbon I contain a colorless or light yellow-brown L and a V bubble. When examined under long wavelength ultraviolet light (365 nm peak of Hg), the L phase of FI fluoresces a deep blue, light blue and light blue-green (40-50° API gravity) i.e., the fluorescence colours characteristic of light oils and condensates (Burrus et al, 1985). Many quartz crystals exhibit a distinct geographic pattern of fluorescence: I with light blue fluorescence tend to be located near the crystal core, whereas dull blue and blue-green fluorescent I are concentrated along the crystal rim. Th vary from 51 to 101°C with two peaks at 80-90°C for crystal core and at 60-70°C for marginal zones.

The I are composed of multicomponent mixtures of hydrocarbons including n-alkanes C10-C23 and phenantrene that can, as a possible product of pyrolysis, indicate higher T of crystallization.

Flat polygonal quartz crystals from shear fractures contain finely dispersed tiny particles of a brown to black non-fluorescent bituminous substance concentrated in growth bands. Further, numerous small (5-20 µm in wide) two-phase I of L hydrocarbons with about 10 vol.% of V phase are present in crystal cores that fluoresce dull blue and deep blue-violet. Brightly yellow and orange fluorescent I indicative of heavier oils occur in crystal rims. Th were measured between 55 and 80°C for crystal cores and from 36 to 50°C for crystal rims.

The above outlined petrographical observations combined with microthermometric data from FI indicate that quartz from extension veins must have crystallized late in the diagenetic history, most probably during deeper burial, at T of about 100°C. The crystallization T of vein quartz documented in this paper is only slightly lower than the maximum burial T based on vitrinite reflectance data acquired from sediments in the close vicinity of the veins. Mineralization of thin quartz in shear fractures probably occurred later, at T between 55 and 80°C, and may have been related to fracturing associated with uplift and erosion. (From authors' abstract by E.R.)

DOBES, Petr, VIETS, John, ZÁK, Karel and **LEACH, David,** 1997, Pb-Zn vein mineralization of the Stríbo ore district, Bohemian massif: An example of epithermal fluid circulation: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 88-89. First author at Czech Geological Survey, Klárov 3 118 21 Prague 1, Czech Republic.

FI have been studied in various minerals of the paragenesis. The I in virtually all the minerals have variable L to V ratios. L-only, V-only or two-phase I of water solution have been found. This is interpreted as the result of continued healing and necking of I at low T after nucleation of the V phase rather than the result of boiling. Therefore Th have been measured in infrequent small 3D clusters of P I with consistent L to V ratios and in S I along healed microfractures. Th varies from 130 to ~100°C for pre-sulphidic and sulphidic minerals to <100°C for late barite and calcite.

Valuable information on solute composition of the I has been determined by cryometry and ion chromatographic technique. FI cryometry have shown a wide range in Te (-38 to -71°C) and Tm (-28 to -0.1°C) of the last crystal of ice in individual minerals, even within single growth-zoned crystals, indicating mixing of at least two F types. Precipitation of the main sulphidic stage and the large quantity of quartz is characterized by high sal F. Eight analyses are given in terms of molar ratios to Cl, for Na, NH_4, K, Mg, Ca, F, Br, SO_4 and S_2O_3. The bromide content is significantly higher than predicted for evaporated seawater (molar Cl/Br = 46 to 198). Samples with elevated bromide also generally have elevated ammonium concentrations suggesting that the F reacted with organic-rich lithologies. The ammonium ions are most likely from trapped ammonia gas in the FI which is reflected by the poor charge balance of samples with high NH_4/Cl values ($NH_4/Cl \leq 1.071$).

Based on S, C, O, Pb and Sr isotopes, local country rocks of the upper crustal rock sequences represent the dominant source of dissolved F components that were extracted from well consolidated and relatively cold crustal rocks by deeply circulating F of variable sal and composition. Late barite and calcite deposition was characterized by a T decrease and F oxidation as a result of influx of low $\delta^{18}O$ shallow circulating F with lower sal. (From authors' abstract by E.R.)

DOMINY, S.C., LeBOUTILLIER, N., SCRIVENER, R.C., BUSSELL, M.A. and **HALLS, C.,** 1993, Late-stage crosscourse veining in South Crofty mine, Cornwall: Preliminary textural and fluid inclusion studies (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). First author at School of Earth Sci., Univ. of Greenwich, London E1 2NG., U.K.

The NE-trending, main-stage cassiterite bearing lodes of South Crofty mine are cut by a series of late-stage barren quartz crosscourse structures. The aim of this work is to establish the textural and F characteristics of these veins and to relate them to the paragenesis and structural evolution of the deposit. They are extensional fissures filled with quartz and chalcedony, with variable amounts of fluorite, pyrite, siderite, bituminous pitch and rare calcite. Two varieties are seen, the first is represented by massive milky quartz with open cavities. Breccias exist where wallrock fragments are isolated by quartz veining and where main-stage lodes are crosscut. The second variety is characterised by banded and vuggy textures with fine-grained chalcedonic quartz, jasper and clay. Vein reactivation has given rise to cockade textures and the deposition of further chalcedony and hematite and chlorite. The present work has shown evidence of mainstage lode reactivation which has displaced the fracture fill crosscourses by a few tens of centimetres. Studies of P FI in banded quartz show a population dominated by L-V I which have degrees of fill >0.85. Preliminary microthermometric work gives a minimum Tt range of 100-175°C and sal range of <1-8 eq. wt.% NaCl. A number of irregularly shaped I give minimum Tt of between 125 and 175°C, a sal range of 19-25 eq. wt.% NaCl and Te close to -52°C suggesting a $CaCl_2$ composition. These F are likely to represent basinal brines that were tapped from adjacent sedimentary basins during wrench-fault activity. (From authors' abstract by E.R.)

DONG, Guoyi and **POLLARD, P.J.**, 1997, Identification of ferropyrosmalite by Laser Raman microprobe in fluid inclusions from metalliferous deposits in the Cloncurry District, NW Queensland, Australia: Mineralogical Magazine, v. 61, p. 291-293. Authors at National Key Centre in Economic Geol., Dept. of Earth Sci., James Cook Univ. of North Queensland, Townsville, Q 4811, Australia.

Ferropyrosmalite, an iron-rich member of the pyrosmalite series [$(Fe,Mn)_8Si_6O_{15}(OH,Cl)_{10}$], has been discovered as one of the most common dm in multiphase FI from many Cu-Au-Co and Pb-Zn-Ag deposits in the Cloncurry District, NW Queensland, Australia.

The FI studied occur in hydrothermal infill and alteration quartz, which is closely associated with sulphide mineralization. They contain L, V, and more than three solid phases at room T. Relative proportions of the main solid phases vary from sample to sample, but are similar within individual quartz grains [dms include halite plus K-Pb chlorides]. This suggests that the solid phases are dm rather than captive phases. One of the common dm in the FI is colourless to pale green, stubby or prismatic with high relief and moderate birefringence. Laser Raman microprobe analysis indicates this mineral has a Raman spectrum with distinct bands at 615 cm^{-1} and 1022 cm^{-1} (Fig. 2). Electron microprobe analysis of stubby or prismatic solids in opened I yields distinctive Si, Fe, Mn and Cl X-ray peaks. Ferropyrosmalite occus as a common retrograde hydrothermal phase in mineral deposits in the Cloncurry district.

During heating experiments the majority of the I decrepitated or stretched prior to total homogenization. Only a few of them survived, and the ferropyrosmalite was nearly always the last phase to be left in the I. With continuous heating, the ferropyrosmalite displayed one of the following three behaviours: (1) complete dissolution at T of 430-505°C, these are also the total Th of the I; (2) transition of the ferropyrosmalite crystal into a new solid phase via dissolution of the ferropyrosmalite crystal and simultaneous growth of a new round or prismatic crystal, beginning at 410-465°C and completed at about 430-510°C; and (3) stable and virtually no detectable decrease in size up to 520°C (the maximum T used in this study). The high Th are considered to represent the T of the mineralizing F prior to ore deposition.

This is the first report of ferropyrosmalite as a dm in FI. Caution should be exercised in the identification of dm using conventional optical properties and SEM techniques. Both ferropyrosmalite and Fe-(Mn)-chloride share many common features, e.g. similar crystal form, colour, relief, birefringence and SEM spectrum if the host mineral is quartz. In this particular case, Laser Raman microprobe analysis has provided an excellent tool to distinguish Fe-(Mn)-chloride from ferropyrosmalite.

It should also be noted that the second strongest band at 1022 cm^{-1} in the Raman spectrum of ferropyrosmalite is very close to the strongest band at 1019 cm^{-1} in the spectrum of anhydrite (Dubessy et al., 1983). Ferropyrosmalite could easily be misidentified as anhydrite if the analysis was only undertaken in the region 800-1200 cm^{-1} where many minerals show characteristic bands. It is therefore necessary to scan the whole region if the presence of ferropyrosmalite or anhydrite is suspected. (From authors' text by E.R.)

DONG, Guoyi, **RYAN, C.G.**, **POLLARD, P.J.** and **WILLIAMS, P.J.**, 1997, PIXE microanalysis of hypersaline fluid inclusions from Cloncurry ore systems: EGRU News (Economic Geol., Research Unit, James Cook Univ., Queensland), September Edition, p. 7-9. First author at Nat'l. Key Centre in Economic Geol., School of Earth Sci., James Cook Univ., Townsville, Qld.

Multiphase, hypersaline FI are one of the most common I types in Cloncurry ore systems. These I are believed to represent early hydrothermal F which were present predominantly during premineralization stages, and less commonly during early stages of mineralization. Results obtained using petrographic observations and conventional heating/freezing measurements on these I are remarkably similar for all studied deposits. The I are characterized by two to six dm at room T, and have very high sal (30-60 wt.% NaCl eq.) and high total Th (average 450°C).

This report presents recently acquired results of PIXE microanalysis of hypersaline FI from Cloncurry mineral deposits, including Cannington Ag-Pb-Zn deposit; Osborne Cu-Au deposit, Starra Au-Cu deposit, and Eloise Cu-Au deposit. The results indicate that the hypersaline FI are very complex chloride brines dominated by Na (inferred from the ubiquitous large halite dx), K (1.8-8.8 wt.%), Ca (1.3-18.0 wt.%), Fe (0.6-14.4 wt.%) and Mn (0.2-4.9 wt.%). However, variations in the compositions of these FI between studied deposits are quite significant, despite the overall similarities in daughter phases, sal and total Th.

The I from Cannington which were entrapped during a high T metasomatic event, contain very high Pb (2.2-8.9 wt.%), high Zn (0.12-0.73 wt.%), low Cu (<100 ppm), and are rich in Mn (1.2-4.9 wt.%) with low Fe/Mn ratios (0.5-2.2).

I from Osborne have very high Fe (2.6-14.4 wt.%) with Fe/Mn ratios of 8-33, low Pb (<50-270 ppm), significant Zn (320-1230 ppm), and variable Cu (78-911 ppm).

FI linked to Au-Cu mineralization at Starra contain high Cu (667-2810 ppm), high Pb (660-2110 ppm) and Zn (680-2430 ppm), have a low Fe/Mn ratio (1.5-2.7), and are very rich in Ba (0.3-1.2 wt.%) and As (620-2430 ppm) (both are more than one order of magnitude higher than values in I from the other deposits).

I from Eloise have low Fe/Mn ratios (0.5-3.2), high Pb (1070-1290 pm) and Zn (2670-4330 ppm), and variable Cu (<50-210 ppm). From authors' text by E.R.

DRAPER, D.S. and **GREEN, T.H.**, 1997, P-T phase relations of silicic, alkaline, aluminous mantle-xenolith glasses under anhydrous and C-O-H fluid-saturated conditions: J. of Petrol., v. 38, no. 9, p. 1187-1224. Authors at GEMOC: Arc Nat'l. Key Centre for the Geochem. Evolution and Metallogeny of Continents, School of Earth Sci., MacQuarie Univ., NSW 2109, Australia.

High-P liquidus experiments on three silicic, aluminous, alkaline M, modelled on glasses found in many mantle xenoliths, show that part of this compositional range is saturated with harzburgite (or possibly lherzolite) under anhydrous conditions. Accordingly, these kinds of L could act as cryptic metasomatic agents. If mantle at ~45-90 km depth is pre-enriched in low-melting-T components, and probably volatiles, via the ascent and percolation of alkaline, mafic L (along geotherms that cross inflections in the solidus of CO_2-bearing peridotite), then subsequent low-degree partial M could yield the L that are ultimately trapped as xenolith glasses. (From authors' abstract by E.R.)

DUAN, Zhenhao, 1997, Current status and future direction of the study of thermodynamics of geological fluids (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 1 (in English).

DUBESSY, Jean, LARGHI, Laurence and **CANALS, Martin,** 1997, Reconstitution of ionic composition of fluid inclusions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 90-91. Authors at CREGU, EP-578, BP-23, 54501 Vandœuvre-lès-Nancy Cedex, France; email (dubessy@cregu.cnrs-nancy.fr).

Unlike laser ablation ICP-MS, laser ablation optical emission spectroscopy does not provide any information on the concentration of chloride. Therefore, this paper is first focused on the determination of Cl^- concentration from the Raman spectroscopy of aq solution. The second part describes the exploitation of the data obtained in terms of bulk composition from the two analytical techniques and the accuracy of this technique is described.

The main modifications of the spectrum of water with increasing chloride concentrations are: i) the shift of the maximum intensity (V_{max}) toward high frequency (V_{max} = 3410 cm^{-1} for pure water, to 3450 cm^{-1} for a 6 molal NaCl solution); ii) the decrease in intensity of the shoulder located around 3200 cm-1; iii) the decrease in the full width at half maximum intensity of the band (FWHM=420 cm^{-1} for pure water, to 260 cm^{-1} for a 6 molal NaCl solution). The decomposition of the stretching band into three band components has been made, but cannot be correlated simply with the salt concentration. Therefore, we used the approach of Mernagh et al. (1989; GCA, 53, 765-771) and his "skewing" parameter S to monitor the modification of the shape of the Raman band and its shift versus the chloride concentration.

The "skewing" parameter S is linear with respect to total salt concentration (wt.%) for the system H_2O-NaCl and the ternary H_2O-NaCl-$CaCl_2$ (Na/Ca=0.3; 1;3). Calcium ion has an effect over the value of the S parameter above 5 wt.%. Therefore, Raman spectroscopy of aq solution can be used to derive Cl^- concentration with an accuracy around 10%.

Laser ablation optical emission spectroscopy (LA-OES) provide the ratios of molalities of elements. These are combined with Raman spectroscopy estimation of Cl concentration and the charge balance equation to yield the concentrations of the elements.

This method can be generalised to other cations and is currently developed together with the improvement of the cation analysis by laser ablation. Improvement in the determination of ion concentration can be made using thermodynamic modelling of ice or salt hydrate melting T with a Pitzer thermodynamic code. (From authors' abstract by E.R.)

DUBLYANSKY, Yuri and **FORD, Derek,** 1997, Paleoenvironment in hydrothermal karst: Evidence from fluid inclusions and isotopes of carbon and oxygen: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 92-93. First author at Inst. of Mineral. and Petrog., SB RAS, Novosibirsk, 630090, Russia; email (dublyan@uiggm.nsc.ru).

Recent studies of hydrothermal caves and their minerals revealed existence of at least two settings, characteristic of hydrothermal karst. These are: (1) deep-seated high-T setting and (2) shallow low-T setting (Dublyansky, 1995). Coupled isotopic and FI studies allow further development of this scheme. For this purpose we performed detailed isotopic profiles along the direction of growth of calcite crystals lining the cave walls. Several examples are discussed below.

In a deep-seated hydrothermal karst, calcite exhibits exceptionally flat patterns of both $\delta^{13}C$ and $\delta^{18}O$. The nearly constant and "heavy" (+1 to +3‰ PDB) values of $\delta^{13}C$ suggest deposition from F, in which dissolved carbon was isotopically equilibrated with the carbon of the bedrock limestone (long residence time, high rock/water ratio). Flat pattern of the $\delta^{18}O$ is somewhat enigmatic.

Th values range from 30 to 68°C with several peaks. An intermediate hydrothermal karst calcite is zoned, with Th dropping from about 70°C in the cave to about 55°C in the rim. The $\delta^{18}O$ drops from -15 to -10, then suddenly jumps to -18 at the crystal tip. A shallow hydrothermal karst crystal containing only all-L I, hence formed <~40°C, has a flat $\delta^{18}O$ curve but wide variations in $\delta^{13}C$ (-2 to -9). We attribute both these features to the input of isotopically light plant-derived soil carbon carried by meteoric waters that recharged deep thermal aquifer. The recharge area was located relatively close to the site of calcite deposition, and the carbon dissolved in the waters did not have time to isotopically equilibrate with the bedrock limestone/dolomite.

Our preliminary results indicate that coupled isotopic and FI studies can provide further insight into the paleoenvironment of hydrothermal karst, as well as other hydrothermal processes. This coupling may be particularly important when dealing with fossil systems developing at or close to the interface between the hydrothermal and the low-T vadose settings. (From authors' abstract by E.R.)

DUBOIS, M. and **MARIGNAC, C.,** 1997, The H_2O-NaCl-$MgCl_2$ ternary phase diagram with special application to fluid inclusion studies: Econ. Geol., v. 92, p. 114-119. First author at Univ. des Sci. et Tech. de Lille, URA 719, Sciences de la Terre, 59655 Villeneuve d'Ascq Cedex, France.

The available data on the system are reviewed and tabulated, and applied to the FI in barite from major hydrothermal fields in the Lau basin (E.R.).

DUBOIS, M., VILLASEÑOR-CABRAL, M.G., SAVARY, V. and GUIBINGA, A., 1997, A fluid inclusion study in the Pb-Zn-Ag district of Zimapán, Mexico: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 94-95. First author at Univ. of Lille, Sédimentologie et Géodynamique, Bldg. SN5, 59655 Villeneuve d'Ascq, France; email (Michel.Dubois@univ-lille1.fr).

Fluorite associated with the sulfosalt deposition stage (Las Animas mine), shows three FI types:

i) Type S: These I contain a salt cube at room T. Bulk homogenization occurs either by salt melting (range 250-304°C) or V disappearance (range 220-320°C). Calculated sal lie between 34 and 38 wt.% eq. NaCl, however the successive hydrate meltings at low T indicate a very complex composition.

ii) Type Lw-c: These large I are two-phase (L+V). They homogenize into the L phase (295±5°C). At low T, ice melts between -6.7 and -4.9°C. Clathrate melting (range -5.6/-3.8°C) indicate the presence of CO_2 in the V phase.

iii) Type Lw1: These two-phase I show very variable sal (2.4 to 13.5 wt.% eq. NaCl) and bulk Th between 288 and 320°C. Eutectic melting occurs between -26 and -23°C.

In the fluorite from the mine Juan Pablo, all FI are only saline, without any volatile component. Four main populations were identified according to the FIP direction and microthermometric behaviour. One population consists of two-phase I showing eutectic melting at ≅-26°C, ice melting at -19.0±0.2°C and hydrate melting at -6.6±0.2°C. Calcite crystals are sometimes present in the I (identified by Raman microspectrometry). Bulk homogenization occurs in a very narrow T range (262±1°C). In other populations, sal are highly variable and bulk Th vary from 250 to 200°C; eutectic melting occurs generally at -26°C but some populations show first melting as low as -60°C.

Samples from the Lomo de Toro mine differ from other samples by the presence of CO_2-bearing I. In these I, CO_2 melts close to -56.6°C, indicating a closely pure CO_2 composition. Clathrate melts between 10.6 and 11.8°C (in the absence of CO_2L and V). CO_2-bearing I are associated with two-phase aq I (sal ranging from 3.5 to 12.0 wt.% eq. NaCl) homogenizing between 200 and 250°C. This association suggests either a boiling process or local removals of early CO_2-bearing FIP by later saline F. (From authors' abstract by E.R.)

DuBOIS, Michel, WEISBROD, Alain, SHTUKA, Arben, MARTINEZ, S.R., The low-temperature (T<120°C) H_2O-RbCl phase diagram comparison with other water-alkali chloride systems. European J. of Mineral., v. 9, no. 5, p. 987-922.

DUDOK, I.V., KALYUZHNYI, V.A. and VOZNYAK, D.K., 1997, The particularities of phase composition and the problems of systematization of the hydrocarbon inclusions in "marmarosh diamonds" of the Ukrainian Carpathians: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 96-97. First author at Inst. of Geol and Geochem of Combustible Minerals, Ukrainian Nat'l. Acad. of Sci., Naukova St. 3a, 290053, Lviv, Ukraine.

Because of their morphological particularities, luster and transparency of these quartz crystals were called "marmarosh diamonds." Typical feature of this quartz is the presence of different hydrocarbon I. These I are represented by hydrocarbon mixtures of G, L and solid phases. At 20°C G and L phases could not be distinguished; their aggregate state may be determined only at the low T. The G phase is mainly methane. The L phase may [be] 1) water solution (L) with low content of salts, the volume of L in the I-up to 3-5%; 2) L hydrocarbon phase resembling "light oil" (L_1); or 3) condensed methane-butane mixture-L_2 (G_2), in normal conditions-L_2 (G_2)-G. Solid phase (B) is represented by bitumens of different composition: authigenic-paraffins and exogenic-anthraxolites, asphaltites, as occur in the free space of the veins. Anthraxolites do not react with G and L phases during the heating up to 250-280°C. F critical T have been found to range from -43 to +80.8°C.

Detailed investigations of hydrocarbon I permits reconstruction of the sequence of mineral-forming process and to trace the evolution of the composition of migrating hydrocarbon F in time. During the first stage the quartz formed in cracks under the domination of high-density (liquefied) methane (together with water solution)-I as G, L+G, L+L_2 (G_2). The T and P were maximal (T-up to 220-235°C, P-to 2.7 kbar). By decreasing in further P-T parameter of F the I such as L+L_1+G, L_1+G, L_2(G_2)+G+B, L_2(G_2)+L_1+B were formed. In the final stage of vein mineral- [material missing in original] methane (64.4-81.5%), minimal content of CO_2 (7.1-13.5%) and traces of heavy HC are noticed. The fact of HC intensive migration along the crack zones in Carpathians is also confirmed by composition of HC I in "marmarosh diamonds". Our data, like another published data, show that methane prevails in G I composition (up to 100%), and in composition of L HC I (45-60%), against the background of significant content of ethane (to 34%), propane (6-8%) and other heavy HC. (From authors' abstract by E.R.)

DUDOK, I.V., PETRICHENKO, O.I. and POBEREZHSKY, A.V., 1997, Hydrocarbon inclusions in vein minerals of the eastern Carpathians as an indicator of oil and gas migration: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 98-99. Authors at Inst. of Geol and Geochem of Combustible Minerals, Ukrainian Nat'l. Acad. of Sci., Naukova St. 3a, 290053, Lviv, Ukraine.

Thermometric investigations of I show the low decreasing of vein minerals formation T from southeast of Ukrainian Carpathians toward northwest, that is correlating with paleotemperature regime of enclosing deposits. The T of vein minerals forming are: calcite-from 250 to 80°C, "marmarosh diamond" quartz-from 220-235°C to 50°C. The P in hydrocarbon I (when T were maximal) change from 1.3 kbar to 2.7 kbar. Phase composition of HC I from "marmarosh diamonds" from Lower Cretaceous rocks of southeastern part of Ukrainian Carpathians is essentially G, in northwestern part-with significant amount of L HC and bitumens in L HC phase.

Analysis of G phase of I in vein calcite and quartz gave the important information about composition of migrating F in different regions of Ukrainian Carpathians and on different stages of vein mineral formation. Summarizing of data on G composition from I in calcite make possible the conclusion about its alteration from inner nappes of Carpathians toward Precarpathians foredeep: decreasing of methane contents from 81.55-86.6% to 21.1% and accordingly the increasing of CO$_2$ contents from 1.8-8.4% to 34.8%. In G composition of I in calcite from potentially oil-G-bearing Lower Cretaceous and the main oil-G-bearing Oligocene sedimentary complexes of Carpathians the maximal content of forming process at the T of 50-75°C and the P of 0.2-0.3 kbar the L hydrocarbons and hard bitumens prevail in the F composition and they form the I like L$_1$+G, L+L$_1$+G, L$_1$+B. Hard bitumens occur as accumulations on crystals faces, or fill the central part of the veins. (From authors' abstract by E.R.)

DUDOK, I.V., PETRICHENKO, O.I., POBEREGSKY, A.V. and **KAROLI, Stanislav**, 1997, Hydrocarbon inclusions in minerals of the sediments in the Ukrainian and Slovakian Carpathians sediments as possible indicator of oil-gas productivity: AAPG Bull., v. 81, no. 8, p. 1371.

Chemical and aggregate composition of hydrocarbon, their thermobaric condition and the time of migration have been determined on the base of FI study of epigenetic and diagenetic minerals. FI of epigenetic minerals have been studied from veins hosted in the Jurassic, Cretaceous and Paleogene sediments occurring in the eastern part of the Slovakian and western part of the Ukrainian Carpathians. Nascent T of minerals varied from 250-230°C to 80-50°C, the P reached 2.7 kbar. The gaseous phase of hydrocarbon is characterized by predominance of methane (in calcite 40-80%, in quartz 80-100%) with insignificant contents of higher hydrocarbon. Hydrocarbon composition and F P regularly change from the Inner Carpathians to the Outer Carpathians geological units. While FI in minerals of internal units mostly consist of methane, for external units of increasing quantity of FI with higher hydrocarbon and solid bitumens is symptomatic. The P changed from 1.3 to 2.7 kbar. Hydrocarbon I in evaporites have been found in the Neogene (Miocene) sediments. These I are solely connected with diagenetic minerals (halite, gypsum) precipitating at T about 70-80°C and at P<0.03 kbar. Higher hydrocarbon dominate in these I and their presence in evaporites is due to hydrocarbon migration from former, terrigenous sediments. the interpretation of the I data for hydrocarbon prospection is complicated by unclear autochthony of hydrocarbon. (Authors' abstract)

DUGGAN, J.P. and **MOUNTJOY, E.W.**, 1997, Diagenetic history of the Swan Hills Simonette oil reservoir (Givetian-Frasnian), deep basin of west-central Alberta, Canada (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A41. First author at Dept. of Earth & Planet. Sci., McGill Univ., 3450 Univ. St., Montral, Canada H3A 2A7; email (duggan@stoner.eps.mcgill.ca).

The Swan Hills Simonette oil field of west-central Alberta basin (Township 64, Range 27W5) is a deeply-buried, partially dolomitized buildup with a complex diagenetic history. The present day burial depth is 3900 m and formation T is 93°C. Highest porosities (20%) occur in dolostones of the lagoon, reef, and fore-reef depositional environments but limestones still retain porosities up to 5%. The diagenetic history is similar to other Devonian buildups of the deep basin and includes early calcites, early burial replacement dolomites, saddle dolomites, late burial replacement dolomites, pyrobitumens, sulphides, late twinned calcites, and anhydrite cements. Maximum Paleocene burial is estimated to be 6500 m and approximately 150°C assuming the geothermal gradient to be 20°C/km. The timing of late cements is constrained by the presence of hydrocarbons in saddle dolomite FI and the Th of L-V FI which indicate saddle dolomites precipitated at T 100-135°C, anhydrites 110-150°C, sphalerite ~150°C, and late calcites 105-135°C. Oxygen isotopes for replacement dolomites (-6 to -9‰ relative to the PDB standard), saddle dolomites (-8.5 to -12.5‰ PDB), and late calcite (-10.4 to 12.8‰ PDB), suggest that the carbonate-precipitating F mixed with the host rock to various degrees. Radiogenic lead in galena ^{206}Pb/^{204}Pb = 22.7-23.2) and radiogenic strontium in saddle dolomites (^{87}Sr/^{86}Sr = 0.7122-0.7331) and late calcites (^{87}Sr/^{86}Sr = 0.7281-0.7369) suggests potential F were derived from the Precambrian basement or Paleozoic clastics sourced from the basement. Faults may have acted as vertical conduits for F migration. (Authors' abstract)

DUNNE, W.M. and **CALDANARO, A.J., Jr.**, 1997, Evolution of solution structures in a deformed quartz arenite; geometric changes related to permeability changes: J. of Structural Geol., v. 19, no. 5, p. 663-672.

Indexed under FI (E.R.)

DURISOVÁ, J. and **DOBES, P.**, 1997a, Character of palaeofluids in the western part of the Bohemian massif, a fluid inclusion study (abst.): in Geological model of western Bohemia related to the KTB borehole in Germany, S. Vrána and V. Stedrá, eds., J. of Geological Sci., [Prague] v. 47, p. 211-212.

The main method of the FI study, carried out in the laboratory of the Czech Geological Survey, was optical microthermometry (Durisová-Hurai 1991). New methodical approaches based on a combination of optical microthermometry and micro-Raman spectrometry of FI were applied as a result of the cooperation between the CGS laboratory and the laboratory of the CREGU in Nancy. The data obtained permitted calculation of the composition of F, to constrain the possible P-T conditions of their existence (calculations of isochores of F of known composition) and to determine redox conditions under the activity of these F (calculations of oxygen and sulphur fugacity).

The new data on palaeofluids from mineral associations of rocks from several geological units of the western part of the Bohemian Massif obtained within the framework of the project "Geological model of Western Bohemia in relation to the deep borehole KTB in the FRG" were correlated with previous data from metamorphic rocks of the Silesian zone (Jeseníky Mts. area) and the eastern part of the Moldanubian Zone (locality Orlík near Humpolec). (Authors' abstract)

DURISOVÁ, J. and **DOBES, P.**, 1997b, Fluid inclusions in granulites (abst.): in Geological model of western Bohemia related to the KTB borehole in Germany, S. Vrána and V. Stedrá, eds., J. of Geological Sci., [Prague] v. 47, p. 212.

The granulites of the Moldanubian Zone of southern Bohemia formed under the conditions of high-P granulite-facies metamorphism and then underwent polyphase retrograde metamorphism under the conditions of amphibolite facies metamorphism and lower during their ascent. FI were studied in quartz porphyroclasts, garnet and exceptionally in mesoperthite. Based on a distribution of I in relation to their host mineral, the composition and density of trapped F, several types of FI were distinguished: three generations of CO_2-rich (± CH_4, N_2), several generations of H_2O-CO_2 (± CH_4, N_2), H_2O-rich I, and N_2-CH_4 V-rich I with a very low density.

The isochores of F do not reach the conditions of peak granulite-facies metamorphism. The data can be explained by the trapping or re-equilibration of I during the superimposed retrograde metamorphism and tectonic processes. The influx of water to the F system during the uplift and the mixing of H_2O-rich F with CO_2-rich F probably enhanced the superimposed plastic deformation of the granulite bodies. (From authors' abstract by E.R.)

DURISOVÁ, J. and **DOBES, P.**, 1997c, Fluid inclusions in quartz veins of the Moldanubian Zone, Sumava (Kasperské Hory) (abst.): in Geological model of western Bohemia related to the KTB borehole in Germany, S. Vrána and V. Stedrá, eds., J. of Geological Sci., [Prague] v. 47, p. 212-213.

FI from various types of quartz veins (partly Au-bearing) were studied in oriented sections to correlate palaeofluids with tectonic and metamorphic processes. Three main types were distinguished: H_2O-CO_2, late H_2O-rich and late N_2-(CH_4) I.

The data suggest that the vein system is probably connected with huge changes in P during the extension deformation. (From authors' abstract by E.R.)

DURISOVÁ, J. and **DOBES, P.**, 1997d, Fluid inclusions in rocks of the Barrandian Upper Proterozoic (locality Mítov) (abst.): in Geological model of western Bohemia related to the KTB borehole in Germany, S. Vrána and V. Stedrá, eds., J. of Geological Sci., [Prague] v. 47, p. 213.

FI were studied in quartz and calcite from an interpillow matrix (a quartz-calcite-chlorite-pyrite assemblage) and from oblique quartz-calcite veins with axinite.

FI in quartz and calcite of the interpillow matrix are mostly composed of a water solution or L methane, or mixtures of these phases±anthraxolite or CH_4 (94 mol%)±CO_2, H_2S and N_2. Quartz, calcite and axinite of the oblique veins contain the H_2O-rich I±CH_4 and CO_2. (From authors' abstract by E.R.)

DURISOVÁ, J. and **DOBES, P.**, 1997e, Fluid inclusions in minerals from veins of the Stribro type in the Upper Proterozoic (abst.): in Geological model of western Bohemia related to the KTB borehole in Germany, S. Vrána and V. Stedrá, eds., J. of Geological Sci., [Prague] v. 47, p. 213-214.

FI were studied in pre-ore dolomite-ankerite, fluorite and quartz with radial microtexture, in sphalerite, and post-ore coarse-grained quartz, barite and calcite. Vein mineralization deposited at epithermal environment under T from 140°C to less than 100°C. Sal of the solution varied gradually during the deposition of minerals from 4.2 to 25 wt.% and decreased again toward the latest stages of the mineralization (sal in barite and calcite is from 0.2 to 14.3 wt.% NaCl eq.). (From authors' abstract by E.R.)

DURISOVÁ, J. and **DOBES, P.**, 1997f, Correlation of the fluid inclusion results from different mineral associations (abst.): in Geological model of western Bohemia related to the KTB borehole in Germany, S. Vrána and V. Stedrá, eds., J. of Geological Sci., [Prague] v. 47, p. 214-215.

Molar composition of selected FI (calculated in forms of H_2O, CO_2 and CH_4 + N_2, are shown graphically for 6 types of ore deposits and metamorphics from microthermometric and micro-Raman spectrometric data). (From authors' abstract by E.R.)

DURISOVÁ, J. and **DOBES, P.**, 1997g, Thermobarometric constraints for the existence of fluids (abst.): in Geological model of western Bohemia related to the KTB borehole in Germany, S. Vrána and V. Stedrá, eds., J. of Geological Sci., [Prague] v. 47, p. 215-216.

The calculations of isochores of trapped F enabled the establishment of P-T conditions under which a F of known composition could have existed and be preserved as FI. As one example, P-T conditions of crystallization of apatite, quartz and scheelite from sillimanite gneisses of the Moldanubian zone are shown. Oxygen fugacities of palaeofluids were also calculated from the FI data obtained from selected samples. (From authors' abstract by E.R.)

DURISOVÁ, J., GOLIÁS, V., LEACH, D., PUDILOVÁ, M., SNEE, L.W., STEIN, H.J., STRNAD, L. and **ZÁK, K.**, 1997, Evolution of crustal fluids in a shear zone during retrograde metamorphism, regional uplift, and cooling (the Kasperské Hory gold deposit, Moldanubian unit, Bohemian Massif) (abst): MAEGS, 10th Meeting Association of European Geological Societies, Sept. 1-5, 1997, Carlsbad, Abstracts: J. Czech Geol. Soc., v. 42, no. 3, p. 52. First author at Czech Geological Survey, Klárov 3, 11821 Prague 1, Czech Republic.

Isotopic and FI studies of the Kasperské Hory gold deposit show that the hydrothermal mineralization was formed in several successive stages of F movement through a regional shear zone during Hercynian retrograde metamorphism, regional uplift and cooling.

Gold-bearing stage 3 mineralization, largely occurring as a relatively younger phase within quartz veins, contains molybdenite, high-T phase similar to cosalite, native Au and Bi, hedleyite and maldonite indicate T of 380 to 260°C. Ore minerals are frequently associated with minor calcite. FI in this calcite and also numerous FI planes crosscutting several older quartz grains, are of the H_2O type, with sal between 0.5 and 8.0 wt.% NaCl eq., and Th between 170 and 300°C. (From authors' abstract by E.R.)

EADINGTON, Peter, 1997, Fluid inclusion technique helps Australian explorers: Oil and Gas Gazette, v. 1, no. 74, p. 24.

In the ongoing search to strike oil-rich columns, CSIRO is employing a new technique in F history analysis which has assisted major players in the Australian oil industry. The new, patented technique, called GOI (grains containing oil inclusions), identifies residual zones or rocks from which oil has withdrawn. Sand grains in oil reservoir rock are examined under a fluorescent microscope to detect oil trapped within the sand grains as oil I. (From author's text by E.R.)

EBERT, S.W. and **RYE, R.O.**, 1997, Secondary precious metal enrichment by steam-heated fluids in the Crofoot-Lewis hot spring gold-silver deposit and relation to paleoclimate: Economic Geol., v. 92, p. 578-600. First author at Key Centre for Strategic Mineral Deposits, Dept. of Geol. and Geophys., Univ. of Western Australia, Nedlands, Western Australia 6907, Australia.

The Crofoot-Lewis deposit is an adularia-sericite-type (low sulfidation) epithermal Au-Ag deposit, whose well-preserved paleosurface includes abundant opaline sinters, widespread and intense silicification, bedded hydrothermal eruption breccias, and a large zone of acid sulfate alteration. Mineralization is believed to have resulted from large-scale convection of meteoric water controlled largely by basin and range fractures and a high geothermal gradient with H_2S for Au complexing derived from organic matter in basin sediments. A wet climate resulted in the formation of a large inland lake which provided abundant recharge water for the hydrothermal system. A fluctuating water table controlled by changing climatic conditions enabled steam-heated acid sulfate F to overprint lower grade mineralization resulting in ore-grade precious metal enrichment. (From authors' abstract by E.R.)

EDRAKI, Mansour and **ASHLEY, Paul,** 1997, New geological interpretations on the Biggenden magnetite skarn, Southeast Queensland (abst.): Geological Society of Australia Abstracts No. 44, p. 28. Author at Dept. of Geol. and Geophy., Univ. of New England, Armidale, NSW 2351.

The Biggenden deposit occurs within turbiditic siltstone/diamictite, limestone and basaltic and andesitic volcanic rocks intruded by granite which has produced a hornblende hornfels grade metamorphic aureole several hundreds of metres wide. Magnetite ore is part of a prograde skarn assemblage, with associated calcite and grandite garnet that replaced prior contact metamorphic assemblages. There is no preference for skarn replacement of marble. Prograde skarn calcite, garnet and clinopyroxene contain hypersaline FI. Development of coarse calcite and prograde skarn has involved considerable desilication of the total rock package, with introduction of Ca, Fe, Mn, Mg, Sn, W, Mo, Bi, Cu, Zn and S. Gold is associated with higher Cu and Bi grades. Mineralogical, FI, C and O isotopic and trace element characteristics of the orebody all indicate a strong magmatic (granitic) influence in its genesis. That the orebody is SiO_2-poor and FeCa-rich could imply that granite-derived hydrothermal F have equilibrated with large volumes of mafic volcanic and carbonate rocks. (From authors' abstract by E.R.)

EICHHORN, Roland, HÖLL, Rudolf, JAGOUTZ, Emil and **SCHÄRER, Urs,** 1997, Dating scheelite stages: A strontium, neodymium, lead approach from the Felbertal tungsten deposit, Central Alps, Austria: Geochim. Cosmo. Acta, v. 61, no. 23, p. 5005-5022.

First author at Inst. für Allgemeine und Angewandte Geologie, Luisenstrasse 37, D-80333 München, Germany.

New Sm-Nd, Rb-Sr and Pb-Pb isotope data of scheelites and their host rocks from the Felbertal scheelite deposit (Central Tauern Window, Eastern Alps, Austria) are presented. We suggest that a midlevel crustal position in an active continental margin setting is the most probable site for the P tungsten source. Tungsten-bearing, ascending F from dehydrated granulites-facies reactions (with F formation) to provide the total tungsten content of 200,000 T the Felbertal deposit. This would imply that the tungsten content in the released F has been some 100 ppm. (From authors' abstract by E.R.)

EILER, J.M., McINNES, B.I.A., VALLEY, J.W., GRAHAM, C.M. and **STOLPER, E.M.,** 1997, Slab-derived fluids in the mantle: Oxygen-isotope evidence from melt inclusions: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 65-66, Lunar and Planetary Inst., Houston. First author at Div. of Geological and Planetary Sci., California Inst. of Tech., Pasadena, CA 91125, U.S.A.

The subduction of rocks, sediments, and F of the oceanic crust at convergent margins is an important process for generating chemical and isotopic heterogeneity in the mantle. Oxygen-isotope variations of minerals and M/FI in xenoliths from subarc mantle can provide valuable constraints on the nature of subducted material and on processes by which they interact with the mantle and contribute to arc volcanism.

Alkali olivine basalts from Simberi and Lihir Islands, Papua, New Guinea, contain olivine xenocrysts and lherzolite and harzburgite xenoliths that sample the mantle. We interpret high $\delta^{18}O$ phonolitic M to be derived by melting of previously depleted mantle sources that have been extensively metasomatized by slab-derived F. [The data] suggest that the slab/mantle hybridization we infer for the sources of phonolitic M is extensive in the local mantle. (From authors' abstract by E.R.)

El KAZZAZ, 1996, [title unavailable–see Taylor, W.E.B., this volume, for citation; page numbers refer to Egyptian Geol. Survey volume as given by Taylor. Ed.]

El Kazzaz (p. 55), based on petrographic, structural, ICP-MS, FI, and oxygen and hydrogen stable isotope data, proposed a greenschist facies metamorphic origin (i.e., T of about 350°C and P about 2 kb) during the earliest deformation phase (D1) for the gold vein and attendant wallrock alteration deposits of central Wadi Allaqi. The FI were exceedingly complex and five main types have been identified including CO_2-rich types. Maximum Tt for those I clearly associated with the P mineralization event have been estimated at 320°C, but many of the deposits from the earliest phase have been altered during the later deformation events thus giving rise to lower Th for other types of I about 100°C. The values of gold in the quartz veins averaged about 4 ppm. The results from a wide-ranging investigation by El Shimi et al. (p. 58-60) of fifteen western Wadi Allaqi deposits supported this conclusion and suggested that the auriferous F tended to migrate from higher P zones to those of lower P. Gold values from quartz veins, which were deposited in the dilation sites along D1 brittle-ductile shear-zones, of up to 30 ppm were given. A mineralogical and FI study of gold-copper-bearing quartz veins hosted by Precambrian granodiorite and metavolcanic ricks in the Hamash area by Kaindl & Helmy (p. 92-94) demonstrated four types of veins: Q1 are thick (0.5-5 m): Q2 are formed of milky quartz; Q3 are coarse-grained with euhedral quartz grains; and Q4 thin, fine-grained and highly mineralized. Electron microprobe studies show that the gold occurs as electrum ($Au_{78}Ag_{22}$) mainly in Q2 and Q4. Th from FI range from 108 to 288°C. Data indicate that the F were of a simple water-sodium chloride composition with low sal in the range of 1.5 to 12.6 wt.%. Gold values of up to 50 ppm were recorded. (Author's abstract)

ELLIOTT, W.C., CABENA, L., GHAZI, A.M., WENNER, D.B. and **HAYNES, J.T.,** 1997, Trace element and oxygen and hydrogen isotopic analyses of illite in K-bentonites from the southern Appalachian basin (abst.): Geol. Soc. Amer. Abstracts with

Programs, v. 29, no. 3, p. 15. First author at Dept. of Geol., Georgia State Univ., Atlanta, GA 30303.

The formation of mixed layer illite-smectite (I/S) in Ordovician K-bentonites within the southern Appalachian basin is coincident with the Alleghanian Orogeny, and it is thought that I/S formed as a result of basinwide F migration caused by convergent tectonism associated with the Alleghanian Orogeny. The measured K/Ar ages of I/S in these middle Ordovician K-bentonites range from 260-300 Ma throughout the southern Appalachian basin. The youngest ages are found at the distal margins of the basin. The percent illite in I/S decreases from >95% to 65% from the proximal basin toward the distal margin. While the chemistry of the F are arguably saline from the analyses of FI in K-feldspar overgrowths (e.g. Hearn et al., 1987), the chemistry and T of the basinwide migrating F have not yet been estimated from the analyses of I/S. (From authors' abstract by H.E.B.).

ELLIS, P.D., GEMMELL, Bruce, CRAWFORD, A.J. and **COOKE, D.R.,** 1997, The geology and mineralisation of the Waisoi porphyry copper deposits, Namosi, Fiji (abst.): Geological Society of Australia Abstracts No. 44, p. 29. First author at Gold Mines of Australia, PO Box 38, Temora, NSW 2666.

Petrological, mineralogical, alteration and FI investigations, combined with field observations of temporal relationships between geological features, have identified evidence for early, regional, greenschist facies, burial metamorphism followed by porphyry-related hydrothermal alteration. The hydrothermal system produced early albitisation, sericitisation, and silicification, prior to introduction of the main mineralising F which produced potassic alteration with most of the copper and gold. This was followed by a chloritisation (intermediate argillic) event, also with significant copper mineralisation. The mineralising event was followed by several late-stage carbonate-rich alteration events.

Although minor chalcopyrite was deposited during the silicification and late-stage carbonate alteration events, most of the Cu and Au was introduced and deposited as chalcopyrite and bornite in conjunction with the potassic alteration episode. F evolved from highly saline 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. (From authors' abstract by H.E.B.)

EN-NACIRI, Aomar, BARBANSON, Luc and **TOURAY, J.-C.,** 1997, Brine inclusions from the Co-As(Au) Bou Azzer district, Anti-Atlas Mountains, Morocco: Economic Geol., v. 92, p. 360-367. Authors at Unité Mixte de Recherche du CNRS et de l'Université d'Orléans, no. 6530, Equipe Ressources, Environnement, et Matériaux, Ecole Supérieure de l'Energie et des Matériaux, 8 rue Léonard de Vinci, 45072, Orléans, France.

Brine inclusions in preore and postore quartz, as well as in postore calcite from different deposits of the Bou Azer district, and Cobalt [Ontario] (Ag ore) represent variations in Ag-Co contents in the same class of Co-Ag-As mineralization.

Hypersaline FI show dm halite and sylvite and many accidentally trapped phases. Te -55 to -70°C, Th 168-220°C. SEM on salts formed during evaporation of opened FI show high $CaCl_2$ and $BaCl_2$ and solid NaCl FI with minor L suggest precipitation of NaCl from the ore F. (E.R.)

ENDRES, A.L., 1997, Geometrical models for poroelastic behaviour: Geophysical J. International, v. 128, no. 3, p. 522-532.

Indexed under FI (E.R.)

EROKHIN, A.M., 1997, Physicochemical features of primary magmatic fluids in metalliferous granites at the Svetloe Sn-W deposit, Chukot Peninsula: Geokhimiya, 1997, no. 1, p. 104-106 (in Russian, translated in Geochem. Internat'l., v. 35 no. 1, p. 95-97. Author at Vernadsky Inst. of Geochem and Analytical Chem., Russian Acad. Sci., ul. Kosygina 19, Moscow, 117975 Russia.

The Svetloe tin-tungsten deposit is the second largest in the Iultin ore area. The deposit belongs to the cassiterite-wolframite-quartz association and consists of a series of closely-spaced quartz veins in sediments. A blind leucogranite stock, which is thought to be ore-generating, was penetrated by boreholes. A study of I in quartz of the granite determines the scope of the present paper. The MI show a low birefringent mineral, presumably muscovite, dominates among the solid phases and accounts for up to 80% of an I by volume. The sharp phase boundaries of G bubbles in the I indicates that the I are partly free of solid phases and filled with a L F phase.

The F of the MI show somewhat lower Th down the stock, which can be accounted for by an increase of the F P. The lowest Th (204-217°C) suggest a higher F P. The maximum P values, calculated from H_2O-NaCl isochores for the T of 700-750°C, are 5.6-6.7 kbar. The water content in the M was estimated at 5-8 wt.% by the method suggested in [Naumov, 1979]. (From author's text by E.R.)

Nothing is mentioned as to the large muscovite (?) dm on heating. (E.R.)

ESPINOLA, M.R., SOLER, A. and **ARCOS, D.,** 1997, Scheelite vein mineralizations associated with the Santa Coloma granodiorite: fluid inclusions and isotope geochemistry: Boletin Sociedad Espanola de Mineralogia, v. 20-A, p. 75-76 (in Spanish).

ESSARRAJ, Samira, BOIRON, M.-C., BANKS, David, PIRONON, Jacques, EL BOUKHARI, Abdelmajid and **CATHELINEAU, Michel,** 1997, Fluids associated to silver deposition in central Anti-Atlas, Morocco: A comparison between Zgounder and Bou Azzer silver deposits: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 100-101. First author at Faculté des Sciences et Techniques, BP 618, Marrakech, Morocco.

Quartz was studied from the Ag-mineralized areas of the Zgounder silver deposit and Bou Azzer Co-As-Ag-Au deposit. FI studies have shown that, in each deposit, a specific process is responsible for silver deposition from similar brines. Such brines have probably a basinal source and circulated at a large scale in the central Anti-Atlas.

Both Zgounder and Bou Azzer deposits show two stages of mineralization: i) quartz and/or calcite associated with a Co-As paragenesis, ii) a major silver deposition which postdates clearly the As paragenesis.

At Zgounder, the first stage is associated to two F types: i) a low sal (around 6 wt.% eq. NaCl) H_2O-rich F and ii) a CO_2-rich F. Both F occur in the same samples and show similar ranges of Th (around 420/449°C to the L and V phase respectively).

At Bou Azzer, the first stage is characterized by the circulation of a hypersaline complex brine (I showing L+V+H±unidentified solids). A previous analysis indicated the presence of K-Cl-Ba ions. Na-K-Ca-Li ions were detected by laser ablation on individual I and the same cations and chlorine by crush-leach technique. [This F] coexists with a volatile rich F characterized by N_2-CH_4±(C_2H_6 G and graphite), and could be the result of an immiscibility process, which could in turn have yielded to the Co-As deposition. A lower sal F has been observed as two-phase (L+V) FI with Te around -42/-45°C, consistent with a dominantly $CaCl_2$-NaCl brines. Sal can reach 14.5 wt.% eq. NaCl+$CaCl_2$ and Th occurs to the L phase in the 200-300°C range.

The major silver depositional stage is associated both at Bou Azzer and Zgounder to the evolution of a hypersaline brine transporting silver in solution. FI from this brine are three-phase I (L+V+halite cube) with similar microthermometric characteristics in the two deposits (Th around 100/210°C to the L and high sal), and especially the very low Te around -75/-70°C typical for the LiCl-H_2O system.

In quartz veins from Zgounder, crush-leach shows Na/K ranges from 11 to 12, Na/Li is more variable and ranges from 250 to 475, Cl/Br range from 300 to 380 and Cl/SO_4 is in the range 1100 to 2100 while in Bou Azzer F display more variable ionic rations depending on the host mineral (quartz or calcite). In both deposits, geochemical signatures are characteristic of F originating from sedimentary basins as demonstrated by the halogen signatures. Br/Cl and I/Cl ratios are typical of deep basinal brines.

Two driving mechanisms, cooling and F mixing, can be considered for silver deposition in Zgounder and Bou Azzer. These mechanisms assume that silver is transported as chloride complexes in brines, and that the main process at the origin of silver deposition is the destabilization of the silver chloride complexes by a decrease of the ionic strength of the solution. (From authors' abstract by E.R.)

ESSER, R.P., McINTOSH, W.C., HEIZLER, M.T. and KYLE, P.R., 1997, Excess argon in melt inclusions in zero-age anorthoclase feldspar from Mt. Erebus, Antarctica, as revealed by the $^{40}Ar/^{39}Ar$ method: Geochim. Cosmo. Acta, v. 61, no. 18, p. 3789-3801. First author at New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801.

Historically erupted (1984) anorthoclase phenocrysts from Mt. Erebus yield K/Ar and $^{40}Ar/^{39}Ar$ apparent ages as old as 700 ka indicating the presence of excess argon. $^{40}Ar/^{39}Ar$ furnace step heating results from anorthoclase reveal a positive correlation between the Cl/K ratio and apparent age. Because chlorine (up to 1700 ppm) is present in M I but not in the anorthoclase crystal lattice, this correlation suggests that the excess argon is associated with M I trapped within the anorthoclase during rapid crystal growth.

Minimizing the effects of the excess argon from M I relies on sample preparation and step-heating. Fine crushing and treatment with hydrofluoric acid removes many of the larger M I. Small M I which remain within the anorthoclase degas primarily at T>1200°C. T<1200°C yield the most accurate ages.

Attempts at post-analytically correcting for the chlorine-correlated excess argon are hindered by the variations in $^{40}Ar_E$/Cl within and between samples. Elevated $^{40}Ar_E$/Cl ratios in bubbles within the M I, as deduced from *in vacuo* crushing experiments, are the most likely cause for some or all of a sample's total $^{40}Ar_E$/Cl variation. In addition, relative solubilities of argon and chlorine within phonolitic M may be partly responsible for variations in $^{40}Ar_E$/Cl. (From authors' abstract by E.R.)

ETCHEVERRY, R., ECHEVESTE, H., SCHALAMUK, I. and AMETRANO, S., 1997, Manantial Espejo: A Jurassic epithermal gold mineralization, Santa Cruz, Argentine: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 177-180. Authors at Instituto de Recursos Minerales, Universidad de La Plata, Argentine.

The Manantial Espejo gold-silver prospect is placed in the recently discovered Cerro Vanguardia epithermal goldfield (Macizo del Deseado, Santa Cruz). FI and isotopic data agree to establish mineralizing solutions of meteoric-hydrothermal sources related to volcanic-sedimentary episodes of Middle to Upper Jurassic age. Ore mineralogy, gangue phases and hydrothermal alteration are consistent with the Low Sulfidation Epithermal model. (Authors' abstract)

ETOH, J., TAGUCHI, S., IZAWA, E. and WATANABE, K., 1997, Fluid inclusions in hydrothermal minerals with boiling geothermal fluid-Example of the Kirishima geothermal area: (abst.): Geothermal Research Soc. Japan Ann. Meeting, Oct. 6-8, 1997, Sapporo Program, unpaginated, No. B17 (in Japanese).

EVANS, M.A., 1997, Changes in pressure/temperature conditions in a deforming fold-and-thrust belt: central Appalachians (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 3, p. 16. Author at Dept. of Geol. and Planet. Sci., Univ. of Pittsburgh, Pittsburgh, Pa 15260; email (mae6+@pitt.edu).

Deformation conditions, such as pore F P and T, within a deforming fold-and-thrust belt are constantly changing as a result of changes in overburden and F evolution. Vein minerals may contain FI that record these changes. In the central Appalachians, multiple syn-orogenic vein sets provide a sequential history of F evolution and hence changes in deformation conditions. These data may then be used to test possible scenarios of thrust propagation, and syn-orogenic erosion and sedimentation. Two specific structural positions within the fold-and-thrust belt are examined in detail.

FI from veins in the North Mountain Thrust footwall record a large increase in overburden during the Alleghanian orogeny. Early bedding parallel (BP) and strike veins (SV) contain CH_4 I that have a minimum Th of -115 to -110°C indicating P of 170 to 200 MPa and an overburden of 6.5 to 7.7 km. Later I in fault zone minerals contain I that have a minimum Th of -136 to -126°C indicating P of 260 to 320 MPa and an overburden of 10.0 to 12.3 km.

FI from the core of the Wills Mountain anticline record a history of burial followed by uplift and erosion during folding and transport across a thrust ramp. Early BP and SV contain CH_4 I that have a minimum Th of -108 to -105°C indicating P of 135 to 155 MPa and an overburden of 5.2 to 6.0 km. Later I in fault zone minerals and cross-fold veins contain I that have a minimum Th of -100 to -95°C indicating P of 95 to 105 MPa and an overburden of 3.7 to 4.0 km. (From author's abstract by E.R.)

EVANS, M.A. and **BARTHOLOMEW, M.J.**, 1997, Fluid evolution in the southeastern Piedmont: Late Paleozoic through Cenozoic: (abst.) Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 3, p. 16. First author at Dept. of Geol. and Planet. Sci., Univ. of Pittsburgh, Pittsburgh, Pa 15260.

Microthermometric analysis of FI from the vein and fault zone minerals from multiple vein orientations and faults at stations located in a wide variety of structural positions across the province indicate at least five separate F trapping events. The highest T I are interpreted to be the earliest I and the lowest T I the latest. There is a decrease in Tt through time and a corresponding decrease in F sal. This suggests that low sal metamorphic F eventually gave way to 0% sal, meteoric water influenced F. Similarly, the amount of CO_2 generally decreases with decreasing T. Most veins contain I from more than one, and possibly up to 4 separate trapping events. FI representing Events 1 through 4 are found in quartz while those representing Events 4 and 5 are found in late calcite.

Event 1 involves the trapping of low sal H_2O+CO_2 I and pure CO_2 I. Th range from 275 to 350°C and water ice melting T range from -4.5 to 0.0°C (6.8-0.0 wt.% eq. NaCl sal). CO_2 melting T range from -56.8 to -56.6°C. The pure CO_2 I have Th of 19.5 to 30.9°C. Event 2 involves the trapping of low sal H_2O+CO_2 I with Th ranging from 210 to 270°C and Tm ranging from -4.5 to 0.0°C (6.8-0.0 wt.% eq. NaCl sal). Event 3 involves the trapping of low sal $H_2O \pm CO_2$ I. Th ranges from 185 to 205°C and Tm ranges from -2.5 to 0.0°C (4.0-0.0 wt.% eq. NaCl sal). Event 4 involves the trapping of low sal H_2O I. Th ranges from 140 to 170°C and Tm generally ranges from -2.5 to 0.0°C (4.0-0.0 wt.% eq. NaCl sal). Event 5 involves the trapping of very low sal H_2O I. Th ranges from 70 to 125°C and Tm is generally 0.0°C and indicates pure water. Event 5 may be broken down into two sub-events; one with Th values of 70 to 90°C, and another with Th values of 90 to 125°C. (From authors' abstract by E.R.)

EVERETT, C.E., WILKINSON, J.J. and **RYE, D.M.**, 1997, Brine infiltration of lower Paleozoic rocks beneath the Navan deposit, Ireland: Implications for the genesis of Irish-type Zn-Pb mineralization (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-208. First author at Dept. of Geol. and Geophys., Yale Univ., P.O. Box 208109, New Haven, CT 06520-8109; email (everett@minerva.cls.yale.edu).

Regional FI data from vein systems crosscutting Lower Paleozoic rocks in Ireland provide the first direct evidence for deep circulation of F which are omparable with mineralizing F within the Carboniferous-hosted base metal deposits.

Beneath the Navan deposit, I within Siluro-Ordovician-hosted ferroan dolomite±barite veins indicate the presence of at least two F types: (F1) 110-170°C, moderate sal (5-11 wt.% eq. NaCl); and (F2) 94-258°C, high sal (18-25 wt.% eq. NaCl). Both F are also observed in altered Old Red Sandstone (ORS)-hosted veins adjacent to an inferred feeder structure, the B Fault. The highest T (Th>170°C) are recorded from subhedral to euhedral S I in barite. These data may indicate leakage, however, now evidence of post-entrapment stretching or leaking of I is observed. Also, no correlation between Th and I size is noted (r2=0.0031, n=51), as would be expected if I had been subjected to a thermal overprint. An alternative explanation is that these data reflect a late, high T hydrothermal event.

Paragenetic and crosscutting relationships suggest that F1 fluids generally predate F2. This is supported by I in paragenetically late yellow sphalerite from within the deposit which contains P I of F1 type, S I of F2 type, and is overgrown by calcite±barite containing F2 I. These data also imply a genetic relationship between mineralizing F and F within the Lower Paleozoic-hosted veins, as inferred from regional C-O isotopic data from carbonates which form an array of progressively lower values from deposits through ORS to the underlying basement.

Ore-type F in basement rocks both proximal and distal to known mineralization are observed elsewhere in Ireland. This suggests that regional, fracture-controlled F flow in Siluro-Ordovician basement rocks is intrinsically linked to the genesis of Irish-type base metal deposits. (Authors' abstract)

EYRE, S.L., WILKINSON, Jamie, STANLEY, Chris and **JOHNSTON, Dave**, 1995, Geochemistry of hydrothermal systems in the southern Irish Midlands (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). First author at Imperial College, London.

See FIR, v. 29, p. 54 (E.R.).

FAN, Hongrui, XIE, Yihan and **WANG, Yinglan**, 1997, Determining daughter minerals in fluid inclusions using scanning electron microscope: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 12 (in English). Authors at Inst. of Geol., Chinese Acad. of Sci., Beijing, 100029.

A review. (E.R.)

FAN, Qicheng, LIU, Ruoxin, XU, Ping and **LIN, Zhuoran**, 1997, Intermediate-acidic silicate melt found in continental mantle of east China: Chinese Sci. Bull., v. 42, no. 10, p. 879-880.

Indexed under FI (E.R.)

FANLO, Isabel and **AYORA, Carlos**, 1997, Fluid inclusions in halite from the Lorraine basin: Implications for the composition of the Triassic ocean: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 102. First author at Cristalografia y Mineralogia Dpto., Ciencias de la Tierra, Edificio Geológicas, C/Pedro Cerbuna, 12, E-50009-Zaragoza.

The evolution of the chemical composition of the ocean along Earth history has been a major geochemical problem. Most marine evaporites have been traditionally interpreted as from evaporation of seawater with a composition similar to present day seawater, and such composition has not changed significantly with geological time, but others have proposed secular variatons, and assume that the solute concentration, and particularly that of Ca and SO_4, is not modified by processes taking place in the basin along [with] the evaporation.

We show in this paper that water-rock reactions may significantly affect the SO_4 content of the brine during evaporation. The detection of such reactions is based on the systematic study of the evolution of brine chemistry throughout an evaporite series. The chemical evolution of the original brine was investigated by X-ray microanalysis of frozen P I trapped in halite. The comparison between the computer calculations and the observed mineral sequences and the solute concentration analyzed in FI enabled us to interpret the evolution of the brine composition in the basin.

As a first approximation, the solute content in FI is consistent with the evaporation of present day seawater. However, SO_4 and K show contents that are variable and significantly lower than expected; Na and Cl appear to be systematically lower and higher, respectively. Bacterial sulfate reduction was discarded. After testing several alternatives, the addition of a small amount of $CaCl_2$ to the basin (1.2 to 1.9% of the total inflow of a hypothetical 1 m $CaCl_2$ brine) explained satisfactorily the lower values of SO_4 analyzed in FI, whereas those of Na and Cl [fit]. The origin of such a Ca-rich brine is still uncertain, although dolomitization of the underlying carbonates and hydrothermal brines are consistent with the upper-Triassic sedimentological and tectonic setting. The depletion in K was attributed to the back-reaction of the brine with early formed anhydrite to form polyhalite. Calculations show that the replacement of only 3% of the total mass of anhydrite by polyhalite accounts for the depletion in K observed in the analyses of FI.

According to calculations, the formation of 70 m of halite requires the evaporation of 6000 to 8000 basins of 1 m depth, depending on the degree of restriction assumed. The degree of restriction is a parameter of the model which is constrained by the paragenesis of halite+anhydrite, and by the amount of Mg recorded in FI. Assuming a rate of evaporation estimated between 1 and 2 m/y, the accumulation of the 70 m of halite studied could last about 10^3 years. From the calculated accumulation rate, significant variations in the SO_4 and K content took place in a few hundred years. This is not consistent with secular changes in the solute content of the ocean caused by global processes. (From authors' abstract by E.R.)

FEIN, J.B. and **WILLIAMS-JONES, A.E.**, 1997, The role of mercury-organic interactions in the hydrothermal transport of mercury: Economic Geol., v. 92, p. 20-28. Authors at McGill Univ., Dept. of Earth and Planet. Sci., 3450 University St., Montreal, Quebec, Canada H3A 2A7.

Despite the common association between mercury deposits and L hydrocarbons, the effects of mercury transport have received little attention. In this study, we estimate the extent of aq mercury complexation, and the partitioning of mercury among aq L, aq V, and an organic phase, quantifying the relative importance of each phase in mercury transport. The calculations suggest that significant mercury transport in the aq L, predominantly as $Hg^o_{(aq)}$, is only possible under relatively oxidizing and alkaline conditions. The frequent occurrence of L hydrocarbons in mercury-depositing hydrothermal systems, however, implies that conditions are reducing and that aq L transport of mercury is relatively unimportant. High concentrations of mercury also can be dissolved in aq V. However, boiling rarely occurs at the depths at which the ore solutions originate, and thus, the presence of a V phase is unlikely during mercury transport. Extrapolation of low-T experimental measurements of mercury solubilities in organic phases enables quantitative estimates of mercury concentrations in L hydrocarbons under hydrothermal conditions. Our calculations suggest that extremely high concentrations of mercury can dissolve in the organic phase and that organic phase transport may control mercury mobilities in many mercury ore-forming hydrothermal systems. (Authors' abstract)

FENG, J.Z., WANG, Shulai, AI, Xia and **LIU, Keming,** 1997, Geochemistry characteristics of fluid inclusion of the Maotang and Putang gold deposits, Henan: Contributions to Geol. and Mineral Resources Research, v. 12, no. 2, p. 27-34. First author at Beijing Inst. of Geol. for Mineral Resources, CNNC, Beijing, 100012.

The Maotang and Putang gold deposits hosted by granitic porphyries and explosive breccia pipes are genetically related to boiling, explosion and dilution of F. According to the geochemistry of FI and field observations, the mineralizing physicochemical condition and F evolution process are studied. (Authors' abstract)

FERKOUS, K., RAMBOZ, C. and **CABY, R.,** 1997, Late gold deposition along the N-S lithospheric Pan African East in Ouzzal strike-slip fault in uplift regime: An approach based on the structural and fluid inclusion studies of the Amesmessa area (Hoggar, Algeria): in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 181-184. First author at ORGM, Boumerdes, Algeria.

The N-S dextral strike-slip lithospheric East in Ouzzal Fault (EIOF) records three retrograde episodes. Highly variable F compositions and densities in the C-O-H system at the two early stages imply mixing of a CO_2 component with a resident aq F and changing F P conditions in the shear zone. The early carbonaceous stage, restricted to ultramylonites and contemporaneous with the major ductile pan-african deformation, occurred at variable T-depth conditions of ≈ 500°-420°C, 13-8 km, and f_{O_2} buffered at ≈ Q-F-M by basic rocks. Such T-f_{O_2}-conditions favoured gold leaching from the ultramylonites. At the later ductile/brittle stage, the F circulated in the shear zone and its margins were H_2O and CO_2-rich, and developed a carbonate alteration in ultramylonites with a low gold mineralization. f_{O_2} conditions were no more buffered by the wall-rocks. Aq F circulated lately in NE-SW and NW-SE fractures in the ultramylonites and in the shear zone margins at T-depth conditions of 300°-170°C and 6-3 km. The shear zone and its eastern margin were then flushed by meteoric waters. The T drop and oxidation related favoured gold precipitation along N-S fractures in ultramylonites. The core and eastern margin of the shear zone reached thermal equilibrium at ≈115°C, whereas the western Archaean block still remained ≈30°C colder. (Authors' abstract)

FISHER, D.E., 1997, Helium, argon and xenon in crushed and melted MORB: Geochim. Cosmo. Acta, v. 61, no. 14, p. 3003-3012. Author at Dept. of Geological Sci., Univ. of Miami, Miami, Florida 33124.

Helium, argon and xenon were measured in vesicles of MORB from a variety of locations and in sequential crushing steps in two locations. Melting extractions, compared to these data, indicate that most of the trapped radiogenic G are contained in the glass matrix and that vesicle/glass equilibrium has not been reached. (From author's abstract by E.R.)

FKIHECH, A., MORALES-RUANO, S. and **FENOLL HACH-ALÍ, P.,** 1997, Fluid evolution in base metal hydrothermal vein deposits in the Northern Internal Rif (North Morocco): in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They

Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 937-xxx. Authors at IACT (CSIC-Universidad Granada), Departamento de Mineralogia-Petrología, Spain.

A paragenetic, microthermometric and isotopic study is given for polymetallic deposits of North Morocco. Cooling, mixing and dilution of solutions due to migration of hot deep F to upper levels, and interaction with host rocks are responsible for precipitation of metals. (Authors' abstract)

FLEET, M.E. and **PAN, Yuanming,** 1997, Rare earth elements in apatite: Uptake from H_2O-bearing phosphate-fluoride melts and the role of volatile components: Geochim. Cosmo. Acta, v. 61, no. 22, p. 4745-4760.

FOLEY, N.K., 1997, Fluid evolution and source of metals in the Bald Mountain volcanogenic massive sulfide deposit, Maine: Evidence from fluid inclusion thermometry and chemistry (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A49. Author at MS 954, U.S. Geological Survey, Reston, VA 20192.

The Bald Mountain Cu-Zn-Au-Ag deposit, located in Aroostook County, Maine, is a low-grade metamorphosed volcanogenic massive sulfide (VMS) body that occurs within an early Paleozoic volcanic belt. The deposit has well-reserved mineralogical textures, a well-defined stringer zone, and an overlying Au-bearing gossan. These characteristics make Bald Mountain a prime candidate for developing a F-mineral reaction path model for understanding the thermal history and determining the chemical evolution of the mineralizing F. Results from this type of study directly address the controversy regarding the roles of recycled seawater and magmatic input of thermal energy and/or ore-forming components in the development of Cu-rich, Au-bearing VMS deposits. Models such as this can be used to determine the origin of the F and, in combination with metal partitioning data, place constraints on the source(s) of ore-forming components.

Primary L-V I at Bald Mountain outline growth zones in euhedral and crustiform quartz and are distributed randomly within lemon-yellow and red-brown bands in color-zoned sphalerite. P I range in diameter from about 25 microns to less than a micrometer, the majority are 10-15 micrometers in diameter. No definitive FI evidence of boiling is present in main-stage minerals and no evidence of CO_2, other than the presence of carbonate, was observed (further tests are under way). L/V ratios indicate Th in the 150-260°C range; some I in uniformly dark red-brown sphalerite and quartz suggest T as high as 350°C. Sal is variable. SEM-EDS analyses of FI decrepitates suggest that the hydrothermal F are enriched in potassium and calcium and depleted in magnesium, relative to seawater; iron contents are widely variable. Primarily L-V I in late quartz veinlets and 'pull-apart' quartz overgrowths are thermally and chemically distinct from main-stage I.

Comparison of results from this study with those obtained for classic VMS deposits elsewhere (Cyprus, Kuroko, Besshi, and Trondheim, Norway) and for modern seafloor-hydrothermal systems, provides convincing evidence that at Bald Mountain the involvement of seawater, contributions from leaching of volcanic rocks, and input from magmatic sources can be modeled using a combination of FI data and recent advances in L-V metal partitioning. (Author's abstract)

FOLEY, N.K., AYUSO, R.A., SEAL, R.R., II, and **OFFIELD, T.W.,** 1997, Fluid evolution and mineralogy of Au-bearing volcanogenic deposits in a regional geologic setting: Examples from the Carolina slate belt, USA (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-59. Authors at MS954, U.S. Geological Survey, Reston, VA 20192; email (nfoley@usgs.gov).

Auriferous iron-sulfide-bearing deposits of the Caroline Slate Belt (CSB) can be characterized by their distinctive bulk chemistry, mineralogy, and FI data--traits that provide a basis to construct models of ore deposition for the deposits. We now interpret [them] to span a continuum from shallow submarine massive sulfide to subvolcanic/epithermal models.

Gold deposits of the CSB have been studied in detail at the Brewer, Haile, Barite Hill, and Howle mines. Mineralogical and FI studies document environments with contrasting oxidation and sulfidation conditions. Various mechanisms were involved in the deposition of gold in the CSB. Th for Barite Hill show a wide range (sphalerite, barite: ~100 to >250°C, quartz: ~100 to 220°C); sal is low (0-4 wt.% eq. NaCl). Trends in the data are consistent with mixing between seawater and hydrothermal F which may have controlled deposition of minerals, thus, endorsing formation of Barite Hill in an ancient seafloor environment. Brewer has a range of Th (100-360°C), sal (0-10 wt.% eq. NaCl), and widely variable CO_2 contents, in P and S I populations (including published data). A complex history of hydrothermal brecciation and mineralization is recorded in cross-cutting quartz veins; FI in enargite and topaz establish controls on ore mineralization. Boiling and mixing are important mechanisms of deposition for ores formed at the subvolcanic-epithermal transition (e.g., Brewer) and corroborate a subvolcanic porphyry setting. Degassing (CO_2), oxidation of the F, conduction, and reduction (in activity of reduced sulfur) are possible depositional mechanisms for gold remobilized in faults (locally) and shear zones (regionally) (e.g., Howie; late gold at Haile). (From authors' abstract by E.R.)

FOLEY, N.K., SLACK, J.F. and **FLOHR, M.J.K.,** 1997, Fluid evolution and mineral deposition in the Bald Mountain volcanogenic massive sulfide deposit, northern Maine (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-59. Authors at MS954, U.S. Geological Survey, Reston, VA 20192; email (nfoley@usgs.gov).

The 32 Mt. Bald Mountain (BM) Cu-Zn-Au-Ag deposit is situated within a weakly metamorphosed (prehnite-pumpellyite grade) early Paleozoic volcanic sequence. BM is a zoned (Cu-rich, Zn-rich) volcanogenic massive sulfide (VMS) system with a well-defined stringer zone, and a Au-, and Ag-bearing gossan. Exceptionally well-preserved mineralogical and FI textures indicate that hydrothermal reworking of earlier stages was important remobilization and local reconcentration of metals, and provides a basis for modeling processes that controlled metal distribution.

Paragenetic studies document seven stages of mineralization. P L-V I outline growth zones in euhedral quartz (I, II, III and VI), and in color-zoned sphalerite (II). No evidence of boiling or CO_2 was observed in I. Microthermometric data on P I indicate a Th range from 150-270°C and sal from 2-9 eq. wt.% eq. NaCl. SEM analyses of FI decrepitates show enrichments in potassium and calcium and depletions in magnesium, relative to seawater; iron contents are widely variable. The patterns of F evolution and mineralogy suggest both black and white smoker environments. Comparison with classic VMS models and modern seafloor-hydrothermal systems provides evidence that F evolution and mineral paragenesis constrained seawater and magmatic contributions (heat and, possibly ore component) during the formation of the deposit. (From authors' abstract by E.R.)

FOMIN, Yu.A., BLAZHKO, V.I., LASARENKO, H.E., DEMIKHOV, Yu.N. and **SHIBETSKY, Yu.A.**, 1997, Thermobarogeochemical and isotopic description of ore-system evolution (Middle-Dniper area): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 104. Authors at State Scientific Centre of Environental Radiogeochemistry, 34 Palladina Avenue, Hyiv-142, 252142, Ukraine; email (isotop@metaldp.kiev.ua).

A wide vraiety of ore deposits of Au, Ag, Bi, Te and polymetals are described but said to be similar in FI and isotopic characteristics (E.R.).

FONAREV, V.I., TOURET, J.L.R. and **KOTELNIKOVA, Z.A.**, 1997, Fluid inclusions in polymetamorphic rocks of the Central Kola granulite area, Baltic Shield: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 105-106. First author at Inst. of Experimental Mineral., RAS, Chernogolovka, Russia; email (fonarev@iem.ac.ru).

In the Archaean Central Kola granulite area, Baltic Shield, a multi-stage metamorphism has been inferred from mineral geothermobarometry. The dominant F found in I is CO_2 (of variable density) eventually mixed with ≤35 mol% N_2. Other I contain pure N_2 (sometimes mixed with up to 7-9 mol% CH_4) or saline aq brines. These are represented by high-density $CaCl_2$-rich solutions, more seldom by later, low-density and low-sal F (3-6 wt.% NaCl eq.)

F density changes for synchronous gaseous I are interpreted by F partial leakage during post-trapping evolution, depending on the physico-mechanical properties of the host-crystal. These various F types are related to various stages in the P-T evolution.

These observations are in agreement with many observations on FI in granulites elsewhere. The earliest F, close to granulite conditions, was a heterogeneous mixture of concentrated Ca-rich brines and high-density CO_2-dominated F. The initial sal of brines, as well as their origin, is unknown. Precise measurements are not easy. Moreover, it is also certain that brine I have been drastically affected by post-trapping changes (I collapse, due to the steep slope of aq isochores), with undoubtedly major changes in the F sal. We can only suppose that the initial concentration was high enough to ensure immiscibility and maintain a low H_2O activity at granulite P-T conditions. Purely gaseous I whose isochores are much closer to the regional P-T path, are better preserved; their origin is also clearer. By comparison with other terranes, we can suppose that most CO_2 has been introduced in the lower crust by external, mantle-derived magmatic sources. At least, suitable supracrustal protoliths for delivering large quantities of CO_2 during prograde metamorphism are lacking. N_2, on the other hand, derives clearly from a specific premetamorphic protolith (BIF). It can mix with externally-derived CO_2 in variable amounts, depending on the proximity of the sedimentary source and F movements during metamorphism. (From authors' abstract by E.R.)

FORTES, P.deT.F.deO. and **GIULIANI, Gaston,** 1997, Fluid inclusions studies associated with massive sulfide and quartz vein ore bodies from Mina III and Mina Nova gold deposits, Crixás greenstone belt, central Brazil: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 107-108. First author at Inst. de Geosciências, Univ. de Brasília, 70910-900, Brasília, DF, Brazil; email (pfortes@guarany.cpd.unb.br).

Both of these large gold deposits are located within an Archaean greenstone belt. At Mina III, two main mineralized zones were defined, the upper and lower ore zones (UOZ and LOZ). At Mina Nova, two main ore bodies were identified, OB1 and OB2. FI studies show two main episodes of F circulation: early F (EFI) found in microfractures which do not crosscut the quartz grain boundaries or widespread as clusters in quartz; and late F (LFI) trapped along microfractures which crosscut quartz grain boundaries.

EFI consist of H_2O-NaCl-KCl-CO_2-CH_4-N_2 FI (type S, common in the UOZ and very rare in the LOZ and OB1), CO_2-CH_4-N_2 FI (type C_1), H_2O-NaCl-CO_2-CH_4-N_2 FI (types CL_1 and LC_1), H_2O-NaCl FI (type L_1) and (H_2O)-CH_4-N_2-(H_2S-C_2H_6) FI (types C'_1 and CL'_1, not found in the LOZ and OB1). All these types of EFI can coexist in a same trail or can occur in distinct parallel or cross-cutting microfractures.

Microthermometric data (halite dissolution, ice melting and clathrate melting T) indicate sal (in wt.% NaCl eq.) in the range of 26.9 to 52.7 (type S), 1.4 to 21.9 (types CL_1 and LC_1), 1.7 to 13.8 (type L1). Type S FI homogenizes to the L in the range of 266 to 460°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.

LFI consist of CO_2-CH_4-N_2 FI (type C_2) and H_2O-NaCl FI (type L_2). Type L_2 FI ice melting T indicate sal in the range of 1.5 to 9.7 wt.% NaCl eq. and these FI types homogenize to the L between 107 and 222°C.

The data suggest a mechanism of heterogeneous trapping (immiscibility), representing 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 micas and amphiboles.

Methane and nitrogen-rich F (C'_1 and CL'_1 EFI types, ((H_2O)-CH_4-N_2-(H_2S-C_2H_6) system) may have been originated from metamorphic reactions involving carbon present in the carbonaceous schist. Isochoric curves of representative EFI indicate trapping conditions compatible with the hydrothermal mineral paragenesis of greenschist facies. (From authors' abstract by E.R.)

FOSSUM, G.P., 1997, Fluid-induced retrograding of granulites in the Gjeving-complex, Aust Agder: Inst. Geol. Univ. Oslo Rapport nr. 70, p. 67 [Thesis, 1994 and 1995], pub. 1997.

The Gjeving complex is a Sveconorwegian (ca 1150-1070 Ma) syn-metamorphic intrusion which has been exposed to granulite facies conditions. In the Gjeving complex, charnockite represents granulite facies. The charnockite is crosscut by pegmatites. Around these pegmatites the charnockite has transformed to a red granitic augen gneiss which represents amphibolite facies.

There are two types of charnockite in the Gjeving complex: one dark green and the other brown. The green charnockite contains two types of FI: a water-NaCl-KCl F with a low sal and a mixed F consisting of water and CO_2. The two types of I have the same relative age. The water activity was high under the charnockite rock formation. It has been determined to lie between 0.85-1.0 using mineral equilibrium reactions. The brown charnockite also contains pure CO_2-inclusions, which have been transposed up to 30-40 [m?] from their original direction. Isochores of aq F and of the mixed CO_2-H_2O I reflect granulite facies PT-conditions. The pure CO_2-inclusions have low density and their isochores reflect amphibolite facies PT-conditions.

The granitic augen gneiss like the charnockite also contains early I with low saline water-NaCl-KCl F and I of mixed CO_2-H_2O F. It also contains late water-$CaCl_2$-NaCl FI which has been derived from pegmatites. Isochores calculated for mixed CO_2-H_2O I reflect amphibolite facies PT-conditions. The late water-$CaCl_2$-NaCl F have high densities.

The charnockite formation took place at high water activity under granulite facies conditions. The rocks then underwent a nearly isothermic decompression. Later the complex has been subjected to nearly isobaric cooling to amphibolite facies PT-conditions. Under the uplift of the Gjeving complex some of the green charnockite recrystallized to brown charnockite. The recrystallisations were caused by ductile strain. It seems that this strain also caused leakage of water from mixed CO_2-H_2O I and the formation of pure CO_2 I. In the brown charnockite the recrystallisation stopped before orthoclase was transformed to microcline. Around the pegmatite where the rock was supplied with water, these transitions are complete and all dry phases, e.g., orthopyroxene have broken down to hornblende and biotite. Isochores for the late water-$CaCl_2$-NaCl F indicate trapping at ~100-200°C.

From author's abstract by E.R.

FRANKS, S.G., HAMEG, Ahmed and **LIANG, Long**, 1997, Diagenetic evolution of Cambrian sandstones, Hassi Bir Rekaiz Area, Algeria: AAPG v. 6, Annual Meeting Official Program 1997, p. A37. First author at ARCO, Plano, TX.

Reservoir quality of Cambrian sandstones in the Hassi Bir Rekaiz area of Algeria is strongly affected by quartz and illite cement. The diagenetic sequence is, from early to late, kaolinite-illite-quartz-dolomite. Aq I trapped at quartz overgrowth boundaries and within quartz overgrowths contain very high sal water (>220,000 ppm NaCl). The only source for waters of this sal are the overlying Triassic evaporites. This clearly places quartz cementation as a post-Triassic event. Th of FI in quartz (95-115°C) coupled with burial history modeling indicates quartz cementation in Cretaceious/Tertiary time. Rb/Sr dating suggests diagenetic illite formed 190-256 ma (Permo-Jurassic). Early diagenetic kaolinite ($\delta^{18}O$=7.1 per mil) precipitated from isotopically light ($\delta^{18}O \leq 14$) meteoric waters during the early Paleozoic when Algeria lay at high latitudes. Kaolinite isotopic composition does not appear to have been reset during transformation to dickite. Late (post quartz) dolomite precipitated from waters of +4 to +11 per mil.

Generation of oil from Silurian source rocks in the source kitchen is modeled to have occurred during Cretaceous/Tertiary time and is coeval with quartz cementation. This is compatible with the abundance of petroleum I in quartz cement. Illite cementation significantly pre-dates oil migration. Therefore, early entrapment of petroleum may help preserve porosity in deeply-buried, quartzose sandstones, but this scenario cannot be called upon to preserve reservoir quality in the illite-cemented sandstones. (Authors' abstract)

FRANZ, Leander and **WIRTH, Richard**, 1997, Thin intergranular melt films and melt pockets in spinel peridotite xenoliths from the Rhön area (Germany): Early stage of melt generation by grain boundary melting: Contrib. Mineral. Petrol., 1997, no. 129, p. 268-283. Authors at GeoForschungsZentrum Potsdam, Telegrafenberg, D-14473 Potsdam, Germany.

Of pertinence to the formation of silicate M I. (E.R.)

FREDA, C., GAETA, M., PALLADINO, D.M. and **TRIGILA, R.**, 1997, The Villa Senni eruption (Alban Hills, central Italy); the role of H_2O and CO_2 on the magma chamber evolution and on the eruptive scenario: J. of Volcanology and Geothermal Research, v. 78, no. 1-2, p. 103-120.

The Villa Senni Eruption Unit (VSEU) belongs to the Tuscolano-Artemisio phase of volcanic activity in the Alban Hills Volcanic District, the closest to Rome of the recent or active volcanoes of central Italy. The most important products of this eruption are represented by pyroclastic flow deposits, named lower and upper flow unit (LFU and UFU, respectively). Three main rock types form VSEU as follows: (1) juvenile K-foiditic scoria clasts of the LFU: (2) juvenile phonotephritic scoria clasts of the UFU: and (3) holocrystalline phonotephritic lithic I (Italites) in the UFU. On the basis of the chemistry, mineralogy and petrography of the three studied rock types their phase relations have been discussed. Other petrologic constraints from laboratory melting experiments are presented and used to investigate the role of volatiles on the evolution of the magma chamber system. Some broad implications on withdrawal pattern are also presented. It has been verified the LFU rock type can be obtained from a parental M of UFU composition by a CO_2-controlled crystal-liquid fractionation of a solid assemblage close in composition to that of Italites. Because it can be proved that the storage of magma occurred at shallow depth within the Mesozoic carbonate country rocks, it is proposed that CO_2 diffusion, originating from thermal decomposition of wall-rock carbonates, controlled the evolution trend of the M at the periphery of the magma chamber, whereas the inner part of the magma body retained the volatile component (essentially H_2O) of the original M. The corresponding eruption model is therefore comprehensive of an early eruptive phase (LFU rock type) involving the more differentiated central magma bulb, whereas the late eruptive phase (UFU rock type) tapped the more mafic peripheral magma. The Italite xenoliths are believed to represent the chilled margins of the magma chamber. (Authors' abstract)

FREITAS-SILVA, F.H. and **DARDENNE, M.A.**, 1997, High fluid pressure, effervescence process, and C-H-O buffers related to Morro do Ouro gold mineralization - Paracatu-Minas Gerais-Brazil: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 109-110. Authors at Inst. de Geosciências-Univ. de Brasilia, Brasilia-DFpBrazil - ZIP 70.910-900; URL (http://www.unb.br/ig/posg/posg.htm).

The large, low-grade Morro do Ouro gold deposit is hosted by lower greenschist facies (chlorite zone) carbonaceous phyllites. PFI and Raman analyses in the auriferous quartz segregations show diverse compositions of a water-dominated H_2O-CH_4-O_2-N_2-NaCl mineralizing F with low sal (2-3 wt.% NaCl) and traces of HS- and low chain hydrocarbons. The high concentration of CH_4 and N_2 together with presence of traces of ethane, propane and HS- indicate the strong involvement of the carbonaceous phyllites and the effective participation of thio and arseno-complexes in the mineralization process. The results obtained show a great importance of carbonaceous phyllites, not only like metal source but also like continuous supply of volatiles able to maintain the system in a continuous effervescence process and to [cause] gold precipitation. (From authors' abstract by E.R.)

FREZZOTTI, M.-L., LUSTENHOUWER, W.J., TOURET, J.L.R., VITI, Cecilia and NEUMANN, E.-R., 1997, Ephemeral carbonate-melts in the mantle: Silicate-carbonate immiscibility in xenoliths from La Gomera (Canary Islands): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 111-112. First author at Dpto. Scienze della Terra, Univ. di Siena, Via delle Cerchia 3 53100 Siena, Italy; email (frezzotti@dst.unisi.it).

Local chemical heterogeneities in the mantle have been interpreted by many researchers as resulting from metasomatism, causing the introduction of incompatible elements into depleted regions of otherwise fertile mantle prior to basalt genesis. In La Gomera mixed carbonate+Mg-rich glass±CO_2 I occur in anhydrous composite xenoliths. We intend here to better define these M and investigate their relationships with mantle metasomatism.

All xenoliths are crosscut by a complex network of late veinlets (≤500 µm), filled with silicate glass, cryptocrystalline aggregates±different minerals (e.g. carbonate, clinopyroxene, spinel). Thin (≤80 µm) cracks filled with glass and/or arrays of silicate glass±carbonate I (Type II) and CO_2-rich FI often radiate from the veinlets into adjacent crystals. The silicate glass present in microveins and cavities is transparent, yellowish in colour. It shows a variable amount of devitrification, and has a composition consisting almost exclusively of MgO (24-35 wt.%), FeO (1-18 wt.%), SiO_2 (40-55 wt.%) and very little or no Al_2O_3, TiO_2, CaO and alkalies. Typical is a very low total at the microprobe analysis (82 and 90 wt.%).

Carbonates (Mg-calcite to dolomite) occur within some Type II MI and cavities, subordinately in the veins. They are always enclosed in the Mg-silicate glass, never in contact with the enclosing mineral. In Type II inclusions carbonate is separated from the glass by a sharp, rounded meniscus, suggesting that it has crystallised from a melted carbonate phase, immiscible in the Mg-silicate M.

These data indicate that peridotites from La Gomera underwent metasomatism with a carbonate-rich M, shortly prior to entrainment in the host basalts. Carbonate and Mg-silicate glass in the MI result from trapping of an initial homogeneous carbonate/silicate M, [which] separated into immiscible carbonate and silicate M [on] quenching. The constant carbonate/silicate M ratio in MI suggest that remnants of the original M (before immiscibility) may have been preserved in the less evolved I.

Numerous CO_2 I trails extending from the vein boundary indicate that some carbonates were destabilized prior to or during the ascent of the xenoliths. The abundant open microcracks in the remaining silicate glass (very low electron-microprobe totals) suggest that only a small fraction of the liberated CO_2 has been trapped in I, the rest being able to escape [sic]. In general, the CO_2 I in mantle xenoliths (at least those unrelated to the host basalt) may witness decarbonation of ephemeral carbonate M. (From authors' abstract by E.R.)

FRIETSCH, Rudyard, TUISKU, Pekka, MARTINSSON, Olof and PERDAHL, J.-A., 1997, Early Proterozoic Cu-(Au) and Fe ore deposits associated with regional Na-Cl metasomatism in northern Fennoscandia: Ore Geol. Reviews, v. 12, p. 1-34. First author at Div. of Applied Geol., Luleå Univ. of Tech., S-971 87 Luleå, Sweden.

Scapolite is widely distributed in 1.9-2.5 Ga volcano-sedimentary rocks and 1.77-2.22 Ga igneous rocks over several hundred square kilometres in northern Fennoscandia. A number of epigenetic Cu-(Au) sulphide and Fe oxide deposits in northern Fennoscandia show a spatial and genetic relationship to this type of alteration, mainly scapolitization and albitization. FI data of the Lapponian Pahtohavare and similar Cu-Au deposits indicate formation T of about 300°C and ore deposition from highly saline aq solutions. The deposition of copper and gold was in places regulated by a redox barrier; graphite in associated schists controlled the reduction reactions of the ore F and metals that were precipitated. Gold and copper were transported by saline, high fO_2, high T solutions as metal-chloride complexes. The ultimate source of F and heat sources is uncertain, but deep-seated crustal magmatic processes seem prerequisite. (From authors' abstract by E.R.)

FRIMMEL, H.E., 1997, Chlorite thermometry in the Witwatersrand Basin: Constraints on the Paleoproterozoic geotherm in the Kaapvaal craton, South Africa: J. of Geol., v. 105, p. 601-615. Author at Dept. of Geological Sci., Univ. of Cape Town, Rondebosch 7700, South Africa; e-mail (hef@geologcy.uct.ac.za)

Chlorite geothermometry, in conjunction with FI microthermometry and the thermodynamic modeling of equilibrium mineral assemblages, was applied to siliciclastic rocks to set constraints on the geothermal gradients. (From author's abstract by E.R.)

Includes a review of the literature on FI studies in the Basin (E.R.)

FRIMMEL, H.E. and GARTZ, V.H., 1997, Which fluids caused the mobilisation of the gold in the Archaean Witwatersrand Basin, South Africa?: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 189-192. Authors at Dept. of Geological Sci., Univ. of Cape Town, Rondebosch, South Africa.

At least five post-depositional alteration events are distinguished in the late Archaean Witwatersrand Basin. The mobilisation of originally detrital gold particles can be ascribed to two distinct F infiltration events during crustal thinning accompanied by the sedimentation of early-Transvaal thrust-related metamorphism, burial and Bushveld-related thermal metamorphism do not seem to have affected the distribution of the gold. (Authors' abstract)

FRITZ, P., 1997, Saline groundwater and brines in crystalline rocks: The contributions of John Andrews and Jean-Charles Fontes to the solution of a hydrogeological and geochemical problem: Applied Geochem., v. 12, p. 851-856. Author at UFZ Centre of Environmental Research Leipzig-Halle, Permoserstrasse 15, 04318, Leipzig, Germany.

An historical review of pertinence to the interpretation of FI data from crystalline rocks, and nuclear waste "storage." (E.R.)

FROST, D.J. and **WOOD, B.J.**, 1997, Experimental measurements of the properties of H_2O-CO_2 mixtures at high pressures and temperatures: Geochim. Cosmo. Acta, v. 61, no. 16, p. 3301-3309. Authors at CETSEI, Dept. of Geol., Univ. of Bristol, Wills Memorial Bldg., Queens Rd., Bristol BS8, 1RJ, UK.

We have experimentally determined volumes of H_2O-CO_2 mixtures between 9.5 and 19.4 kbar at 1100-1400°C. A synthetic FI technique (Sterner and Bodnar, 1991) was used to capture H_2O-CO_2 F of known composition in precracked corundum. The densities of the F were determined from measurements of the Th along the CO_2 L-V equilibrium curve. The experimentally determined volumes show good agreement with the MRK equation of state of Holloway (1977) for mole fractions of CO_2<0.5.

Further results are reported for the volume of pure water at 14.5 kbar and 1000-1400°C, determined from FI experiments of the type described by Brodholt and Wood (1994). These results were used to derive an EOS applicable to the calculation of H_2O PVT properties in the range 1-80000 bar and 800-1600°C. This new equation and the EOS of Frost and Wood (1997) for CO_2 were used to determine excess volumes for H_2O-CO_2 mixtures. Over the range of experimental conditions, H_2O-CO_2 F show small positive deviations from ideal mixing, with excess volumes >0.6 cc/mol. (Authors' abstract)

FUERTES-FUENTE, Mercedes, MARTIN-IZARD, Agustín, BOIRON, M.-C. and **MANGAS, Jose,** 1997, P-T path and fluid evolution of granitic pegmatites from Galicia Central (northwest of Spain): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 113-114. First author at Dpto. Geología, Univ. de Oviedo, Arias de Velaso s/n, 33005 Oviedo, Spain.

FI have been studied in each of 4 sets of pegmatites. In Franqueira deposit emerald and phenakite were sampled from phlogopitite. On Forcarei Sur samples, the study was carried out on quartz, beryl and metasomatic apatite from a replacement albitic unit of an albite pegmatite and on quartz from the spodumene-quartz rich core of an albite-spodumene pegmatite. In Lalin, quartz was sampled in an albite pegmatite. Quartz, beryl and garnet from the wall-zone samples have been studied in Forcarei Norte.

Most pegmatite sets display rather complex evolution, with complex CH_4-bearing low-sal aq F, complex CO_2-bearing higher-sal aq F, and S saline F, with several stages of circulation.

An overall model of P-T evolution of F composition is described starting with dm (silicates)-rich aq I formed above the 500°C melting of dms, and ending with low-sal aq F <250°C and 0.5 kbar. (From authors' abstract by E.R.)

FULIGNATI, Paolo, GIONCADA, Anna, MAINERI, Cinzia and **SBRANA, Alessandro,** 1997, A first insight into the magmatic-hydrothermal system related to 79AD eruption magmatic chamber of Vesuvius (Italy): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 115-116. Authors at Dip. Scienze della Terra, Univ. di Pisa, Via S. Maria, 3, Pisa, Italy; email (fulignati@dst.unip.it).

In the 79AD eruption a shallow magmatic chamber was emptied producing a caldera collapse. Xenoliths of subvolcanic wall rocks and of portions of the magmatic chamber were ejected. Mineralogical and FI studies on these xenoliths give insights into the outer shell of the magmatic chamber and the related hydrothermal system.

Type I xenolith is thought to represent a cognate rock from magmatic-chamber walls. This nearly holocrystalline rock is composed of sanidine, with minor sodalite, cancrinite or scapolite, and many accessory phases. Sanidine crystals contain monophase silicate MI and VI. Four types of two-phase I are present: a) rare silicate M+variable amounts of essentially pure CO_2, b) silicate M+shrinkage bubble, c) silicate M+salts, in highly variable ratios, d) late H_2O-CO_2 I, with a small amount of low-sal (5-6 wt.% NaCl eq.) aq L. Th_{CO_2} occurs into V in the range 2-15°C. Multiphase I [type "c" above?] consist of silicate M+V bubble+Na and K chlorides±birefringent and opaque solids. On heating multiphase I, first melting of silicate glass was observed around 600°C; melting of salts occurs between 480 and 800°C; homogenization of bubble into the M phase was observed from 828 and 970°C. SEM/EDS on opened I revealed Na and K chlorides, fluorite, cancrinite and/or scapolite, pyrite, Fe-oxides and rare calcite. Raman analyses indicate no G in the bubbles, with the exception of a few I containing traces of CO_2, and in one case, H_2S.

Type II xenoliths derive from subvolcanic rocks and occur in caldera-related eruption deposits. Calcite in a strongly altered mafic mineral (amphibole? shows) L+V+S halite-bearing aq I, with Th_{tot}=356-400°C (L) and sal of 30-33 wt.% NaCl eq.; and L+V late aq I, with final Th = 341-398°C (L) and sal between 4.6-18.6 wt.% NaCl eq. Other types of xenoliths show somewhat similar FI.

In the feldspatoid-bearing syenite, the association of early silicate M+saline M+aq V with silicate M+CO_2 and hypersaline aq I is strongly indicative of immiscibility phenomena between silicate M/saline M/carbonic F occurring at late magmatic stages. The obtained results from altered subvolcanic rocks indicate that a hydrothermal circulation developed in the surroundings of the 79AD magmatic chamber; textural and microthermometric characteristics of FI further suggest a dilution of early high-T and high sal F, which may reflect important meteoric contributions to the magmatic F system. (From authors' abstract by E.R.)

FYFE, W.S., 1997, Deep fluids and volatile recycling: Crust to mantle: Tectonophysics, v. 275, no. 1-3, p. 243-253.

Indexed under FI (E.R.)

GALAMAY, A.R., 1997, Origin of the middle Miocene Badenian salts in the Carpathian region: Przeglad Geologiczny, v. 45, no. 1, part 1, p. 1012-1017 (in Polish).

Indexed under FI (E.R.)

GALAMAY, A.R., BUKOWSKI, Krzysztof and **PRZYBYLO, Jerzy,** 1997, Chemical composition and origin of brines in the Badenian evaporite basin of the Carpathian Foredeep: Fluid inclusion data from Wieliczka (Poland): Slovak Geol. Mag. 3, no. 2, p. 165-171. First author at Inst. of Geol. and Geochem. of Combustible Minerals, Nat'l. Acad. of Sci. of Ukraine, Naukova 3a, 290053 Lviv, Ukraine.

The chemical composition of brine I in chevron halite from all stratified parts of the Wieliczka deposit (Badenian salt formation, Polish Carpathian Foredeep basin) has been determined for the first time. This deposit is unique considering the amount, sizes, and preservation of chevron structures in halite crystals. Some of these crystals reach 15 cm. I sizes range from fractions of to 600 µm. Cubic, one-phase FI are the most common. The data show that brines belonged to Na-K-Mg-Cl-SO_4 type. Seawater was the main source of salt formation, and its composition was close to modern water. The sedimentation occurred in relatively shallow basin by evaporation, and brine concentration did not proceed beyond the initial and middle stages of halite precipitation. (Authors' abstract)

GALAMAY, A.R. and **KAROLI, Stanislav,** 1997, Geochemistry of the Badenian salts from the East Slovakian Basin, Slovakia: Slovak Geol. Mag. 3, no. 3, p. 187-192. First author at Inst. of Geol. and Geochem. of Combustible Minerals, Nat'l. Acad. of Sci. of Ukraine, Naukova 3a, 290053 Lviv, Ukraine.

The chemical composition of P FI in chevron halite occurring in the Badenian Zbudza evaporite formation in the East Slovakian Basin shows that the brine belonged to the Na-K-Mg-Cl-SO_4 type and that during salt accumulation the ratio of ions was close to modern seawater when saturated to the corresponding stage. A slightly decreased content of SO_4 caused by inflow of continental water into the basin was recorded. The brine concentration did not rise over the initial stages of halite precipitation. Bromine content in the halite (13-89 ppm) also indicates a marine genesis for the salt, a very low brine concentration, and the impact of continental water. (Authors' abstract)

GAMMONS, C.H. and **WILLIAMS-JONES, A.E.,** 1997, Chemical mobility of gold in the porphyry-epithermal environment: Economic Geol., v. 92, p. 45-59. Authors at Dept. of Earth and Planet. Sci., McGill Univ., 3450 University St., Montreal, Quebec, Canada H3A 2A7.

Using recently published experimental data, we have calculated the solubility of gold for simplified magmatic F that cool between 500 and 300°C. The isobaric model applies to magmas emplaced at hypozonal or mesozonal depths, whereas the boiling model is more appropriate for shallow porphyry deposits. (From authors' abstract by E.R.)

GAMMONS, C.H., YU, Yunmei and **WILLIAMS-JONES, A.E.,** 1997, The disproportionation of gold (I) chloride complexes at 25 to 200°C: Geochim. Cosmo. Acta, v. 61, no. 10, p. 1971-1983. First author at Dept. of Earth and Planet. Sci., McGill Univ., 3450 University St., Montreal, Quebec, Canada H3A 2A7.

The disproportionation of aq Au (I) chloride complexes at elevated T has been investigated experimentally using the solubility method. At 300°C, the dominant gold species in aq HCl solutions is $AuCl^-_2$. Upon cooling, this aurous complex partially decomposes. $AuCl^-_2$ may be the dominant form of dissolved gold in brines with near-neutral pH (e.g., seawater), as well as hydrothermal F that are both saline and oxidized. Cooling or dilution of solutions saturated with $AuCl^-_2$ could result in deposition of Au via a disproportionation reaction, as in our experiments. (From authors' abstract by E.R.)

GAMO, Toshitaka, OKAMURA, Kei, CHARLOU, J.-L., URABE, Tetsuro, AUZENDE, J.-M., ISHIBASHI, Junichiro, SHITASHIMA, Kiminori, CHIBA, Hitoshi and **the Shipboard Scientific Party of the ManusFlux Cruise,** 1997: Acidic and sulfate-rich hydrothermal fluids from the Manus back-arc basin, Papua New Guinea: Geology, v. 25, no. 2, p. 139-142. First author at Ocean Research Inst., Univ. of Tokyo, Nakano, Tokyo 164, Japan.

Hot (≥ 88-120°C) and acidic (pH ≤ 2.1) hydrothermal F rich in sulfate were discovered venting in the DESMOS caldera (depth-1926 m), eastern Manus back-arc basin, Bismarck Sea, surrounded by Papua New Guinea. The abundant sulfate (≥ 32.8 mM, higher than the seawater value of 28 mM) with elemental sulfur deposition around the vents, and remarkably low δD (H_2O) and $\delta^{34}S$ (H_2S) values (-8.1‰ and -5.6‰, respectively), are suggestive of the incorporation of a magmatic F and the disproportionation of the exsolved SO_2 from a magma body. The DESMOS F may be similar in origin to the acidic sulfate-chloride hot springs associated with subaerial volcanic activity. In contrast to the typical hydrothermal end member Mg concentration of 0, the DESMOS F are rich in Mg (46-52 mM), probably because of Mg dissolution by acid attack upon magnesium silicate materials. (Authors' abstract)

GAO, Huaizhong, LU, Wanjun, ZHANG, Baomin and **ZHANG, Wangseng,** 1997, Study of fluid inclusions of gold deposits in Sangequan, East Junggr: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 8 (in English). Authors at China Univ. of Geosci., Wuhan, 430074.

There are large quantities of FI with many types in the auriferous quartz veins, which indicate that the processes of vein-forming and ore-forming have many stages. The existence of CO_2-rich I and high photodensity values of H_2O and CO_2 show that the ore-forming F are H_2O-CO_2 system hypogenic solutions with low sal. P reduction and boiling, or the immiscible separation of CO_2 is occurred during the metallizing process. The evidences of geology and FI show that the alteration zone in Shuangshishan is a favorable prospective area. (Authors' abstract)

GARCIA, E., VINDEL, E., LÓPEZ, J.A., BOIRON, M.-C. and **CATHELINEAU, M.,** 1997a, Geometry of fluid migration in granites: The example of the Spanish Central System: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 117-118. First author at Dpto. Crystallography and Mineralogy, Univ.

Complutense, 28040 Madrid, Spain; email (eugarcia@eucmax.sim.ucm.es).

The geometry of the ore F migration was investigated in the San Rafael W(Sn) mineralized granites from the Spanish Central System. The geometry and the chronology of FIP have been investigated by several techniques. F trapping occurred by means of a complex succession of reopening and microfracturing/F events.

Significant changes in the F composition occurred between the main stages of microfissure formation and F migration. Early aq-carbonic F, of probably metamorphic derivation, migrated through well-defined regional trajectories. Migration of aq-carbonic F is rather limited to the mineralized areas. Aq F show more complicated patterns, because they are late and their migration is issued the previous deformation stages by reopening of preexisting microfissures [sic]. Both early and late stage F migrated homogeneously in the granites related to the stress field. The data obtained on microstructural markers can be compared with the results of the stress field reconstruction and can help to establish the chronology of stress tensors. (From authors' abstract by E.R.)

GARCIA, E., VINDEL, E., LOPEZ, J.A., BOIRON, M.C. and CATHELINEAU, M., 1997b, Geometry of hydrothermal circulation in mineralized granites, Spanish Central System: Boletin Sociedad Espanola de Mineralogia, v. 20-A, p. 51-52 (in Spanish). Indexed under FI (E.R.)

GARCIA IGLESIAS, Jesús and LOREDO, Jorge, 1997, Fluids evolution in a Cu-Co-Ni epithermal vein (Carreña de Cabrales, Asturias, Spain): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 119-120. Authors at Dpto. de Explotación y Prospección de Mnas, Univ. de Oviedo, Escuela de Minas, Independencia 13. 33004 Oviedo, España.

The mineral deposit shows at least three major mineralization stages. The first consists of the main sulphide phase and quartz; the second stage is characterized by fine bands of carbonates, quartz and barite, and minor amounts of sulphides; and the third includes massive calcite with scarce sulphides.

FI analyses were carried out in quartz and calcite from all three stages. All consisted of L+G at room T, and have Th in L.

Th of stage 1 are below 120°C; Te is between -80 and -70°C; and Tm ice are between -40 and -35°C. Stage 2 data from quartz are similar, but calcite shows Th=90-100°C; Te=-45 to -40°C, and Tm ice=-15 to -10°C. Stage 3 shows lower T of sal.

The deposit contains bravoite, and these data are in agreement with the stability field of bravoite; they confirm the typical epithermal character of this mineralization; and they are in accord with a mixing regime between the ascendant hydrothermal solutions metal carrier and meteoric F, with progressive influence of the vadose waters. (From authors' abstract by E.R.)

GARRIDO, C.J. and BODINIER, J.-L., 1997, Distribution of trace elements in anhydrous spinel peridotites from Ronda ultramafic massif: Implications for the nature of large-ion-lithophile-element, rare-earth-element, and high-field-strength-element reservoirs and mantle fluids in the sub-continental lithospheric mantle: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 78-79, Lunar and Planetary Inst., Houston. First author at Dept. of Geol. and Geophys., Woods Hole Oceanographic Inst., Woods Hole MA, U.S.A.; email (cgarrido@whoi.edu)

We report ICP-MS analyses of Rb, Ba, Th, U, Nb, Ta, REE, Sr, Zr, Hf, and Sc in leached separates of clinopyroxene, orthopyroxene, olivine, and spinel in anhydrous spinel peridotites. [The data] for Rb, Ba, Th, U, Nb, and Ta indicate that an important part of the budget of the highly incompatible elements may be hosted in M/FI in these minerals.

In Ronda minerals, two-phase F (M?) I typically occur as healed cracks similar to S F/MI documented in peridotite xenoliths worldwide. Textural observations indicate that M/FI in Ronda minerals are of mantle origin, and thereby might represent trapped metasomatic M in the subcontinental lithosphere.

Assuming that the concentration of the highly incompatible elements in olivines and spinels is dominated by FI, some inferences about the composition and nature of these M/F can be inferred from the ratio of incompatible elements in those minerals.

Mass balance calculation in a remarkably fresh peridotites from Ronda shows that the whole-rock budget of trace elements in spinel peridotites is dominated by several contrasting reservoirs. The REE, Zr, and Hf budget is controlled by the crystallographic contribution of clinopyroxene and, to a lesser extent, orthopyroxene. Conversely, about 50% of the Rb, Ba, Nb, and Ta budget is hosted by a "grain boundary component." This grain boundary component consists of a Ti-oxide (+phlogopite) micrometer-layer of metasomatic origin coating spinel surfaces. The rest of the Rb, Ba, Nb, and Ta and over 70% of the U and Th budget is hosted by FI in silicates, especially in olivine. Therefore, a significant part of the budget of some radiogenic elements might be hosted in FI in the continental lithosphere instead of being controlled by crystallographic partitioning in mantle phases. (From authors' abstract by E.R.)

GARRIDO, Mirta and DOMINGUEZ, Eduardo, 1997, Geology, hydrothermal alteration and fluid inclusions of La Voluntad porphyry copper deposit, Neuquén Province, Argentina: Revista Geológica de Chile, v. 24, no. 1, p. 91-108 (in Spanish; Engl. abst.). First author at Dept. e Geologia, Univ. Nacionai del Sur, San Juan 670, 8000 Bahía Blanca, Argentina.

In La Voluntad porphyry copper deposit, the mineralization is related to a tonalite from the Chachil Plutonic Complex (Permian) intruded in the metamorphites of Piedra Santa Formation (Lower Paleozoic). Rhyolitic volcanic rocks from the Choiyoi Group (Triassic) cover unconformably the tonalite. The low mineralized vein densities indicate a hydrothermal system of low permeability with a weak fracturation attributed to a low hydrothermal F volume. The mineralization-alteration proceeded in two main stages. During the first stage, a low intensity pervasive potassic hydrothermal alteration with disseminated pyrite and chalcopyrite and scarce molybdenite was developed. During the second, a high intensity fracture related phyllic alteration was overprinted to the early potassic alteration. The mineralization consists of pyrite, chalcopyrite, bornite, molybdenite, sphalerite, arsenopyrite and scarce wolframite. FI indicate absence of hypersaline and presence of moderate to low sal F, with T between 240-420°C and sporadic boiling during main mineralization. This deposit belongs to a Permo-Carboniferous metallogenic cycle of unknown potential, related to a magmatic arc which trend SE south of Cerro

Charchil, obliquely to the Andean Range. (Authors' abstract)

GATTER, István, 1997, Fluid inclusion characteristic of the epithermal style mineralizations at the Central Mátra Mts. (NE Hungary): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 121-122. Author at H-1088 Budapest, Muzeum krt.4/a, Hungary; email (gatter@ludens.elte.hu).

A review of the FI studies of the many ore stages, from published 1987 work by Gatter and by Molnar (E.R.).

GEBRE-MARIAM, Musie, GROVES, D.I. and **McNAUGHTON, N.J.,** 1997, Aqueous and CO_2- and CH_4- rich inclusions at the Archaean Golden Kilometre gold deposit: Multiple fluid sources and depositional mechanisms: Chron. de la Rech. Min., 1997, no. 529, p. 59-73. First author at Centre for Teaching and Research in Strategic Mineral Deposits, The Univ. of Western Australia, Nedlands, WA 6907, Australia.

The Archaean Golden Kilometre gold deposit (~16t Au production) is a mesozonal deposit represented by laminated quartz veins in an Fe-rich quartz gabbro cut by structurally late, brittle to brittle-ductile faults in a lower greenschist facies greenstone belt. Late free gold is sited largely in healed fractures and spider veinlets in the quartz veins. Three groups of FI show strong textural, spatial and temporal relationships to the gold, and hence represent F tapped during the gold mineralisation event. Type 1 inclusions represent low-sal H_2O-CO_2-CH_4 F with highly variable H_2O±NaCl to CO_2±CH_4 ratios and densities (0.71-0.99 g/cm^3), interpreted to be trapped from a homogeneous parental H_2O-CO_2-CH_4-NaCl F undergoing immiscibility during supercritical F decompression at 225-280°C and 500-1500 bars. Type 2 I are monophase, supercritical CH_4±CO_2 I with density of 0.19-0.33 g/cm^3. The very high CH_4 contents of some I excludes an origin by phase separation of a F of the type parental to Type 1 inclusions, and the F are instead interpreted to result from interaction of such a F with graphitic sedimentary rocks in the ore environment and/or metamorphic dehydration of such rocks. Type 3 I represent two-phase aq I with either low (type 3A) or high (Type 3B) sal which homogenise at approximately 80-195°C. Type 3A I are interpreted to represent incursion of surface water into the hydrothermal system. Independent evidence for such surface water is provided by the hydrogen and oxygen isotope compositions of gold-related hydrothermal minerals. Type 3B I are interpreted to represent late F unrelated to mineralisation. (Authors' abstract)

GEORGE, S.C., KRIEGER, F.W., EADINGTON, P.J., QUEZADA, R.A., GREENWOOD, P.F., EISENBERG, L.I., HAMILTON, P.J. and **WILSON, M.A.,** 1997, Geochemical comparison of oil-bearing fluid inclusions and produced oil from the Toro Sandstone, Papua New Guinea: Organic Geochemistry, v. 26, no. 3-4, p. 155-173.

GEORGE, S.C., LISK, Mark, EADINGTON, P.J., KRIEGER, F.W., QUEZADA, R.A., GREENWOOD, P.F., and **WILSON, M.A.,** 1997, Fluid inclusion record of early oil preserved at Jabiru Field, Vulcan sub-basin: Exploration Geophysics, v. 28, p. 66-71. First author at Australian Petroleum Coop. Research Centre, CSIRO Div. of Petroleum Resources, P.O. Box 136, North Ryde, NSW 2113.

Oil trapped in FI in a sample of Plover Formation sandstone from the main oil zone in Jabiru-1A has been subjected to detailed geochemical comparison with production oil from the well. Fluorescence microscopy of the sandstone showed that predominantly blue-fluorescing oil I occur in 69% of quartz grains, both within quartz overgrowths and on healed fractures within detrital quartz grains. There are some notable similarities and differences between the FI oil and the production oil. These differences are interpreted to be due to lower maturity rather than source rock facies variation. Aromatic hydrocarbon ratios confirm a small but consistently lower maturity for the FI oil. For example, the calibrated methylphenanthrene index shows an equivalent reflectance of 0.84% for the FI oil, compared to 0.92% for the production oil. These geochemical data suggest that the oil trapped in FI in Jabiru-1A is from the same source rock but was generated at a lower maturity than the average of the oil now in the reservoir, and was trapped soon after initial charge mainly by thin quartz overgrowths. Further charge to the Jabiru structure was of progressively higher maturity oil. (From authors' abstract by E.R.)

GERALDES, M.C., PETRONILHO, L.A. and **SILVA, D.,** 1996, Trace elements and Pb isotope variations in galena from the Onça gold deposit, Mato Grosso, Brazil: Fluid mixing from hydrothermal and crustal sources: Bol. IG-USP, Sér. Client., v. 27, p. 81-98 (in English).

This study deals with the petrography of sulfides and quartz veins, Pb isotopes, major and trace elements in galena, microthermometry and Raman spectrometry of FI, with the objective of delineating temporal and spatial aspects of the F circulation patterns during the origin of the Onça gold deposit, Mato Grosso State, Brazil.

The Pb isotope and mineral chemistry data indicate variable sources for the Pb isotopes, major (S and Pb) and trace elements (Sb, Ag, Zn and Se), with increases or decreases of the contents during the growth of the galena crystals. The results suggest that the variation may be due to the contamination of the hydrothermal solution by mixing with components derived from supracrustal host rocks of Pontes e Lacerda metavolcanic-sedimentary sequence.

The mineral chemistry and FI studies suggest two possible sources for the hydrothermal solutions: (1) deep solutions that originated during the regional metamorphism represented by the Aguapeí metamorphic event where the solutions present aq-carbonic composition and low sal. Geologic control of the mineralization is in agreement with this hypothesis because the ore bodies are syntectonic with foliation formed during the Augapeí event; (2) high contents of base metals indicates a plutonic influence in the origin of the F. Geologic controls also are in agreement with this hypothesis because pegmatitic intrusion was synchronous with the mineralizations.

The Pb isotope and FI relations allow the conclusions that the compositions of the hydrothermal solutes were variable during the emplacement of the quartz veins and the growth of galena crystals. The earlier solutes had hydrocarbons and were more radiogenic, whereas the later solutes had base metals and were less radiogenic.

The Onça deposit originated during a metamorphic event by the effect of hydrothermal solutions related to plutonism, and with an important contribution from the host rocks as recorded by the influence of isotope, major and trace element compositions on the growth of ore-forming minerals. (Authors' abstract)

GHADERI, M., CAMPBELL, I.H., PALIN, J.M. and SYLVESTER, P.J., 1997, Eu anomalies in scheelite: implications for the oxidation state of hydrothermal gold mineralisation in Archaean greenstone belts: (abst.) The Australian National Univ. Research School of Earth Sci., Annual Report 1997, p. 159-160.

GHAZBAN, Fereydoun and HAJIKAZEMI, E., 1997, Significance of saddle dolomite formation in Cretaceous dolomitized carbonates of west central Iran (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-127. First author at Geol. Dept., Fac. of Sci., Tehran Univ., Tehran, Iran; email (Farhan@Khayam.UT.AC.IR).

Saddle dolomite occurring in the Lower Cretaceous carbonate strata in west central Iran produces information concerning the nature of the F and mechanisms responsible for base metal sulfide mineralization.

Based on depleted $\delta^{18}O$ (-13.9 to -11.0‰) and FI freezing and Th, the saddle dolomites occurring with dolostones and associated sulfides have formed from hydrothermal (90 to 110°C) saline (~10 wt.% $CaCl_2$).

Depleted $\delta^{13}C$ (-6.4 to -2.7‰) of saddle dolomites indicate the presence of organically derived carbon, produced by oxidation of hydrocarbons derived from Jurassic shales via thermochemical sulfate reduction. $\delta^{34}S$ of the S-bearing minerals indicates such a process. Interaction with shales is also indicated by high $^{87}Sr/^{86}Sr$ ratios of saddle dolomite (0.70838 to 0.71048) compared to those of the host dolostones (0.70752 to 0.70918). The overlap in isotope ratios implies isotopic modification and/or recrystallization of dolostones by F responsible for saddle dolomite precipitation.

It is concluded that saddle dolomite formed in a hydrothermal system due to thermochemical interaction of organometal-bearing F with sulfate-bearing brines. At the early stages of the brines evolution they caused recrystallization of dolomitic sedments. (Authors' abstract)

GIANELLI, Giovanni, RUGGIERI, Giovanni and MUSSI, Mario, 1997, Isotopic and fluid inclusion study of hydrothermal and metamorphic carbonates in the Larderello geothermal field and surrounding areas, Italy: Geothermics, v. 26, no. 3, p. 393-417. Authors at CNR-Internat'l. Inst. for Geothermal Research, 2 Pizza Solferino, 56126 Pisa, Italy.

FI and C and O isotopes have been studied on six calcite veins from the shallow part (480 to 1515 m) of the Larderello geothermal field, as well as on dolostones from the deep part of the field (1939 to 3177 m). FI observations suggest that boiling processes probably occurred during calcite precipitation in most of the veins. The F were characterised by an apparent sal from 1.3 to 22.2 wt.% NaCl eq. and a Th from 137 to 296°C. Apparent sal/Th covariations of the latter veins are interpreted as being the result of a mixing process between a low-T, high-sal F and a higher-T, moderate-sal F. The remaining thermal and isotopic data indicate that the Paleozoic dolomitic layers do not seem to contribute significantly to the production of CO_2. (From authors' abstract by E.R.)

GIBERT, François, GUILLAUME, Damien and LAPORTE, Didier, 1997, Experimental study of fluid immiscibility in H_2O-NaCl-CO_2 at 5-7 kb and 900°C using synthetic fluid inclusions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 123-124. Authors at Univ. B. Pascal, CNRS/UMR 6524, 5 rue Kessler, Clermont-Ferrand F63038, France; email (Gibert@opgc.univ-bpclermont.fr).

The aim of this study is to acquire new experimental data on the F immiscibility field at high T and P using synthetic FI technique. To control the composition of the F mixtures produced, three kinds of analyses were performed: (a) capsules were opened at controlled T in order to assess the amounts of H_2O and CO_2 produced; (b) microthermometric measurements of melting T of solid CO_2 were performed; and (c) a Raman spectroscopic study was carried out. These analyses demonstrated that CO_2 is the only gaseous species in the FI (no CO, CH_4, H_2 or N_2 detected).

The limits of F immiscibility were investigated at 900°C, 7 kb and 5 kb (Fig. 1). Our results are in agreement with Johnson 1991, and allow [us] to define more precisely the limits of the immiscibility field. For this T decreasing the P from 7 to 5 kb increases the extent of the two-phase domain (Fig. 1).

The immiscibility field shows a complex evolution with T and P (Fig. 2). At low T (500°C) the extent of the two-phase domain first decreases with rising P (1 to 3 kb) and then increases (5 kb). At higher T (700-900°C) a P increase causes a reduction of the immiscibility field. At 5 kb decreasing T from 900 to 500°C seems to have no dramatic effect. It should be noted that the equation of state of Duan et al. (1995), based on Johnson (1991) and Frantz et al. (1992) experiments, predicts an enlargement of the miscible domain at 7 kb and 500°C.

Because of the contrasted wetting behavior of the CO_2-rich and the aq-rich phases, the enlargement (from intermediate to high P) of the immiscibility field in the domain of natural F compositions could explain the occurrence of CO_2-rich FI in granulite facies rocks. Further experiments on this subject are in progress. (From authors' abstract by E.R.) *See figures on page 238.*

GIEB, Johann, 1991 (released 1997?), On the genesis and polymetamorphic overprinting of the Radenthein magnesite deposit and its enclosing rock series (Kärnten, Austria): PhD dissertation, Philipps Univ., Marburg, Germany, 151 pp. (in German, Engl. Abst.).

The stratiform Radenthein magnesite deposit is part of a thick, strongly metamorphically overprinted garnet-mica-schist series (Radenthein mica schist series). This belongs to the "Altkristallin" of the Middle Austro-Alpine Unit, originally a volcanogenic-sedimentary series in which the magnesite layer (deposit chain) can be attributed to a formation in a closed basin or an evaporite basin, in which also a black shale facies developed.

Massive bedding of magnesite and dolomite, overlain by a magnesite-dolomite transition zone, relict stratification, as well as the appearance of tourmalinite and kyanite-talc-schist on the contact zones of the deposit indicate a sedimentary evaporitic formation. For many decades this deposit was considered a typical epigenetic-metasomatic sparry magnesite deposit of Alpine age. This genetic interpretation can no longer be supported.

The Radenthein mica schist series and its included magnesite deposit display the same geologic evolution. The presently existing magnesite-marble displays the same tectonic elements and metamorphic overprinting as the crystalline series. Six deformation phases and three metamorphic events can be observed. Relic mineral paragenesis of a first metamorphism (M1) indicate upper greenschist facies PT-conditions (500°C and 4 kb). The pre-alpine amphibolite facies overprinting (M2) occurred under conditions of at least 624°C and 6.4 kb. Characteristic parageneses are staurolite + muscovite + quartz for the mica schist series and talc + kyanite for the intercalated magnesite deposit and its contact zones. During the alpine overprinting (M3) PT-conditions of around 300°C and 2 kb prevailed.

Micro-fabrics, developed during the polyphase overprinting of the carbonate body, indicate static and dynamic recrystallization. Typical features are cataclasis, accretive crystallization, rotational crystallization, the formation of subgrains and strain-induced boundary migration. Furthermore, old magnesite porphyroblasts exhibiting strong postcrystalline deformation are overgrown ("oversprouted") by idioblastic magnesite. Around these idioblasts the typical features of mineral growth in P shadows are present.

Primary FI are "wiped out" during recrystallization. The several maxima of the Th correspond to the T range prevailing during the regional metamorphic overprinting. (Author's abstract)

FI data, including Tm ice, Tm CO_2, Th, Th CO_2, and Tm NaCl, and G analyses for H_2O, CO_2, CH_4 and N_2 from decrepitation over a range of T up to 325°C are presented (pp. 114-127). (E.R.)

GIESECKE, Lynne, GOLDSTEIN, Arthur and **SELLECK, Bruce,** 1997, A fluid inclusion study of pre-, syn-, and post-tectonic quartz mineralization in the Taconic slate belt (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 1, p. 48. Authors at Dept. of Geol., Colgate Univ., 13 Oak Dr., Hamilton, NY 13346; email (lgiesecke@center.colgate.edu).

The T and sal of F which were present during mineralization can be determined by analysis of FI in the mineral deposited. We have restricted our study of Taconic mineralization to analysis of P two-phase aq I in quartz because it is less prone to resetting than is calcite. In the Taconics, we have identified pre-, syn- and post-tectonic quartz mineralization which allows us to determine some of the characteristics of F present before, during and after a tectonic event. Because the Taconic orogeny was driven by incorporation of the paleo-passive margin of eastern North America into the Taconic Accretionary Prism, we can use our results to speculate on the nature of F at depth in modern accretionary prisms. Studies of F expelled from modern prisms also provide a framework for interpretation of our results. The early veins all show fairly high Th averaging between 150-160°C and have sal much higher than sea water. Syntectonic mineralization is distinctly different, with somewhat lower T (140-150°C) but generally much lower sal than sea water, although some syntectonic veins display the highest sal we have found. Post-tectonic veins have characteristics similar to syntectonic mineralization, moderate T with very low sal, but are distinct in the presence of CO_2 I. The distinct T, sal and gas content of the quartz deposited before, during and after tectonism suggests different sources of the waters which moved through the Taconic slates. Early F were most likely derived from porosity reduction and de-watering. F present later were likely derived from smectite to illite conversion, resulting in very low sal. Post-tectonic F were also likely derived by clay diagenesis, but the presence of CO_2 is suggestive of an organic-rich source of F, possibly the para-autochthonous carbonates which underlie the Giddings Brook thrust slice. (From authors' abstract by E.R.)

GILES, A.D. and **MARSHALL, B.,** 1997, Genetic interpretations of the Woodcutters' Pb-Zn-Ag deposit, Northern Territory, Australia: Geometric, fluid inclusion and isotopic constraints: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 821-824. Authors at Univ. of Tech., Sydney, N.S.W., Australia.

The Woodcutters' epidiagenetic Pb-Zn-Ag deposit comprises replacement ore bodies, that occupy hingezone culminations along two horizontal upright antiforms, and vein-type 'feeder' mineralization associated with pre-D_1 faults. Emplacement and remobilization were pre- to early syn-D_1, the latter being coeval with lower greenschist facies metamorphism (~425°C). F-I populations in translucent sphalerite, quartz and carbonate were trapped late in the deposits' history and are essentially unrelated to ore genesis. $\delta^{34}S$ for the ore minerals (pyrite, sphalerite and galena), and for pyrite in the dykes and country rock, ranges from 6.8-21.7‰. This is consistent with sedimentary and/or igneous sulfur-sources; it is compatible with shale/carbonate-hosted Pb-Zn sulfide deposits. However, the narrower range for ore and dyke-rock sulfides ($\delta^{34}S$ = 6.8-12.7‰), than for country-rock diagenetic pyrite ($\delta^{34}S$ = 17.3-21.7‰), could reflect a magmatic input. (Authors' abstract)

GILLIAM, C.E. and **VALLEY, J.W.,** 1997, Low $\delta^{18}O$ magma, Isle of Skye, Scotland: Evidence from zircons: Geochim. Cosmo. Acta, v. 61, no. 23, p. 4975-4981.

GIULIANI, G., FRANCE-LANORD, C., ZIMMERMANN, J.L. and **CHEILLETZ, A.,** 1997, Composition of fluids, δD of channel H_2O and $\delta^{18}O$ of framework oxygen in beryl: Genetic implications for Brazilian, Colombian and Afghanistani emerald deposits: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 949-xxx. First author at ORSTOM and CRPG-CNRS, Vandœuvre-les-Nancy, France.

Composition of F, δD of channel H_2O and $\delta^{18}O$ of framework oxygen in beryl from granitic pegmatites and greisens, and emerald from Brazil, Colombia and Afghanistan allows one to constrain the origin of the parental F from which they grew. (Authors' abstract)

GIULIANI, G., FRANCE-LANORD, C., ZIMMERMANN, J.L., CHEILLETZ, A., ARBOLEDA, C., CHAROY, B., COGET, P., FONTAN, F. and **GIARD, D.,** 1997, Fluid composition, δD of channel H_2O, and $\delta^{18}O$ of lattice oxygen in beryls: Genetic implications for Brazilian, Colombian, and Afghanistani emerald deposits: Internat'l. Geology Review, v. 39, p. 400-424. First author at Inst. Français de la Recherche Scientifique pour le Developpement en Cooperation (ORSTOM), 213 rue La Fayette, 75480 Paris cedex 10, France.

The F composition, δD of channel H_2O, and $\delta^{18}O$ of lattice oxygen have been determined in beryl and emerald from a variety of geological environments and used to constrain the origin of the parental F as grown. Step-heating analyses performed by quadrupolar mass spectrometry were used to quantify the composition of the F phases in beryl from granitic pegmatites and greisens and emerald from Brazil, Colombia, and Afghanistan. An important conclusion is that beryl and emerald have a similar F composition, with concentrations of

H_2O>90% of the total water in the mineral irrespective of the age or tectonic settings.

In Brazil, δD is compatible with both magmatic and metamorphic origins. A magmatic origin is supported for emeralds associated with the pegmatitic Socotó and Carnaiba deposits (mean δD = -37.8±8‰) and a metamorphic origin is suggested for the Santa Terezinha shear-zone type (mean δD = -32.4±3‰). A metamorphic origin is proposed for Colombian emeralds. Afghanistani emeralds have a δD composition of channels (mean δD = -46.3±1.3‰) that is compatible with both magmatic and metamorphic origins. (From authors' abstract by E.R.)

GLEBOVITSKY, V.A., SAMORUKOVA, L.M. and **SEDOVA, I.S.**, 1997, Fluid components in minerals of Tervussky granite massif (north-western Priladozhie): Proceedings of the Russian Mineralogical Society, Pt. 126, no. 3, p. 1-19 (in Russian; Engl. abst.).

Contents of H_2O, CO_2, CO, H_2, CH_4, C_nH_m, N_2 in minerals from 7 samples of Tervussky massif granitoids were determined by the chemical mass spectrometry method with thermical activation of samples. The intrusion is related to the class of postfolding and postmetamorphic formations of the Svekofennian endogenic cycle which crystallized in the wide interval of T: 1000-700°C. It was revealed that saturation of minerals with F increases along the row: Qtz → Kfs → Pl → Ms, Bt, so as in leucosomas of migmatites with the same mineral parageneses. According to the H, C and N ratios, quartz and K-feldspar were crystallized simultaneously, on the contrary to plagioclase which began to segregate, together with biotite, at the earlier stage. According to positive correlation between H and C, C and N, H and N in anhydrous minerals, it is possible to assume an initially unit F, which has been in equilibrium with the M, and the S origination of FI with different composition: aq with various mineralization degree, CO_2, water-carbonic acid with admixtures of N_2 and CH_4. (Authors' abstract)

GLEESON, Sarah, BOYCE, Adrian, STUART, Fin, FALLICK, Tony, WILKINSON, Jamie, HERRINGTON, Richard and **SHAW, Harry**, 1995, The genesis of base metal mineralising brines, southwest England (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). First author at Fluid Processes Research Group, Dept. of Geol., Imperial College, London.

The low T, high sal F responsible for Pb-Zn "cross-course" mineralisation in southwest England have been frequently interpreted as basinal brines, possibly derived from off-shore Permo-Triassic sequences. A detailed microthermometric, chemical and isotopic study of FI in post-Variscan quartz±carbonate±anhydrite veins hosted by both Palaeozoic basement (Porthleven, south Cornwall) and Permo-Triassic sediments (Western Approaches) has been carried out to test this hypothesis.

F compositional and isotopic data from both vein groups are similar suggesting a common origin. Cl/Br and Na/Br ratios of I F fall along the sea-water evaporation trajectory indicating that partially evaporated seawater may have been the ultimate source of the brines. The $\delta^{34}S$ composition (≈ +9.8‰) of off-shore anhydrite suggests that the sulphur source was probably originally Permo-Triassic seawater.

The stable isotopic composition of the I water shows a remarkably wide spread in δD (-35 to -103) over a narrow range of calculated F $\delta^{18}O$ (+1 to +5). The more negative δD values would conventionally be interpreted as indicating interaction with organic matter, although high altitude meteoric precipitation has also been suggested. The former hypothesis is weakened because of the negative correlation of δD with the organophilic halogens (Br and I), and the latter alternative cannot simply explain the spread of data observed. It is probably that F/rock interaction processes have lowered the δD of the original F without apparently causing a corresponding shift in F $\delta^{18}O$.

Cation compositions also provide constraints on F-rock interactions. The concentrations of alkali earth elements when compared with other major F components are not consistent with evaporation processes but may be explained by dolomitisation and/or albitisation processes which are recognised in the basin sequences. However, small volumes of excess ^{40}Ar in the I F rule out significant F interaction with K-rich rocks and any influence of granite related F. These data are consistent with F-rock interactions occurring at low T in carbonate rich units or young basinal sediments.

This study, one of the first to attempt to relate in situ palaeo-basinal brines with basin margin mineralisation, illustrates that the mineralising F in southwest England have cation, anion and isotopic signatures that are comparable with many present day formation waters and are broadly similar to F mobilised in fractures in the Permo-Triassic sequence. However, the inferred genetic relationship between the two F is not simply reflected by F chemical and isotopic parameters indicating there are problems inherent in extrapolating back to the basinal source and accounting for the geochemistry of mineralising basinal brines. (Authors' abstract)

GOLDFARB, R.J., NESBITT, B.E. and **NEWBERRY, R.J.**, 1997, Gold vein formation during Cordilleran orogenesis: A consequence of metamorphic devolatilization, calc-alkaline magmatism, or (and) deep circulation of meteoric fluids? (abst.): Geological Society of Australia Abstracts No. 44, p. 32-34. First author at U.S. Geological Survey, Box 25046, Denver Federal Center, Denver, CO 80225.

The goldfields of the Cordilleran orogen have many features in common that hint at a common oreforming process. The deposits show great vertical continuity (1-2 km), and geochemical studies indicate that the ore F were consistently CO_2-rich and characterized by isotopically heavy oxygen compositions of 4 to 12 per mil. Low sal are consistent with the generally limited (<2-5%) sulfide content of the ores. Despite the many similarities, the source for the F that deposited the Cordilleran veins is controversial. Nesbitt (1991) argues that meteoric water is the predominant F type in the mesothermal vein deposits of the Canadian Cordillera. Analyses of noble gas isotopes and halogens within ore stage FI from the Alleghany district of the Sierra foothills has provided further supported to the meteoric hypothesis (Bohlke et al., 1989).

Goldfarb et al. (1993, 1996) have favored ore F produced during prograde greenschist-to-amphibolite facies metamorphic reactions in the crust. The spatial association between gold and greenschist facies rocks, the volatile chemistry of the ore F, and F δD and $\delta^{18}O$ have been stressed as supporting the metamorphic model. The extremely broad range in δD for FI waters, and the fact that waters from the least milky and deformed quartz are significantly heavier than meteoric waters, have been pointed out as evidence that much of the δD_{FI} data represent waters trapped in S FI trails during uplift of the already formed ore systems. Newberry et al. (1995) and McCoy et al. (1996) have recently postulated a magmatic F source for many of the gold lodes in interior and southwestern Alaska and central Yukon. Many significant gold ores in these regions are essentially identical in age to host plutons and there seems to be a spatial association between gold and those plutons with a low P oxidation state. Lead, sulfur, and carbon isotopes, with values significantly different from other Cordilleran gold vein deposits, have been argued to reflect magmatic signatures. McCoy et al. indicate country rocks in interior Alaska were metamorphosed to lowest amphibolite facies >20 m.y. before gold veining and thus were not a possible F source. Geochemical data are interpreted as supporting a model in which CO_2-rich, gold-bearing F are exsolved from highly differentiated granite magmas. Early, pre-gold, high-sal, magmatic(?) brines have been documented in a few of these systems.

[The above] might be the result of the fact that a very similar F chemistry could evolve through a variety of processes. It is such a near-neutral pH, moderate T, low sal, low fO_2, and relatively high H_2S synorogenic F that is critical for the gold ore regardless of F source. (From authors' abstract by E.R.)

GOLOVIN, A.V., SHARYGIN, V.V. and **SMIRNOV, S.Z.,** 1997, Genetic relationships between secondary silicate-melt inclusions in minerals of spinel websterite xenoliths and host basalt (Pipe Bele, Khakassia, Russia): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 125-126. First author at Novosibirsk State Univ., 630090 Novosibirsk, Russia.

Secondary silicate-M and FI have been observed mainly in clinopyroxene of spinel websterite. The sizes of the I vary from 2 to 50 µm, and all are associated with polysulphide globules. M and FI are generally confined to the same healed fissures in the host clinopyroxene. Th of silicate MI occurred at 1100-1200°C. Tm CO_2 are -57.4-60.0°C. Their homogenization into L phase occurred at +25°C. Raman spectroscopy shows that F of these I are composed of CO_2 (93 mol%) and N_2 (7 mol%).

Primary silicate-MI (10-30 µm) in Ti-augite phenocrysts of the host basanite have Th=1130-1160°C.

Glasses of heated I from websterite clinopyroxene drastically differ in major element composition from the xenoliths. In general, these glasses have compositions practically similar to the host basanites and glass of a heated I in clinopyroxene from basanite, differing from them in higher SiO_2 only.

Residual glasses of silicate-MI in clinopyroxene from both websterite and basanite have similar compositions. MI in basanite olivine contain higher SiO_2 (up to 71 wt.%) and lower Al_2O_3 (18-20 wt.%). The wide variations in the major element contents seem to be related to the composition and the quantity of phases which formed inside the I.

Thus, in terms of compositions there are no principal differences in between glasses of both heated and unheated silicate-MI in minerals from both websterites and the host basanites. On the basis of the above data, we suggest that S MI in websterite clinopyroxenes are the result of the invasion of basanite L into xenolith at P>2.6 kb and T>1200°C. The broad compositional variations for heated glasses of these I may be attributed to the partial reaction between the initial basanite M and clinopyroxene of the xenolith. Our conclusions are in contrast with those of Schiano and Clocchiatti (1994). According to these authors, S silicate-M I in minerals of sub-continental and sub-oceanic mantle xenoliths represent small-volume metasomatic M which migrate in the upper mantle. (From authors' abstract by E.R.)

GOLOVIN, A.V., SMIRNOV, S.Z. and **SHARYGIN, V.V.,** 1997, Primary CO_2 inclusions in orthopyroxene of a websterite xenolith from the Bele Pipe (Khakassia, Russia): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 127. First author at Novosibirsk State Univ., 630090 Novosibirsk, Russia.

The Bele pipe is one of typical diatremes of Khakassia. It is composed of basanites and their breccias. Basanites contain numerous crustal (granulites) and mantle (lherzolites, pyroxenites) xenoliths up to 20 cm in size (Ashchepkov et al, 1995).

Primary CO_2 I (15-25 µm) were found in orthopyroxene of a spinel websterite xenolith (cpx+opx+sp). The following observations suggest their P nature: (1) I are not confined to any fissures or cleavage of the host orthopyroxene; (2) they are not associated with silicate-MI (unlike S FI). All show evidence of partial opening (haloes around them or fractures extended from them).

Tm=-57.3°C, which indicates that the trapped F is CO_2 with minor amounts of other volatiles. H_2O has not been found during cryometric study. The homogenization into L phase for an I with partial leakage occurred at -25°C. It corresponds to 1.055 g/cm^3 density calculated on the basis of the CO_2 V-L equilibrium. Raman spectroscopy shows that F of this I is composed of CO_2 (95 mol%) and N_2 (5 mol%). Methane and other hydrocarbons were not detected.

Unfortunately, the direct data on T of P FI trapping are absent. However, T of last mineral equilibrium for the studied xenolith may be considered as minimum T of I trapping. Its estimation calculated on the basis of two-pyroxene geothermometer (Brey and Köhler, 1990) is 940°C. Using the above data on the density and composition of CO_2-rich F, FLINCOR program for Windows (version 1.2.3, Ph.Brown, 1989) and the data on the CO_2-N_2 system (Van den Kerkhof, 1988), the trapping P for this P I can be estimated as exceeding 8.5 kb at 940°C. This value represents the lower limit for entrapment P, because the FI has been partly opened. Trapping of these P FI has, possibly, occurred at even higher PT-parameters, which means a mantle setting. (From authors' abstract by E.R.)

GOMEZ, Gabriel and **MARTINEZ, Estela,** 1997, Fluid evolution in gemstone miarolitic cavities and quartz veins in a shallow granite intrusive, Sierras Pampeanas, Argentina: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 128-129. Authors at CONICET Cátedra de Química Analítica Mineral, FCEFyN Univ. Nacional de Córdoba, Velez Sarsfield 299, (5000) Córdoba, Argentina.

The existence of elbaite and superb smoky quartz crystals are potential indicators of the presence of gemstone quality specimens.

The values of Th_t (241-364°C) and sal (1.5-8.8%) for the miarolitic cavities suggest a F mixture evolution trend between CO_2-bearing magmatic F ($Th_{CO_2}V$=28.1-28.9°C) with moderate sal and notably poorer in saline content F (meteoric water?) under isothermal conditions. Later quartz veins showed sal values lower than 1 eq. wt.% NaCl together with a T drop, suggesting a common origin and the possible influence of meteoric water. It appears that magmatic F at the early stage of forming miarolitic cavities interacted in a mixing process with meteoric water in nearly isothermal conditions. Quartz veining events occurred later under lower P-T conditions and probably in an environment dominated by diluted magmatic or meteoric F. (From authors' abstract by E.R.)

GOMEZ, M.C. and **ALIOTTA, Guida,** 1997, Hydrothermal fluid evolution in the W San Martin deposit, Argentina: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 130-131. Authors at Dep. de Geologia, Univ. Nac. del Sur, San Juan 670, 8000 Bahía Blanca, Argentina; email (mgarrido@criba.edu.ar).

The W San Martin mine is located in the northeastern part of the Patagonian Massif, Río Negro Province, Argentina. Tungsten mineralization occurs in veins genetically related to a highly differentiated Permian granitic stock and Precambrian metamorphic rocks. Four types of FI were recognized.

Type I: PS or S aq I containing two phases at room T: a F and a V. The absence of CO_2 hydrate formation during freezing constrains X_{CO_2} to 0.01 mole fraction.

Type II: P or PS I containing an aq F, CO_2L and/or CO_2V.

Type III: P or PS I containing CO_2L or L+V at room T. Non-aq phase was observed but may be recognized as a film wetting on the walls of the I.

Type IV: P I with one phase at room T. They did not show changes on cooling or freezing.

The first stage of mineralization formed quartz, potassium feldspar and hübnerite, and type II FI are dominant. CO_2 densities range from 0.80 to 0.88 g/cm^3 and total homogenization to the L phase occurred at T higher than 360°C although numerous I decrepitated before homogenization.

The second stage of mineralization includes quartz, hübnerite, cassiterite and fluorite, and all the FI types are present.

The third stage of mineralization includes quartz with pyrite, chalcopyrite, sphalerite and galena, with only type I FI, with Th 218-225°C.

The results indicate that during the tungsten mineralization, there was a progressive CO_2 depletion in the hydrothermal F from stage 1 onward. At stage 2, the data suggest that there were two homogeneous phases, at about 280-330°C. This immiscibility could have been produced by a drop in F P that leads to effervescence in water. (From authors' abstract by E.R.)

GONZÁLEZ PARTIDA, E., GUTIÉRREZ, A.G., and **RODRÍGUEZ, V T.,** 1997, Thermal and petrologic study of the Ch-A well from the Chipilapa-Ahuachapan geothermal area, El Salvador: Geothermics, v. 26, no. 5/6, p. 701-713. Authors at Inst. de Investigaciones Eléctras, A.P. 1-475, 62001 Cuernavaca, Morelos, México.

Mineralogical variations define four zones which, in turn, represent different thermal zones. FI analyses performed at 100 m intervals indicate that a low to moderate sal F with ice melting T of -0.7 to -2.2°C was involved in the hydrothermal alteration of the rocks. At shallow depths, positive values of +1.6°C were found, which probably indicate an increase in volatile components. Minimum Th gradually increased with depth. They range from 110°C at very shallow depths (153 m) to 244°C at total depth (2700 m); however, peak or maximum T of 265-286°C are found at various depths between 1400 and 2500 m. Bottom-hole FI T agree well with static T. It is believed that well Ch-A encountered a mineral paragenesis that does not correspond with present thermodynamic conditions of the reservoir and that the geothermal system has undergone natural cooling. (From authors' abstract by E.R.)

GONZÁLEZ, M.M., 1997, The fluid inclusions on gold quartz of La Candelaria, Córdoba Province: Analysis of their origin and their application on mining prospecting: Doctoral thesis, Univ. Nacional del Sur, Bahía Blanca, Argentina, 336 pp (in Spanish, Engl. abst.); email (Gonzalez@criba.edu.ar)

The metamorphic Precambrian rocks of the Candelaria District host several economically important mesothermal gold deposits (e.g.: La Higuerita, La Bragada, Paso del Molle, etc.). According to the structural setting, ore mineralogy and wall rock lithologies, three different types of veins can be distinguished in the Candelaria District:

type A: plastically deformed segregation veins with different grade of concordance with the host rocks; they have been probably generated during syn-metamorphic processes

type B: quartz veins associated to pegmatites dikes; and

type C: quartz veins developed in zone of intense fracturation. Those veins do not show any ductile deformation. They are centimetric to decimetric in width and contain P sulphides.

Gold mineralization in the Candelaria area is spatially associated with shear-hosted quartz veins. Structures which host mineralization are typically no larger than 100 meters long and 2-5 meters wide, with grades <20 g/t Au. Systematic FI studies using petrographic and microthermometric 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.

The results of this study are based on the analysis of the FI and the distribution of deformed quartz-rich veins and lenses. The development of different quartz generations with clearly distinguishable types of FI, initial CO_2-rich and progressively higher H_2O content, implies that F had been trapped under variable P-T conditions. Considering all these chemical and physical characteristics, it is proposed that the gold mineralisations of the Candelaria District formed from CO_2-rich hydrothermal systems, which were active during the reactivation of the NNE-SSW shear zone under extensional conditions. The genesis of the deposits favours the metamorphic-hydrothermal mobilization and concentration model. (Author's abstract)

GONZALEZ, M.M. and **MAS, G.R.,** 1997, Fluid inclusion petrography in ductile deformed gold-quartz veins: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-

CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 132-133. Authors at Dep. de Geología, Univ. Nac del Sur, San Juan 670, 8000 Bahía Blanca, Argentina: email (gonzalez@criba.edu.ar).

In the Candelaria gold district, metamorphized Precambrian-early Paleozoic rocks display different quartz veins cross-cutting the rocks; some host mesothermal gold mineralization.

FI studies were made on plastically deformed segregation quartz veins. Three types of FI, dominantly S, have been found in the coarse grain quartz mosaic, occurring in groups or as trails along deformation planes. These show a multimodal Th histogram consisting of 3-4 subsets:

Type I: Isolated, probably P FI. CO_2-rich, with F=80-85%. Most have Th >380°C and frequently decrepitate before homogenization. There are some dendritic I with an "implosion-halo" texture, impying later changes of internal underpressure (Vityk and Bodnar, 1995).

Type II: These are 1- or 2-phase CO_2-rich, and small (<10 μm). They are restricted to the ductile deformed quartz which has undergone intense recrystallization and are present as planes of various relative ages. Bulk densities are ~0.81 g/cm^3 (rarely as low as 0.77) and Th L at T of 200-250°C. These two types would be formed by phase separation of a relatively low sal H_2O-CO_2 F.

Type III: These consist of H_2O-rich F+V at room T; ThL=180-290°C. They are late secondaries.

This study indicates a complex hydrothermal history, with a reactivation of the shear zone under extensional conditions. The P-T conditions are estimated to be higher than 380°C and about 4 kb.

The quartz veins were formed by a CO_2-rich F, with 10-12 wt.% eq NaCl, during or after the main metamorphic event. (From authors' abstract by E.R.)

GOODFELLOW, W.D., PETER, J.M. and **LENTZ, David,** 1997, Genetic attributes of massive sulphide deposits of the Bathurst Mining Camp, New Brunswick, Canada (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A56. First author at Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8.

The Bathurst Mining Camp contains over 30 Zn-Pb-Cu-Ag massive sulphide deposits that are hosted within a Middle Ordovician bimodal sequence of felsic and basaltic volcanic rocks with intercalated sediments that formed in a marine back-arc continental rift. Reduced sedimentary rocks indicate that the water column was stratified with anoxic bottom waters during episodes of ore formation. Three hydrothermal events spanning about five million years are currently recognized: from oldest to youngest, the Caribou, Brunswick and Stratmat horizons.

The pyrrhotite-chalcopyrite assemblage in sulphides from the vent complex and feeder zone suggest that the ore-forming F were probably >300°C. FI microthermometry indicates that ore F sal at the Brunswick deposits ranged between 7 and 13 eq. wt.% NaCl. (From authors' abstract by H.E.B.)

GORSHKOV, A.I., YANAN, Bao, BERSHOV, L.V., RYABCHIKOV, I.D., SIVTSOV, A.V. and **LAPINA, M.I.,** 1997, Inclusions in diamond from the Liaoning diamond deposit (China) and their genetic meaning: Geokhimiya, 1997, no. 1, p. 58-65, (in Russian, translated in Geochem. Internat'l., v. 35 no. 1, p. 51-57). First author at Inst. of Geol. of Ore Deposits, Petrography, Mineral. and Geochem., Russian Acad. Sci., Staromonetnyi per. 35, Moscow, 109017 Russia.

Various I (rutile, zircon, aluminum-free phlogopite, magnetite, graphite, Ca-Mg-siderite, lonsdaleite ingrowths, Fe-sellaite, fluorite, rare-earth minerals, kaolinite, Fe oxides, feldspar, and barite) were detected in diamond microcrystals from Liaoning (China) by analytical transmission electron and scanning electron microscopy. These I reflect various stages of the geological evolution of diamond microcrystals. (Authors' abstract)

GOTTIKH, R.P. and **PISOTSKII, B.I.,** 1997, Manifestation of reductive degassing in crystalline rocks: Doklady Akademii Nauk, v. 354, no. 6, p. 790-793 (in Russian, translated in Transactions (Doklady) Russ. Acad. Sci./Earth Sci. Sect., v. 355, no. 5, p. 723-726.) Authors at All-Russia Inst. of Geological Geophysical, and Geochemical Systems, Varshavskoe sh. 8, Moscow, 113105 Russia.

Based on petrographic, thermobarogeochemical, chromatographic, and *f*-radiographic data on 80 boreholes, which reached the basement, we discovered in the rocks a wide spectrum of carbonaceous materials, which are representd by graphite, schungite, various bitumens, bitumenoids, and hydrocarbon G. They occur both as I in minerals and in the free state and allow us to decipher their origin. (From authors' text by E.R.)

GOTTIKH, R.P., PISOTSKII, B.I., ZINCHUK, I.N. and **CHEREVICHNAYA, L.F.,** 1997, Gases in crystalline rocks of the South Tatar Arch: Dokl. Ross. Akad. Nauk, v. 354, no. 4, p. 517-519 (in Russian, translated in Trans. (Dokl.) of the RAS/Earth Sci. Sections, v. 354, no. 4, p. 615-617. First author at All-Russia Inst. of Geological Geophysical, and Geochemical Systems, Varshavskoe sh. 8, Moscow, 113105 Russia.

Gases were released, by heating, from crystalline rock from deep under an oil field, with simultaneous decrepigram sounding. The release in 250-573°C interval "corresponds mainly to the release of F occluded in I." Major constituents found were CO_2 and CH_4, with minor H_2 and C_nH_m. (E.R.)

GRAUPNER, T., SPOONER, E.T.C., BRAY, C.J., KEMPE, U. and **KREMENETSKY, A.A.,** 1997, Geochemistry of hydrothermal fluids from the Muruntau Au-quartz vein ore field (>4300 tonnes Au), Uzbekistan: Initial volatile/ion chromatographic and microthermometric data: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 134-135. First author at F. Gordon Smith Fluid Inclusion Lab, Dept. of Geol., Univ. of Toronto, 22 Russell St., Toronto, Ontario M5S 3B1, Canada; email (graupner@zircon.geology.utoronto.ca).

The Muruntau Au ore field, one of the largest defined, lies in a sequence of greenschist to amphibolite facies metamorphosed siltstones and shales. Au is preferentially concentrated in "stockwork-type" and "central" quartz veins. In addition to gold, pyrite and arsenopyrite, which represent the major ore minerals, the quartz veins contain carbonate, sericite, scheelite, K-feldspar, and accessory apatite. Strong hydrothermal alteration is widespread in wall rocks at Muruntau.

P I are restricted to the earliest stage quartz and are characterized by very similar volatile compositions. The

S F is aq, low sal and extremely low in non-H_2O volatiles; it occurs in I trails cross-cutting grain boundaries.

In the CO_2/CH_4 vs. CO_2/N_2+plot, all data from the Muruntau ore veins define an inclined line consistent with phase separation. The highest values for CO_2/CH_4, consistent with the highest degrees of phase separation, were measured in samples from the high grade mineralized "central" veins and, in addition, from an adjacent wall rock quartz nodule which also contains Au. The phase separation model for Muruntau is supported by a Cl^- vs. CO_2/CH_4 plot, which clearly shows a sal increase from the low grade ore veins to the high grade mineralization. Br^- shows a similar trend to chloride, and the Cl^-/Br^- ratios are nearly constant with increasing CO_2/CH_4 ratios. This phase separation trend suggests an effective mechanism, probably in addition to others, for the precipitation of Au from the hydrothermal F. (From authors' abstract by E.R.)

GRAWINKEL, Andrea and **STÖCKERT, Bernhard,** 1997, Hydrostatic pore fluid pressure to 9 km depth – Fluid inclusion evidence from the KTB deep drill hole: Geophysical Research Letters, v. 24, no. 24, p. 3273-3276. Authors at Inst. für Geologie, Ruhr-Universität, D-44780 Bochum, Germany.

The KTB drill hole (Germany) provides a unique opportunity to study the pore F P as a function of depth in metamorphic continental crust to 9101 m depth and to ambient T of ca. 265°C. Open fissures identified in cuttings and cores along the entire profile are partially coated by minerals crystallized from the pore F. The FI in these minerals reflect pore F composition and P. A NaCl-dominated aq F with low sal is encountered to ca. 4 km depth, whereas the F is $CaCl_2$-dominated with a higher sal of ca. 4 to 24 wt.% NaCl eq. between 4 and 9 km depth, consistent with analyses of the free F (available to 6 km depth) and hydraulic tests. The densities of the FI invariably indicate a hydrostatic pore F P to 9 km depth and thus confirm the predictions based on rock strength. (Authors' abstract)

GREEN, D.G. and **MOUNTJOY, E.W.,** 1997, Constraining the timing of burial cementation in deep Devonian reservoirs (Kaybob South, Swan Hills Fm. and Pine Creek, Leduc Fm.) of west-central Alberta (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A58. First author at Dept. of Earth and Planet. Sci., McGill Univ., Montreal, Canada H3A 2A7.

The Leduc Pine Creek and Swan Hills Kaybob South reservoirs (3100 to 3600 m) display a similar sequence of burial diagenesis. In order of occurrence, saddle dolomite, pyrobitumen, anhydrite and coarse crystalline calcite cements occur as fracture, vug and mold filling phases.

FI in saddle dolomite cements (Th-127-167°C; Tm = -18 to -27°C), Sr isotopes (saddle dolomite $^{87}Sr/^{86}Sr$ = 0.7088-0.7131) and stable isotopic values for carbon (1.52 to -7.37‰ PDB) and oxygen (-4.5 to -10.01‰ PDB) indicate that saddle dolomites were derived from hot, radiogenic F. Bulk crushing of saddle dolomite cements (FI gas compositions with abundant CO_2, moderate methane and wet gases) indicate that saddle dolomites were precipitated in brines containing gaseous hydrocarbons.

Anhydrites contain two-phase I (Th = 158-180°C; Tm = -14.8 to -19.5°C) that coexist with three-phase hydrocarbon I (Th = 104-116°C). Sr isotopes of anhydrite are radiogenic ($^{87}Sr/^{86}Sr$ = 0.7094-0.7209). Moreover, based on the intimate association with pyrobitumens, anhydrite cements were emplaced during deep burial when oil was cracked to gas.

Latest stage coarse crystalline calcite (Th = 124-164°C; Tm = -16.8 to -24°C) also contain hydrocarbon bearing I (Th = 57-82°C). Bulk crushing of calcite cements yielded gases rich in methane with moderate amounts of CO_2 and wet gases. Calcite $^{87}Sr/^{86}Sr$ = 0.7170-0.7310 and stable isotopic values are depleted in carbon (-3.58 to -10.18‰ PDB) and oxygen (-8.74 to -11.63‰ PDB). Calcite was precipitated during deep burial from hot, radiogenic brines after much of the reservoir oil was cracked to gas.

The presence of hydrocarbon I (anhydrite and calcite) and gaseous hydrocarbons in FI (saddle dolomite and calcite), indicate that saddle dolomite, anhydrite and calcite cements probably were emplaced during deep burial and hydrocarbon maturation in the late-Cretaceous to early-Tertiary. The hot and saline brine compositions (FI Th and Tm), radiogenic Sr isotopes, and depleted oxygen isotopes, also provide further evidence for the late-timing and deep burial. (Authors' abstract)

GRISHINA, Svetlana, PIRONON, Jacques, KONTOROVICH, Alexei, POLOZOV, Alexandr and **ARISKINA, Oksana,** 1997, Hydrocarbon inclusions in Cambrian salt deposits of Siberian platform: A clue for oil geochemistry understanding in metamorphic salts: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 136-137. First author at Inst. of Mineral. and Petrol., Siberian Dept. of RAS, 630090 Novosibirsk, Russia; email (grishina@uiggm.nsc.ru).

Oil I have been previously described from these sylvite-rich salt beds. They are generally S LI or solid residues as a result of thermal decomposition. The T is suspected to be as high as 200-300°C, reaching 400-700°C at the contact with dolerite intrusions. FTIR measurements show different compositions of the same I types for the regions affected and not affected by dolerite intrusion:

Organic I without dolerite intrusion show: gas I (CH_4-rich and N_2-rich); L waterless hydrocarbon I (transparent and essentially aliphatic); two-phase dark L hydrocarbons inside brine I; and multiphase I in planes.

Organic I with dolerite intrusion show: gas I (CO_2-CH_4-N_2-H_2S-bearing); L waterless hydrocarbon I (red or black and essentially aromatic oil enriched in CO_2 and sometimes in CSO); multiphase I; and solid organic matter inside gas I.

Aliphatic oil I occur in regions far from magmatic intrusion whereas aromatic oil I have been found at the vicinity with magmatic body. Averaged Th of two-phase oil I are 120°C for aliphatic I and 270°C for aromatic I. Gas I were found only at the contact with magmatic bodies in halite, but they were found in wells with and without magmatic intrusion in sylvinite. N_2-rich and CH_4-rich gas I were found only in halite associated with sylvite. Gas I on the contact with magmatic bodies are CO_2-rich; their CH_4 content is <3 mol% in halite environment.

Composition of organic I in halite of Cambrian salt deposit is controlled by two main factors: evaporite deposition stage and presence of magmatic intrusions. Sylvite environments, enriched in CH_4, N_2 and aliphatic oils, can be considered as an important petroleum source rock. Aromatic oils, CO_2 and sulphur compounds which are trapped in halite and sylvite environments result from thermal influence in the vicinity of magmatic bodies. (From authors' abstract by E.R.)

GROBE, Matthias and **MACHEL, H.G.,** 1997, Petrographic and geochemical evidence for fault-controlled hydrothermal mineralization of the Brilon reef complex, Germany: AAPG Bull., v. 81, no. 10, p. 1775.

Intervals of pervasive dolostone associated with minor base metal sulfide mineralization have been encountered in drill cores from the Devonian Brilon Reef Complex in the northeastern Rhenish Schiefergebirge, Germany. Because of striking petrographic similarities with pervasively dolomitized hydrocarbon reservoir rocks and host rocks of MVT deposits around the world, the Brilon Reef Complex serves as a case study to enhance the understanding of the origin and formation of these deposits. Both pervasive dolomitization and sulfide mineralization in the Brilon Reef Complex postdate the Variscan deformation and are related to deep-reaching Saxonian normal faults. Mineralization occurs preferentially in and around breccia zones and is characterized by the presence of grey matrix dolomite, replacive coarse crystalline whitish dolomite, saddle dolomite cement followed by sulfide minerals, and late calcite cements. In some intervals "zebra" dolomite fabrics occur. Microthermometric data from FI of saddle dolomite, sphalerite, and late stage calcite indicate precipitation of these mineral phases from highly saline F (16-22 eq. wt.% NaCl, Th = 70-120°C) of $NaCl$-($MgCl_2$)$CaCl_2$ composition. Isotopic ($\delta^{18}O$, $\delta^{13}C$) and trace elements trends in the limestones immediately adjacent to the mineralized intervals are suggestive of hydrothermal alteration and can be utilized as a predictive tool to locate mineralization. Integration of these data into the regional hydrologic framework suggests that the mineralizing F may share a common origin with present-day brines in the Munsterland Basin directly north of the Brilon Reef Complex. Surface-controlled basin-wide groundwater movements, together with hydrothermal convection caused by increased heat flow during the Mesozoic and early Tertiary, may have led to a migration of brines along fault systems resulting in dolomitization and sulfide mineralization in the Brilon Reef Complex. (Authors' abstract)

GÜBELIN, E.J. and **PERETTI, A.,** 1997, Sapphires from the Andranondambo mine in SE Madagascar: Evidence for metasomatic skarn formation: J. of Gemmology, v. 25, no. 7, p. 453-516. First author at Lucerne.

Mineral I in gem quality saphires from the new mining area in southern Malagasy (Andranondambo) include a wide variety of minerals typical of the host skarns. Based on the different generations of P FI in the sapphires, various generations of solid I and the absence of hibonite I, it is concluded that the Andranondambo sapphires have formed during several different metasomatic events. The later blue sapphire generations have grown from CO_2-rich F of complex chemical composition with minor concentrations of fluorine, water and metals such as aluminum, titanium, iron, chromium and zinc as well as other elements (Mg, Si, Ca, Na, K, P, Zr, U, Th). (From authors' abstract by E.R.)

GUEDES, Alexandra, DÓRIA, Armanda, NORONHA, Fernando and **BOIRON, M.-C.,** 1997, Fluid inclusion studies in Paleozoic C-rich metasedimentary rocks from northern Portugal: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 138-139. First author at Centro de Geologia da Univ. do Porto, Fac. de Ciências, 4050 Porto, Portugal; email (aguedes@fc.up.pt).

FI were studied in structures filled by quartz, concordant with the metamorphic foliation, in the lydites and the black schists. Several types of quartz were recognised: a major filling of synmetamorphic deformed milky quartz concordant with the main foliation, a recrystallised quartz resulting from deformation of the former milky quartz and a clear quartz with a slight undulose extinction.

In general, the three types of quartz exhibit specific FI. According to the microthermometric and Raman data, two main F types are distinguished:

–aquo-carbonic F (H_2O-CO_2-CH_4-(N_2-H_2S) with a CO_2-CH_4 volatile rich phase, and various water contents, and

–aqueous F, a low density volatile phase (CO_2-CH_4-N_2-H_2S) only detected by the presence of clathrates (Lw-c, Lw-m) or only water (Lw).

From these geothermometric data, the maximum conditions in the Valongo region are 360°C and 170 MPa. In the Chaves region, the conditions vary from ~150 MPa and 370°C to 400 MPa and 550°C.

The bulk F composition and fO_2 fugacity estimation show that water-rich and rather oxidising F occur in Valongo region. These F were not equilibrated with the C-rich wall rocks. In contrast, the presence of methane-rich F in other areas suggests an interaction of the F with C-rich rocks under relatively reducing conditions. (From authors' abstract by E.R.)

GUERCI, Alain, CATHELINEAU, Michel, BANKS, David, KOMNINOU, Ali, AYT OUGOUGDAL, Mohammed and **POTY, Bernard,** 1997, Numerical modelling of water-rock interaction using fluid inclusion compositions: The example of the alpine fissures: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 140-141. First author at CREGU and EP578, BP 23, 54501 Vandœuvre-lès-Nancy, France; email (guerci@cregu.cnrs-nancy.fr).

The goal of this study is to reproduce the major alpine water-rock interactions observed in and around alpine fissures from the Mont Blanc granites using the FI data and the geochemical code EQ3/6. A special attention has been given on three major stages of alteration: the quartz dissolution, the crystallization of the main fissure fillings (quartz-chlorite), and the later alteration of the previous alteration minerals by an ankerite-muscovite assemblage. A special effort has been paid to the effects of P on chemical equilibria.

Geochemical modelling has been carried out using the detailed compositions issued from the crush-leach studies and the code EQ3/6 in its modified version by Komninou (1996). The modifications allow the code to deal with T from 100 to 450°C (0-300°C for the standard version) using two thermodynamic databases generated with SUPCRT92 for P of 1 kbar and 3 kbar (at saturated V pressure for standard version).

The reproduction of the quartz dissolution in the granite is somewhat difficult to obtain as the initial altering F is unknown. The interaction between a F displaying the chemistry of the I speciated at 3 kbar and the granite under oxidising conditions at 1 kbar and 370°C produces a mineral assemblage rather similar to the observed one. The simulation of the third alteration stage has been carried out by adding 1.5 mole of CO_2 per kg to the stage 2 F. The resulting F was used to react with the quartz-chlorite-(adularia) assemblage at 1 kbar. The best result is obtained when the T is dropped from 370 to 270°C, as carbonates are saturated only in this system at T <290°C.

The results of the numerical modelling show that the code may reproduce rather satisfctorily the alterations which occur in an alpine granite. The main difficulty in simulating the water-rock interactions comes from the lack of data on input F, as most F trapped in newly formed minerals as FI correspond to F already changed in composition during the alteration process. (From authors' abstract by E.R.)

GUHA, Hillol and **MISHRA, Biswajit,** 1997, Fluid inclusion studies in quartz-wolframite veins, Chhendapathar, Bankura District, West Bengal, India: Eos Trans. AGU v. 78 (17), Spring Meet. Suppl., p. S337. Authors at Dept. of Applied Geol. and Geophys., I.I.T. Kharagpur, WB 721302, India.

FI studies of quartz samples showed three types of I: 1) aq biphase (T_m237-377°C; sal 8.24-16.05 wt.% eq. NaCl; and density 0.792-0.989 gm/cc). 2) monophase carbonic (T_mCO_2 and T_hCO_2, mol% CH_4 was in the range of 1.31 to 11.69. 3) aq polyphase (T_h 231 to 346°C; sal 35.19 to 49.91 wt.% eq. NaCl; density 1.117 to 1.228.

Aq polyphase I are characterized by $T_{s\ (NaCl)}$>T_h, resulting in the disappearance of the V bubble first, and the halite crystal later. $T_{s\ (NaCl)}$ ranged from 256 to 423°C. From the intersections of isochores of these three distinct types of I three independent estimates of T-P were made (360°C, 1.6 kb; 400°C, 2.35 kb; 444°C, 1.91 kb). The polyphase I show a strong positive correlation between sal and T, implying progressive mixing of an initial hot saline solution with a low saline relatively cooler F. On the other hand, the aq I indicate simple cooling under conditions of negligible variation in sal. As both groups of I are associated with carbonic I, the evolution of ore F at Chhendapathar can be traced as follows: the probable hot F may be either metamorphogenic or magmatic (associated with granite) in nature with a composition in the H_2O-CO_2-NaCl system. The F started evolving at crustal P of about 2 kb, and T above 450°C, first by splitting into a carbonic (and aq carbonic) as well as an aq F of high sal. After this initial splitting, the high saline hot aq F mixed with meteoric water (?), followed by simple cooling. The T of tungsten mineralization could have been anywhere at the low T-low sal range in the figure above. (Authors' abstract) *See figure on page 233.*

GUILHAUMOU, Nicole, DUMAS, Paul, CARR, G.L. and **WILLIAMS, G.P.,** 1997, Infrared synchrotron microspectromertry: Applications to microanalysis in the micron scale range: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 142-143. First author at Département de Géotectonique-Univ. Pierre et Marie Curie 75252 Paris Cedex 05.

Infrared microspectrometry, using synchrotron radiation as a source (IMS) is used for chemical in situ microanalyses of the F entrapped in minerals. The brightness of the source and configuration of the apparatus using a confocal arrangement and a completely purged system permitted a few microns lateral resolution. Constituents of small FI <20 μm, volatiles in glass MI and hydrogen bond in dry minerals can be analysed. The stability of the beam and short acquisition times permit recording of profiles and mapping of the elements.

IMS opens up applications to reservoir studies as it can help to separate them by recording average composition of individual FI along sealed cracks or overgrowth zones.

Unprecedented details have been obtained by mapping the chemical elements in larger size FI in fluorite. Mapping of the different F confirm that in unmixed CO_2, oil and water individual FI, all the CO_2 is in the V phase, aliphatics in the L, and L H_2O is wetting the wall of the cavity.

Volatiles as gaseous CO_2 (typical band at 2334 cm^{-1}) and V H_2O (OH stretching at 3595 and 3711 cm^{-1}) are detected in the vitreous part of naturally quenched glass I hosted in olivine in basalt. As they represent a sampling of the magma, it implies first that the magmatic F was not outgassed during ascent, and second that H_2O was still a constituent of the magma.

Microanalyses were performed on diopside single crystals in order to test the ability of the Synchrotron IMS technique to record short hydrogen concentration profiles (tens to hundreds of microns) in nominally anhydrous minerals containing few hundred ppm of hydrogen. We recorded the evolution of the intensity of OH absorption bands (at 3648 cm^{-1}) from the edge toward the core of each crystal. The diffusion coefficient calculated from this profile is higher than what was first expected (10^{-13} or 10^{-14} m^2/s) and the profile found is thus longer than expected. However, these experiments clearly show that the measurement of short hydrogen profiles in minerals is feasible. (From authors' abstract by E.R.)

GUNTER, W.D., WIWCHAR, B. and **PERKINS, E.H.,** 1997, Aquifer disposal of CO_2-rich greenhouse gases: Extension of the time scale of experiment for CO_2-sequestering reactions by geochemical modelling: Mineral. and Petrol., 1997, no. 59, p. 121-140. Authors at Alberta Research Council, Edmonton, Alberta, Canada.

Previous work suggested water-rock reactions in deep aquifers in sedimentary basins could sequester injected-CO_2-waste from industry, thereby reducing greenhouse G emissions. Experiments suggest that CO_2-trapping reactions are expected to take hundreds of years to complete. This is sufficient time for the trapping to occur as the residence time of a packet of F in a deep low-permeability aquifer in a sedimentary basin is measured in ten-thousands to hundred-thousands of years. (From authors' abstract by E.R.)

GÜNTHER, Detlef, AUDETAT, Andreas, FRISCHKNECHT, Rolf and **HEINRICH, C.A.,** 1997, A 193 nm excimer laser ablation-inductively coupled plasma-mass spectrometer system for fluid inclusion analysis: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 144-145. Authors at Swiss Federal Inst. of Tech. Zurich, Inst. of Isotope Geol. and Mineral Resources, CH-8092 Zurich, Switzerland; email (guenther@erdw.ethz.ch).

Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) and LA-ICP-Atomic Emission Spectrometry (LA-ICP-AES) are microanalytical methods for direct analysis of single FI in different host minerals. They have been demonstrated on different synthetic FI as well as mineral samples. Calibration studies with dual sample introduction systems (solution nebulisation and laser-induced aerosol introduction) as well as micro-wells in combination with solid reference materials have been used for calibration. The stability and plasma conditions of the dual sample introduction systems lead to lower sensitivity due to compromised carrier gas flow rates and a number of interference problems.

The present paper demonstrates capabilities of a 193 nm excimer (ArF) laser system equipped with a petrographic microscope in combination with an ICP-MS, especially developed for the analysis of single FI. Advantages of constant energy densities, high repetition rate and fast switching between different pit sizes in addition to a homogeneous beam profile are demonstrated in increased flexibility and improvements in the ablation behaviour of quartz and fluorite. The importance of the opening procedure will be illustrated with natural I, which contain a lot of dxls. I are opened with the smallest possible pit size to relase the F P, leading to the first signal [as shown in figure 1]. Immediately afterwards the I is drilled out using a bigger pit size diameter resulting in a second signal [see figure 1]. Integration of the total signal lead to better relative standard deviations and a more representative sampling. The relative standard deviation of 15 element concentrations (based on Na as internal standard element) in Mole Granite FI were <20% in 39 I measured in one trail. (From authors' abstract by E.R.)

GUO, Naiyan and **YU, Xiaoguo,** 1997, Organic inclusion study of YC 13-1 gas field in Qiong Dongnan Basin: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 10 (in English). Authors at Exploration and Development Research Center of China Nat'l. Offshore Oil Corp., Gaobeidian, 074010.

The type, distribution, Th and components of organic I in authigenic quartz of the YC 13-1 gas field sandstone show that a G migration began in the Pliocene. At that time, the strata were buried to a depth of about 3.0 to 3.3 km [and the] G reservoir was not yet formed. The large-scale migration occurred in the end of Pliocene to Quaternary, with its depth about 3.4 to 3.9 km. The main accumulation stage is Quaternary. Based on the component characteristics of organic I, the F media and G source are discussed. (Authors' abstract)

GURENKO, A.A. and **CHAUSSIDON,** Marc, 1997, Boron concentrations and isotopic composition of the Icelandic mantle: Evidence from glass I in olivine: Chemical Geol., v. 135, p. 21-34. First author at CRPG-CNRS, BP 20, F-54501 Vandœuvre-lès-Nancy Cedex, France.

Quenched tholeiitic glasses and glassy rims of tholeiitic lava flows and pillow lavas from the neovolcanic rift zone on Iceland (Reykjanes and Hengill fissure swarms) contain olivine phenocrysts (Fo_{87-91}) with abundant P glass I. These I and host glasses were analyzed by ion microprobe for boron concentrations and isotopic comositions. I are believed to represent P or near-P mantle M that have not been modified at shallow levels. Boron concentrations and B/K ratios in these M I are highly variable, whereas their $\delta^{11}B$ values are nearly constant. (From authors' abstract by E.R.)

GUTSALO, L.K. and **PLOTNIKOV, A.M.,** 1997, The calculation method and estimation of CO_2 distribution along with carbon isotope fractionation factors in hydrothermal carbonate system during a disequilibrium CO_2 release from water solution: Dokl. Ross. Akad. Nauk, v. 352, no. 2, p. 230-234 (in Russian, translated in Trans. (Dokl.) of the RAS/Earth Sci. Sections, v. 352, no. 1, p. 84-88.

HAAK, Volker and **JONES, A.G.,** 1997, KTB and the electrical conductivity of the crust: J. of Geophys. Research, B, Solid Earth and Planets, v. 102, no. 8, p. 18,289-18,305. Indexed under FI (E.R.)

HAAPALA, I., 1997, Magmatic and postmagmatic processes in tin-mineralized granites: Topaz-bearing leucogranite in the Eurajoki Rapakivi granite stock, Finland: J. of Petrol., v. 38, no. 12, p. 1645-1659. Author at Dept. of Geol., P.O. Box 11, FIN-00014 Univ. of Helsinki, Finland.

Miarolitic cavities indicate the presence of a separate F phase during late stages of crystallization of the topaz-bearing granite, and greisen-type Sn-Be-W-Zn mineralization is closely associated with it. Subsolidus reactions have modified the petrography and geochemistry of the topaz-bearing granite. The presence of magmatic topaz is indicated by petrographic features and crystallized M I entrapped in topaz. The magmatic origin of accessory cassiterite in the topaz-bearing granite (average 80 ppm Sn) is indicated by mode of occurrence and chemical composition of cassiterite. Some of the rhyolite dykes contain topaz as phenocrysts and as small prismatic crystals in the groundmass showing locally fluidal texture. These features indicate that the late-stage magma was highly enriched in F and Sn. Strong exsolution of alkali feldspar has produced intergranular albite rims. The topaz-bearing granite had originally anomalous geochemistry and mineralogy, and its anomalous character was further increased during postmagmatic F-rock interaction. In interpreting the origin of such highly evolved granites, the role of Na-metasomatic albitization has often been overemphasized at the expense of exsolution and re-crystallization. (From author's abstract by E.R.)

HÁBER, Milan, JELEN, Stanislav, MAT'O, L'uboslav, KOVALENKER, V.A., and **NAUMOV, V.B.,** 1997, Genetic model of the meso- and epithermal mineralization in the central zone of the Banská Stiavnica Stratovolcano (Slovak Republic) (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 31-32 (in English), ISBN 5-88918-002-9. First author at Geological Inst., Slovak Acad. of Sci., Severná 5, 974 01 Banská Bystrica, Slovak Republic.

The Banská Stiavnica-Hodrusa ore district is one of the largest in the Carpathian arc and has an over thousand-year-long history for precious/base metal ores. There are various types of ore mineralization, e.g., from porphyry and skarn copper occurrences, mesothermal Au-carbonate-quartz vein type and epithermal base/precious metal, and metasomatic base metal ores.

Mesothermal and epithermal paragenetic assemblages indicate successive mineralizing events immediately in relation to the polyphase tectonic events-deformation stages D_1 to D_4. Later mineralizing events show evidence for heterogeneous F developed in an uplifted collapsing system combined with younger extension tectonics which created conditions for later influx of meteoric waters. The ore-forming processes were accompanied by concominant decrease in T, sal, oxygen and sulphur activities. Generally, the hydrothermal precious/base metal mineralization originated in the three successive cycles separated from each other by T inversion and also by a change in other essential parameters along the boundary between the mesothermal and epithermal mineralization and between 3rd and 4th stages of the epithermal mineralization (Table 1 [omitted])

Contrasting behaviour of precious/base metal complexes in the ore-forming solutions as well as diverse thermodynamic parameters cause partial temporal and spatial separation of the precious/base metal ore mineralization. Essential portion of the carbonate-quartz vein filling with the earlier mesothermal precious metal mineralization (1st mineralization cycle) was formed at relatively high (395-230°C) T in acid and subneutral solutions. T decrease was accompanied by gradual pH increasing from 3.6 to 4.5.

The precious/base metal mineralization of the 2nd cycle consists of three mineralization stages: (1st) hematite-quartz, (2nd) sphalerite, and (3rd) rhodonite-carbonate-quartz. It was formed at T 380-200°C, pH 4.7-6.0, lg a_{S_2} from -11 to -14 and lg a_{O_2} from -32 to -41 in depth from 0.75 to 1.60 km.

The mineralization of the 3rd cycle is represented by the two stages: (4th) galenite-chalcopyrite, and (5th) sulphosalts-barite. These stages originated at T 310-50°C, pH 3.5-7.6, lg a_{S_2} from -8 to -17 a lg a_{O_2} from -30 to -46 in depth from 0.4 to 1.1 km.

Sal of the hydrothermal solutions with content of CO_2, CH_4, N_2, Na^+, K^+, F^-, Cl^-, SO_4^{2-}, Cu, Pb, Ag, Fe, Zn in range from 0.4 to 11.5 wt.% NaCl eq.

Analyses of lead isotopes reflect extraordinary uniform isotopic composition of the Pb-rich ores, and implying a well-homogenised and gigantic magmatic source. Strontium isotope data from the vein carbonates and barite are analogous to the values characteristic of marine carbonates, which suggests the basement carbonate rocks as the major Sr source of the mineral-forming solutions. [Data also listed for $\delta^{18}O$, δD, and $\delta^{34}S$, and $\delta^{13}C$.] (From authors' abstract by E.R.)

HAGGERTY, R. and **BOTTRELL, S.H.**, 1997, The genesis of the Llanrwst and Llanfair veinfields, North Wales: Evidence from FI and stable isotopes: (Source lost). Authors at Dept. of Earth Sci., The Univ. of Leeds, Leeds LS2 9JT, U.K.

The Llanrwst Pb-Zn and the Llanfair Pb-Zn-Cu veinfields consist of sporadic mineralization in sediments. FI data from both veinfields indicate mineralization took place from $CaCl_2$-bearing brines, up to 26 wt.% NaCl eq., between 125 and 190°C with cooler (<100°C), more dilute F associated with later thrusting at Llanrwst. Sulphur at both veinfields was derived during the main phases of sulphide precipitation from the host rocks, with paragenetically late sulphides and sulphates deriving sulphur from $\delta^{34}S$-enriched surface waters. Carbon and oxygen isotopic data on vein carbonates show that both deposits formed from waters that had undergone extensive water-rock interaction. Carbon was derived from at least two sources: marine carbonate dominated at Llanfair, whereas organic matter in the host rocks was more significant at Llanrwst. These data indicate that the veins formed from evolved brines which migrated along fault systems to the loci of deposition during a phase of extensional tectonics in late Devonian to Tournasian times. (Authors' abstract)

HAILIANG, Chang and **HUILAN, Huang**, 1997, Characteristics and origin of melt-fluid inclusions (abst.). Authors at Yichang Inst. of Geol. and Mineral Resources, Yichang, 443003. Publication source unknown, as it was lost in transit from PRC to USA (E.R.).

There exists a mix-up in the terminology of "melt-fluid inclusion." In this paper the authors discuss the connotation of M-FI and demarcate that only the anomalous I simultaneously captured which the silica M and F (H_2O, CO_2, etc.) in an immiscible M-F system may be called "melt-fluid inclusion"; and those should be called MI which consist presently of silica M and F but only a M phase was captured during the I were trapped. Taking the I in topaz from the Jianfengling pegmatoid for an example, the authors describe in this paper the characteristics of the M-FI. (Authors' abstract)

HALAS, Stanislaw, SZARAN, Janina and **NIEZGODA, Halina**, 1997, Experimental determination of carbon isotope equilibrium fractionation between dissolved carbonate and carbon dioxide: Geochim. Cosmo. Acta, v. 61, no. 13, p. 2691-2695.

HALL, D.L. and **LARESE, R.E.**, 1997, Constraining petroleum migration histories with fluid inclusions: Annual Meeting Abstracts - American Assoc. of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, 1997, v. 6, p. 46.

Understanding oil and G migration is key to managing petroleum exploration risk, hence the need to continually develop improved organic and inorganic mineralogical and F tools which can be used to infer the former presence of oil and G. FI may represent the most complete samples of reservoir hydrocarbons, and are often documented along migration pathways penetrated by wells without conventional shows. Three applications are discussed. 1) Evidence for migration. Detection and quantification of the abundance and stratigraphic distribution of petroleum FI allows mapping of dominant migration pathways and potential reservoir intervals. Recent advances in microanalytical techniques allow for more routine biomolecular analysis of included petroleum, hence permitting migration paths to be tied to source rock and source maturity. Limitations include addressing possible alternate sources of petroleum I (e.g., those inherited to recycled detritus, or generated in situ from mature, disseminated kerogen), as well as understanding the controls on I formation and preservation. 2) Product type. Prediction of petroleum type and quality from I is possible through microthermometry. Advanced analytical techniques can estimate GOR, other production characteristics and detailed chemistries. 3) Timing relationships. Petrographic and microthermometric analysis can be used to understand relationships between petroleum migration and porosity evolution, and can place relative or absolute constraints on timing of migration. These data along with product type can be used as input for basin models, which can then place additional absolute timing constraints on regional migration. Ultimately, these data can be used to assess charge/trap associations. (Authors' abstract)

HALLAGER, W.S., SUISINOV, Kubentay, BASKIN, D.K., GARBER, R.A., HARRIS, P.M. and **WARNER, J.L.**, 1997, Two-stage hydrocarbon migration model for the Tengiz Field, Kazakhstan: AAPG Bull., v. 81, no. 8, p. 1380.

The Tengiz Field, located in western Kazakstan bordering the Caspian Sea, produces a light 42° API gravity oil from a >1500 m section of Carboniferous and Devonian platform carbonates. About one-third of the average 7% porosity in the upper 500 m is filled with solid organic matter consisting of solid bitumen and thermally mature (spent) kerogen. Paleotemperature in the uppermost reservoir (Bashkirian) is estimated at 130°C from solid bitumen reflectances and spore coloration indices. Present day oil was likely generated off-structure from a more mature, Permian source which migrated into the Bashkirian reservoir during the present cycle of burial in a 18°C/km thermal gradient. This oil, which represents essentially all of the producible petroleum, formed S FI in calcite spar cements along with a distinct, tarry bitumen in vugs and veins. (From authors' abstract by E.R.)

HALLBAUER, D.K., 1997, The application of capillary ion analysis to the geochemistry of natural aqueous fluids and in particular to the analysis of fluid inclusions in minerals: Proc. 30th Int'l. Geol. Congr., v. 9, p. 409-424, H. Yunhui and C. Yawen, eds. Author at Dept. of Geol., Univ. of Stellenbosch, PB XI, Matieland, 7602, Rep. South Africa; email (dkh@maties.sun.ac.za)

See FIR 29, p. 72 (E.R.)

HALTER, W.E., WILLIAMS-JONES, A.E. and **KONTAK, D.J.**, 1997, Origin and evolution of the greisenizing fluid at the East Kemptville tin deposit, Nova Scotia (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 118. First author at Dept. of Earth and Planet. Sci., McGill Univ., 3450 University Str., Montréal Qué. H3A 2A7; e-mail (Werner@Geosci.Lan.McGill.Ca)

Large scale alteration at East Kemptville was investigated using petrographic and chemical analyses. Leucogranite was first sericitized, then altered to quartz-sericite greisen, and in turn to cassiterite-bearing quartz-topaz greisen. Prior to complete solidification of the leucogranite magma, tectonic fracturing induced a P drop and caused a F phase to separate. This F was responsible for the early sericitization and mobilized ore metals. The F was then focused in fractures and caused greisenization. Based on fractionation of oxygen isotopes between cassiterite and quartz, the deposit and related greisenization took place at a T of 450°C. The P is estimated to have been approximately 3.8 kb from isochoric projection of FI Th to a T of 450°C. FI Th are relatively constant in the Sn-mineralized greisen indicating that T was therefore not a factor in cassiterite precipitation. The activity of Cl^- and the fugacity of O_2, respectively calculated from mass action equations and measured by G chromatographic analyses of FI, decreased during F/rock interaction, favoring cassiterite dissolution. Hence, the only change in an intensive parameter that can account for the precipitation of cassiterite was the pH increase associated with the replacement of muscovite by topaz during the formation of quartz-topaz greisen. (Authors' abstract)

HAN, Yujing, ZHANG, Zeming and **LIU, Rong**, 1997, Melt inclusions in eclogites from high-pressure and ultra-high pressure metamorphic belt in the Dabie Mountains, China: Proc. 30th Int'l. Geol. Congr., v. 16, p. 255-263, H. Yunhui and C. Yawen, eds.

See FIR 29, p. 73 (E.R.)

HAN, Y.-J., ZHANG, Z.-M, LIU, R. and **HUANG, H.-L.**, 1997, Melt inclusions in HP and UHP eclogites from Dabie Mountains, China: Fifth International Eclogite Conference, Abstract Supplement No. 1 to Terra Nova, v. 9, p. xx. Authors at Dept. of Geol., China Univ. of Geosci., Wuhan 430074, China; email (liangjun@public.wh.hb.cn)

The Dabie high-P (HP) and ultra-high P (UHP) metamorphic belt lies in the eastern part of the Qinling-Dabie orogenic belt which is sandwiched between the North China and Yangtze continental blocks. The eclogites mainly occur as lenses and layers intercalated in the metamorphic supracrustal rocks of the Dabie Mountains. MI have been discovered for the first time in HP and UHP eclogites. Petrographical, microthermometric and Raman spectroscopic studies have been made of the I. The MI are isolated within omphacite, kyanite and coesite crystals, their morphologies are negative crystal shaped or irregular, ranging from 8 to 30 mm [µm?] in size. The Th for the MI generally vary between 820 and 950°C. MI, consisting of a silicate glass phase and a G phase with the dominant CO_2 have been discovered in UHP eclogites with rarely developed symplectic texture; while the F-M immiscible I have been found in HP eclogites and UHP eclogite with well-developed symplectite. They are composed of silicate glass, G and L phases. The major component of G phase is mainly CO_2, and the L phase belongs to the H_2O-NaCl system with a fairly high sal of 15.9-22.0 wt.% eq. NaCl. The formation of symplectite in eclogites may be related to the presence of the aqueous solution. The composition of glass phase from a kyanite eclogites is close to its host mineral kyanite. H_2S and OH- detected by Raman analyses are respectively molecules and ions in monomer $[SiO_4]$ networks. The glass phase from coesite-bearing eclogite corresponds to a type of frame (SiO_2) [sic, SiO_4?] network, with a composition close to the host mineral coesite. Thus the host minerals possibly crystallized from the M of corresponding compositions, and the M are likely of anatectic origin related to subduction. (Authors' abstract)

HÄNNI, H.A., KIEFERT, Lore, CHALAIN, J.-P. and **WILCOCK, I.C.**, 1997, A Raman microscope in the gemmological laboratory: First experiences of application: J. of Gemmology, v. 25, no. 6, p. 394-406. First author at SSEF Swiss Gemmological Inst., Basel, Switzerland.

Discusses and illustrates the use of Raman spectroscopy to analyze FI in gemstones. (H.E.B.)

HARLOV, D.E. and **FRANZ, L.**, 1997, Evidence for potassium-rich fluids during the genesis of granulites from the Ivrea-Verbano zone, northern Italy: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 87-88, Lunar and Planetary Inst., Houston. Authors at GeoForschungsZentrum Potsdam, D-14407 Potsdam, Germany; email (dharlov@gfz-potsdam.de)

Following Hansen et al., we postulate that the Kfs veins seen in the Ivrea-Verbano Zone granulites are evidence of a pervasive, high-T, low-H_2O activity, K-rich brine, coupled with a separate CO_2-rich phase, and that these brines were the principle dehydration mechanism for these rocks. Additional evidence for the presence of these F takes the form of primary N_2-CH_4-CO_2-H_2O-NaCl-$CaCl_2$-rich FI. Recent experimental work by Aranovich and Newton and by Shmulovich and Graham indicates that under granulite P-T conditions the activity of H_2O in these KCl-NaCl brines goes at least as $X^2{}_{H_2O}$, thus allowing for them to be more H_2O-rich than previously thought. Alkali and volatile-rich basalt underplating, represented today by the basal metagabbros in the Ivrea Zone, is the most likely source of the heat and F responsible for the genesis of these granulites. (From authors' abstract by E.R.)

HARLOV, D.E., NEWTON, R.C., HANSEN, E.C. and **JANARDHAN, A.S.**, 1997, Oxide and sulphide minerals in highly oxidized, Rb-depleted, Archaean granulites of the Shevaroy Hills massif, south India; oxidation states and the role of metamorphic fluids: J. Metamorphic Geol., v. 15, no. 6, p. 701-717.
Indexed under FI (E.R.)

HARMS, E., SACHS, P.M. and **SCHMINCKE, H.-U., 1997**, Syneruptive SO_2 degassing and F-, Cl-, Br- and H_2O- inventory of the Plinian phonolitic Laacher See eruption (13,000 BP) (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 19. Authors at Dept. of Volcanol. & Petrol., GEOMAR Forschungszentrum, Wischhofstr. 1-3, 24148 Kiel; e-mail (eharms@geomar.de)

We have quantified the stratospheric injection of SO_2, F and Cl during the Plinian eruption of Laacher See volcano (13,000 BP) by comparing volatile elements between MI and partially degassed pumice glasses.

S-concentrations in MI increase from ≤300 ppm (top of magma column) to 1700 ppm (lower part of magma column), evidence for a strong pre-eruptive S-gradient within the Laacher See magma column. Pumice matrix glasses have much lower S-contents (≤300-1000 ppm). An estimate yields a minimum atmospheric SO_2-input of at least 10-12 Mt during the eruption.

Surprisingly, F-concentrations in MI are significantly lower (750-3000 ppm) than in the matrix glasses (max. 8000 ppm in the topmost part of the magma column). Apparently, fluorine became enriched in the M after crystallization of the mafic phenocrysts with a major increase in the magma chamber roof prior to eruption. Whether or not F was significantly lost in the G phase during the eruption can thus not be reconstructed. All MI and pumice glasses have Cl-contents between 2000 and 4000 ppm, indicating only minor syneruptive Cl-degassing.

Br is only enriched in hauyne (2-30 ppm) and in MI within hauynes (2-100 ppm). Degassed pumice glasses are extremely Br-depleted (<1-3 ppm), which underpins a Br-diffusion towards the growing hauyne with a high Br-gradient at the crystal/melt interface.

Ion probe analyses show up to 5 wt.% H_2O in MI from the top of the magma column contrasting with 0.2-2.0 wt.% H_2O in the matrix glasses, evidence, that most of the H_2O was released into the G phase during the eruption. (Authors' abstract)

HARTMANN, L.A., TAKEHARA, Lucy, LEITE, J.A.D., McNAUGHTON, N.J. and **VASCONCELLOS, M.A.Z.**, 1997, Fracture sealing in zircon as evaluated by electron microprobe analyses and back-scattered electron imaging: Chemical Geol., v. 141, p. 67-72. First author at Inst. de Geosciências, Univ. Federal do Rio Grande do Sul, Poto Alegre, RS, Brazil.

The internal structure of zircon is commonly revealed by back-scattered electron (BSE) images. Grains from a 750-700 Ma old calc-alkaline mafic metatonalite from southernmost Brazil show relict igneous faces, irregular and diffuse metamorphic overgrowths, and fracture sealing. Sealing of fractures is observed as light grey patches in BSE images. EPMA profiles show strong but differential increases in Hf and U in the sealed fractures, unlike the common assertion in the literature that fractures are only pathways of leaching. Sealing of fractures occurs near borders of grains as well as in their cores and is not visible during standard petrographic examination; thus careful BSE image evaluation is needed before either in situ or whole grain isotopic determinations are made. (Authors' abstract)

HASENBERGER, Katharina, KANDUTSCH, Georg and **KIRCHNER, E.Ch.**, 1997, What are the reasons for different habits of quartz crystals from alpine fissures of the eastern Tauern window (eastern Alps, Austria)? Microthermometry–what can it contribute to an explanation?: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 146-147. Authors at Inst. of Mineral., Univ. Salzburg, Hellbrunnerstraße 34, 5020 Salzburg, Austria.

Observations in the field have shown that different kinds of habit exist which are not bound to certain types of host rocks. Quartzes with prismatic habit contain exclusively two-phase aq I with a volume of the gas bubble from 20 to 30% and a sal between 1.3 and 6.0 wt.% NaCl eq.; the Th values are between 176 and 290°C. Homogenization generally goes to the L phase. Quartzes with acute rhombohedral habit contain, besides two-phase aq I, three-phase, CO_2-bearing I and in many cases up to three different dm which could not be determined optically. Homogenization occurs between 305 and 360°C both to the F and to the V phase. The CO_2 content varies from 30 to 80%, the melting point of clathrate is between 8.7 and 10.0°C, which points toward low sal. The melting point of CO_2 in all samples is between -56.6°C and maximum -58.5°C; this [results from] considerable content of N_2 and/or CH_4. The composition of the I is independent of the chemistry of the neighboring rocks. (From authors' abstract by E.R.)

HAUCK, S.A., SEVERSON, M.J., ZANKO, L., BARNES, S.J., MORTON, P., ALMINAS, H., FOORD, E.E. and **DAHLBERG, E.H.**, 1997, An overview of the geology and oxide, sulfide and platinum-group element mineralization along the western and northern contacts of the Duluth Complex: Special Paper - Geological Society of America, 1997, no. 312, p. 137-185.
Indexed under FI (E.R.)

HAWKESWORTH, C.J., TURNER, S.P., McDERMOTT, F., PEATE, D.W. and **van CALSTEREN, P.**, 1997, U-Th isotopes in arc magmas: Implications for element transfer from the subducted crust: Science, v. 276, p. 551-555. First author at Dept. of Earth Sci., the Open Univ., Milton Keynes, MK7 6AA, UK.

Uranium-thorium isotope results from island arc volcanic rocks were used to investigate the rates of transfers of fluids and sediments from the downgoing slab. Uranium, but not thorium, is readily mobilized in the F. A negative array between thorium/cerium and neodymium-143/neodymium-144 indicates that significant amounts of the thorium in arc rocks are derived from subducted sediments, although perhaps only about 30% of the thorium in subducted sediments is returned to the crust in this way. The transfer times for F through the mantle wedge are about 30,000 to 120,000 years, whereas those for sediment M may be several million years. The low average uranium/thorium ratios of bulk crust primarily reflect different crustal generation processes in the Archaean. (Authors' abstract)

HAYASHI, Shu, YOKOYAMA, Takushi, MOTOMURA, Yoshinobu and **IZAWA, Eiji,** 1997, In-situ analysis of micron size gold in siliceous precipitate from geothermal water using laser sampling ICP-MS (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 231 (in English), ISBN 5-88918-002-9. First author at Dept. Mining, Fac. Eng., Kyushu Univ., Japan.

In-situ direct analysis of trace concentration of gold using Laser Sampling ICP-MS was developed to determine the concentration and speciation of invisible gold in a siliceous precipitate collected from the Hatchobaru geothermal power plant in Japan. In-situ Laser Sampling ICP-MS analysis was conducted on polished thin-sections. At minimum energy conditions (9 mJ/pulse), the Q-switched laser produces a sampling pit with a diameter of approximately 100-B5m and a depth of around 10 = B5m [sic] on the surface of a polished thin-section. The technique of nonmatrix matched standardization was used for calibration and quantification of gold. The average gold value of 18 single laser shots is in agreement coincides with that of the bulk gold concentration, and has a detection limit which is extremely low (<0.3 ng/g). Furthermore, the silver concentration by semi-quantitative Laser Sampling ICP-MS analysis is also similar to that of bulk silver concentration.

Result of the in-situ Laser Sampling ICP-MS analysis in conjunction with EPMA data indicate that occurrence of gold in the siliceous precipitate can be divided into two types; the one is submicron size grains of composite Au-Ag-Te mineral or electrum, and the other is extremely fine particles (<0.15 = B5m in size) which may be chemically combined with amorphous silica. It is proposed that the submicron Au-bearing grains were formed from hot reservoir F at depth and later transported to the surface by upward hydraulic action of the F where they adhered to the surface of siliceous precipitate. Processes other than chemical precipitation, such as physical transport and adhesion of submicron Au-bearing grain, play a role in concentration of gold and other trace elements in siliceous precipitate which was formed from geothermal F. On the basis of the high concentration of gold in amorphous silica, we proposed that chemical interaction between gold and silica is also an important mechanism for the concentration of gold and precious metal in siliceous precipitate. (Authors' abstract)

HAYBA, D.O., 1997, Environment of ore deposition in the Creede mining district, San Juan Mountains, Colorado: Part V. Epithermal mineralization from fluid mixing in the OH vein: Economic Geol., v. 92, p. 29-44. Author at U.S. Geological Survey, MS 956, National Center, Reston, VA 20192.

Detailed FI studies on coarse-grained sphalerite from the OH vein, Creede, Colorado, have shown that the abrupt color changes between growth zones correspond to abrupt changes in the nature of the ore F. Within each growth zone, however, the composition of the F remained constant. The base of a distinctive orange-brown growth zone marks a sharp increase in both T and sal relative to the preceding yellow-white zone. The orange-brown growth zone can be correlated along much of the vein and is believed to represent a time-stratigraphic interval. Along the vein, T and sal of FI within this interval show a systematic decrease from about 285°C and 11.5 wt.% NaCl eq. near the base of the vein to about 250°C and 8 wt.% NaCl eq., respectively, near the top of the vein. The iron concentration of this sphalerite growth zone shows a similar pattern, decreasing from about 2.8 to 1.2 mol% FeS.

When plotted on an enthalpy-sal diagram, the FI data define a spatial trend indicating the progressive mixing of deeply circulating hydrothermal brines with overlying, dilute ground waters. The hydrothermal brines entered the OH vein from below at a T, sal, and density of approximately 285°C, 11.5 wt.% NaCl eq., and 860 kg/m^3, respectively, whereas the overlying ground waters appear to have been preheated to roughly 150°C and had an assumed sal of 0 wt.% and a density of 920 kg/m^3. The greater density of the heated ground water promoted mixing with the hydrothermal brine within the open fracture, causing sphalerite deposition. Although there were also episodes of boiling during vein mineralization, boiling appears unimportant for this sphalerite. Isotopic evidence and geochemical modeling studies also indicate that mixing was the depositional mechanism for sphalerite.

An important aspect of the mixing hydrology of the Creede system involves an aquitard overlying the OH vein. This low permeability zone restricted the flow of ground water into the vein from above and forced the upwelling hydrothermal F to flow laterally along the vein. The mixing environment thus occurred along the interface between a deeply circulating hydrothermal convection cell and a topographically driven shallow groundwater system. (Author's abstract)

HE, Mingyou, 1997, Thermodynamic study of uranium migration forms in the West Qinling uranium field: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 2, p. 181-188 (in Chinese; Engl. abst.). Author at Inst. of Geochem., Academia Sinica, Guiyang 550002.

This paper has analysed constituents of FI in quartz and calcite formed at different stages of uranium-bearing hydrothermal solution in the West Qinling uranium field and, using thermodynamic method, calculated migration forms of uranium in uranium-bearing hydrothermal solution. The results show that at the early ore-forming stage, the uranium-bearing hydrothermal solution mainly contains K^+, Na^+, Ca^{2+}, Mg^{2+}, Cl^-, CH_4, CO_3^{2-} and CO_2, and is deficient in SO_4^{2-}, and at the middle and late ore-forming stages, with the elevation of the emplacement of uranium-bearing hydrothermal solution and the variation of the environment, K^+ and Cl^- tend to decrease, Na^+ somewhat increases, and Ca^{2+}, Mg^{2+}, CH_4, CO_3^{2-}, CO_2 and SO_4^{2-} obviously increase. The mixing of the groundwater with the uranium-bearing hydrothermal solution, as [is?] evidenced by the fact that the groundwater at the oxidation-reduction interface is of SO_4^{2-}–HCO_3^-–Ca^{2+} and Mg^{2+} types, and the water body is rich in Ca^{2+}, Mg^{2+} and SO_4^{2-} ions. Thermodynamic calculation of uranium migration forms in uranium-bearing hydrothermal solution demonstrates that at the early and middle ore-forming stages uranium in the uranium-bearing hydrothermal solution migrates mainly in the form of $[UO_2\ (CO_3)^0]$, whereas in the residual hydrothermal solution of the late stage, the migration form of $[UO_2\ (SO_4)^0]$ becomes dominant. It is therefore inferred that the change of uranium migration forms might be attributed to the entry of large quantities of SO_4^{2+} ions derived from meteoric water, and that the uranium-bearing hydrothermal solution is derived from the depth instead of from meteoric water. (Author's abstract)

Includes a table (p. 183) of 27 analyses of FI from quartz and calcite for the 11 constituents noted (E.R.).

HE, Zhili, XU, Jiuhua, YANG, Zhenlin and **DU, Jiafeng,** 1997, Preliminary study on the ore-forming conditions of the Au-Pb-quartz vein type ore deposit, China: Proc. 30th Int'l. Geol. Congr., v. 9, p. 133-142. Authors at Dept. of Geol., Univ. of Sci. and Tech., Beijing, 100083, China; email (licylxj@public.bta.net.cn).

See FIR, v. 29, p. 77-78 (E.R.).

HÉBERT, Ronan, 1997, Mineral and fluid thermobarometry within the Variscan shear zone of Monteferro-El Rosal (NW Galicia, Spain): A preliminary investigation: Terra Nova, v. 9, p. 24-27. Author at Dépt. de Géologie, Univ. de Cergy-Pontoise, 8, Le Campus, 95011 Cergy-Pontoise cedex, France.

The Monteferro-El Rosal shear zone is characterized by an intense ductile deformation produced during the third phase of the Variscan orogeny. The petrology of the metasediments and the study of the FI from synkinematic andalusite-bearing quartz veins indicate that the major Variscan phase of deformation occurred at around 2.5-4 kbar and 565±25°C. (Author's abstract)

HEDDERLY-SMITH, D.A., 1997, A geochemical examination of the Dixie Valley Fault, Nevada; implications for the propagation and behavior of seismogenic normal faults: Doctoral thesis, Univ. of Utah, Salt Lake City, UT, 301 pp.

Indexed under FI (E.R.)

HEDENQUIST, J.W., 1997, Hydrothermal processes and metallogenesis; present understanding and future research directions: Abstracts-Geological Society of Australia, v. 44, p. 38.

A review including application of published FI data (E.R.).

HEDENQUIST, J.W., IZAWA, E., ARRIBAS, A. and **WHITE, N.C.,** 1996, Epithermal gold deposits: Styles, characteristics, and exploration: Resource Geol. Special Pub., number 1.

This is a wall poster (in English; 1.0 x 1.5 m in size), accompanied by a booklet with all text and captions of the poster translated to four languages (Japanese, Spanish, French, and Chinese). This poster is also available in B4 book form, in color, for use in the field. It may be ordered from The Society of Resource Geology, Nogizaka Bldg., 6-41, Akasaka 9-chome, Minato-ku, Tokyo 107, Japan. Fax +81 (3) 3475-0824; e-mail (J90117@simail.ne.jp).

This poster, one of a series, provides an excellent summary of the mechanisms of formation of these ore deposits and the interrelations of the various types, exploration, etc., using data from FI studies. (E.R.)

HEDENQUIST, J.W. and **SHINOHARA, H.,** 1997, K-silicate- to sericite-stage transition in porphyry Cu deposits: Collapse of magmatic plume, or overprint by meteoric water? (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-359. Authors at Mineral Resources Dept., Geological Survey of Japan, 1-1-3 Higashi, Tsukuba 305 Japan.

K-silicate alteration of porphyry Cu deposits is typically overprinted by a later stage of lower T chlorite alteration accompanied by sericite halos to quartz veins. The early stage is associated with V and hypersaline L at >500°C, and isotopic compositions indicate that the F is magmatic in origin (e.g., published studies on Yerington, Ely, Bingham, Santa Rita, Bell, El Salvador, Far Southeast-FSE). F associated with the later sericite alteration is <350°C and of low sal (5-10 wt.% eq. NaCl), and has a magmatic to meteoric water proportion of, e.g., >90:<10 (FSE), 70:30 (Santa Rita) to 30:70 (Yerington), assuming simple mixing of the two end members (as observed in active volcanic-hydrothermal systems). Meteoric water can penetrate rock only to a T of ≈350°C, above which the rock is quasi-ductile and fractures cannot stay open except during periods of high strain, thus precluding a meteoric-water "quench" of the magmatic system at depth. Rather, thermal collapse of the magmatic-F plume may be caused by changes during crystallization of the parent magma chamber.

The rate of F exsolution from a saturated, stagnant magma chamber is a function of the rate of crystallization, with the thickness of the crystallized portion increasing in proportion to the square root of time. Early magma-chamber convection will increase this rate by a factor of two, until the magma viscosity increases and convection ceases (at a crystal content ≤50 vol.%). Magma-chamber intrusion into rock at ambient T results in rapid crystallization initially (to 25-50 vol.% crystals in only 10-25% of the time for complete crystallization). Depending on the timing of saturation, the rate of F exsolution and advective heat loss will be ≈4 to 10 times higher during early crystallization relative to the later stage. Thus, the rate of F exsolution and subsequent advective heat and mass flux during the later stage of crystallization can be as much as an order of magnitude lower than during the early stage of exsolution. This sharp decrease can explain the lower T (and hence beginnings of meteoric water entrainment) during the later, sericite stage, despite the (locally major) magmatic-F component to the porphyry hydrothermal system. The lower sal reflects that of the bulk exsolved magmatic F, which does not intersect its solvus due to the "collapsed" isotherms. (Authors' abstract)

HENRY, Adam, TRACY, R.J. and **BODNAR, R.J.,** 1997, Modification of garnet zoning and fluid inclusions during polymetamorphism: Eos Trans. AGU v. 78 (17), Spring Meet. Suppl., p. S336. Authors at Dept. of Geological Sci., Virginia Tech, Blacksburg, VA 24061; email (adhenry@vt.edu)

Information from garnet zoning and FI are frequently used to constrain P-T paths in metamorphic belts. During polymetamorphism both of these features may be significantly modified, leading to false interpretations of the tectonic history of a region. High resolution compositional imaging of garnets and detailed textural analysis of FI from the Manhattan Prong, NY, provide insight to the mechanisms that cause re-equilibration of both solid and F phases. Textural evidence of metamorphic overprinting yields P-T estimates from these garnets of 650-700°C and 4-5 kb.

Negative crystal-shaped, P, CO_2-rich FI in garnet cores homogenize to L between 17 and 23°C (ρ~.76 g/cc). Many CO_2-rich FI in cores of overgrown garnets show a characteristic 'decrepitation halo' and homogenize to L between 2 and 18°C which indicates they have re-equilibrated to a higher density (ρ~0.92 g/cc). In these samples high density (ρ=0.85-0.97 g/cc) CO_2-rich FI are also found along healed microfractures near garnet rims, in matrix quartz, and along twin lamellae in plagioclase. Based on their similar densities, these I are interpreted to have formed at the same time as the re-equilibration of the FI in garnet cores.

Thermobarometric P-T estimates and FI isochores from both regional and polymetamorphic samples are in good agreement and indicate that contact metamorphism occurred at lower T and slightly higher P compared to regional metamorphism. The presence of FI with decrepitation textures in some regional samples indicates that while thermal modification of garnet zoning is localized, re-equilibration of FI occurred over a larger area. Therefore FI may be a more sensitive indicator of polymetamorphism than garnet zoning in some tectonic settings. (From authors' abstract by E.R.)

HENRY, A.T., TRACY, R.J. and **BODNAR, R.J.**, 1997, Polymetamorphism in SW New England: Geothermobarometry and fluid inclusion evidence from the Manhattan Prong (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 1, p. 52. Authors at Dept. of Geological Sci., Virginia Tech, Blacksburg, VA 24060; email (adhenry@vt.edu).

The western limit of Acadian metamorphism in SW New England approximately coincides with Cameron's Line. Recent studies show that Acadian thermal effects may extend farther west and may have modified the preexisting Taconic T3 metamorphic gradient. Compositional imaging, geothermobarometry and FI studies of garnet from the Manhattan Prong provide quantitative estimates of the conditions of multiple metamorphic events, constraining models for the tectonic evolution of this area.

Low density (ρ=0.76 g/cc) CO_2-rich FI in garnet cores provide constraints on the regional metamorphic conditions. CO_2 I in cores of overgrown garnets show textural evidence of reequilibration to higher density (ρ=0.94 g/cc). In these samples high density (ρ=0.85-0.97 g/cc) CO_2 I are also found in matrix quartz and plagioclase which formed at the same time as garnet overgrowths during the reequilibration of the FI in garnet cores.

Anomalously low P-T estimates for peak Taconic metamorphism may result from reequilibration upon slow cooling or, alternatively may reflect modification by the later metamorphism. Overprinting metamorphic conditions, which occurred at lower T but higher P at the time of emplacement of numerous granite plutons, may represent a period of late magmatism following the Acadian Orogeny. This interpretation is inconsistent with that of Hames et al. (Geology, 1989) which proposed significant decompression during rapid unroofing after the Acadian. (From authors' abstract by E.R.)

HENRY, C.D., ELSON, H.B., McINTOSH, W.C., HEIZLER, M.T. and **CASTOR, S.B.**, 1997, Brief duration of hydrothermal activity at Round Mountain, Nevada, determined from $^{40}Ar/^{39}Ar$ geochronology: Econ. Geol., v. 92, p. 807-826. First author at Nevada Bureau of Mines and Geol., Univ. of Nevada, Reno, Nevada 89557.

The Round Mountain gold-silver deposit is one of the world's largest volcanic-hosted precious metal deposits [with] at least 16 million oz (500,000 kg) Au. The deposit occurs in ash-flow tuff that is ponded within its source caldera, along and overlying the caldera ring fracture. Host rocks have undergone propylitic, potassic, and high-level silicic and intermediate argillic alteration. These are interpreted either as a temporal sequence from early propylitic to late silicic and argillic or as a spatial progression from a potassic core outward to a propylitic halo. Hydrothermal circulation was probably considerably <0.5 m.y. [based on precision $^{40}Ar/^{39}Ar$ ages]. Adularia that crystallized and remained at T of 275°C, the maximum T inferred from FI data, would yield age spectra with age gradients spanning the lifetime of the system. The hydrothermal system probably was active for less than the uncertainty in the ages of individual samples, possibly as little as 50,000 years. (From authors' abstract by E.R.)

HEZARKHANI, Ardeshir and **WILLIAMS-JONES, A.E.**, 1997, Copper solubility and deposition conditions in potassic and phyllic alteration zones, in the Sungun porphyry copper deposit, Iran (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A67. Authors at Dept. of Earth and Planet. 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 is associated with both potassic and sericitic alteration. The T of early potassic and late sericitic stages of alteration/mineralization are estimated from FI and isotopic data to have been 360-450°C and 300-360°C, respectively. These sources of data also indicate that the hydrothermal system involved magmatic and meteoric waters, and boiled extensively.

Thermodynamic data were used to delineate the stability fields of the various alteration and ore mineral assemblages as a function of fS_2, fO_2, and pH for the two alteration/mineralization stages. These calculations show that at 450°C, the fO_2 was between -20 and -23, and the pH between 5.5 and 6.5, and that at 360°C, the corresponding values were -31 to -27, and 4 to 8, respectively. The solubility of chalcopyrite was evaluated using data of Xiao et al. (1997). At the onset of potassic alteration (450°C), copper solubility is calculated to have been >100,000 ppm, whereas the copper content of the P magmatic F is estimated from FI data to have been 1200-3800 ppm. This indicates that the F was initially undersaturated with respect to chalcopyrite, which agrees well with the observation that veins formed at T>400°C contain molybdenite but rarely chalcopyrite. Copper solubility decreases rapidly with decrease of T, and at 400°C is approximately 1,000, i.e., in the range estimated from FI data. At T<300°C, this solubility drops to<1 ppm. These observations are consistent with conclusions that the bulk of the chalcopyrite deposited at Sungun is hosted by veins formed at T between approximately 300 and 380°C. Other factors that reduce chalcopyrite solubility are increase in pH, and decreases in fO_2 and aCl^-. We propose that the Sungun deposit formed partly in response to the sharp T decrease and pH increase which accompanied boiling, and partly as a result of the additional heat loss, increase in pH and decrase in aCl^- which occurred as a result of mixing of acidic Cu-bearing magmatic waters with cool meteoric waters of lower sal and near-neutral pH. (Authors' abstract)

HILL, B.M. and **DARLING, R.S.**, 1997, Fluid inclusion evidence for "shield-type" brine mineralization in post-metamorphic, hydrothermal sphalerite, Balmat-Edwards District, Northwest Adirondacks, NY (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 1, p. 52. First author at Dept. of Physical Sci., Onondaga Community College, Syracuse, NY 13215; email (hillb@goliath.sunyocc.edu).

P FI in vuggy sphalerite from the Balmat-Edwards District were analyzed to develop an understanding of post-metamorphic, hydrothermal events in the Adirondack Lowlands. At room T, P FI contain water V and brine. Some I contain a small, dxl of halite; however, others nucleate halite only upon freezing. The I incompletely freeze between -86 and -80°C only upon warming from L N_2 T (-196°C). Freezing is characterized by slow dendritic growth of ice coupled with the peritectic conversion of halite to hydrohalite. Eutectic melting occurs at T between -55 and -50°C, and is followed by cotectic melting of ice and hydrohalite. Final ice melting T occur over a narrow range from -36 to -35°C. Hydrohalite peritectically converts to halite at T between 0 and 10°C. Final halite melting T occur from 97 to 121°C. V to L Th range from 139 to 154°C.

This low T phase behavior is characteristic of $CaCl_2$-NaCl-H_2O F enriched in $CaCl_2$. The final ice, hydrohalite and halite melting T yield brine compositions of approximately 20 wt.% $CaCl_2$ and 10 wt.% eq. NaCl. The Ca/Na weight ratios, geologic setting and elevated T suggest the post-metamorphic sphalerites formed from heated F similar in composition to Canadian Shield brines described by Frape et al. (1984). This new data, coupled with that from the Long Lake calcite-fluorite veins (Bird and Darling, 1996), demonstrate widespread influence of "shield-type" brines on post-Grenville, hydrothermal mineralization in Precambrian rocks of northern NY. (Authors' abstract)

HIRSCHMANN, M.M., BAKER, M.B. and **STOLPER, E.M.,** 1997, Alkali- and silica-rich melts in the mantle: Effect of pressure and origin of siliceous melt inclusions: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F813. First author at Dept. of Geol., Univ. of Minnesota, 108 Pillsbury Hall, Minneapolis, MN 55455, U.S.A.; email (Marc.M.Hirschmann-1@tc.umn.edu)

Alkali-rich silica-rich MI occur widely in spinel lherzolite minerals (Schiano & Clocchiatti, 1994), but the origin of such L and their role, if any, in basalt petrogenesis are poorly understood. Silica-rich M could form by percolation of small M volumes through large quantities of peridotite. If such L, enriched in alkalis by exchange with peridotite, equilibrate with the mantle at depths <1.5 GPa, they can be silica-rich. Such L are likely restricted to the shallow lithosphere (<45km), and are probably not important metasomatic agents in sub-lithospheric sources of oceanic basalts. (From authors' abstract by E.R.)

HOA, T.T., PHUONG, N.T., THANH, H.H. and **PETROV, V.G.,** 1997, Bo-Va quartz-vein's gold deposit in North Vietnam: Seminar on Geol. and Metallic Minerals, Hanoi 4-6 Dec., 1997, Extended Abstracts, Geol. Assoc. Vietnam, p. 23-26. First author at Inst. of Geological Sci., Nat'l. Center for Natural Sci. and Tech. of SRV, Nghia Do-Tu Liem Hanoi Vietnam, Box 603, Hanoi 10000.

The Bo-Va gold district is situated in a low-grade metamorphic terrain (phyllites with occasional layers of graywacke, sandstones and limestones). A FI study has been undertaken on regional quartz veins unrelated to and remote from the gold deposit, and quartz veins and silicified rocks from the ore zones. Five FI types have been recognized: (I) early FI rich in CO_2; (II) [low-saline I unrelated to Au] this type is rich in H_2O I and follows across several quartz grains and thus are showed its formation in the late stages of vein-forming processes; (III) this type is L-rich, two-phase I at room T. and can be approximated by a H_2O-CO_2-NaCl mixture; (IV) N_2-rich I; (V) CO_2 gaseous one-phase I are very rare and occur along FI trails.

The brittle and extensional structure setting, the open-space textures of the veins, and the low $\delta^{18}O$ value of the F involved in ore formation are rather typical of classical mesothermal gold deposits which are formed n the upper crustal levels where the involvement of meteoric water is obvious. F related to the origin of quartz veins are of a C-O-H-N system, CO_2 being the major volatile component. The F composition is typical for retrograde metamorphic F, which is supported by oxygen isotope data. The FI data suggest that the origin of the vein system is with high probability connected with huge changes of P during the extension deformation under the conditions of lithostatic P the earliest veins would have formed already at depths of about 15-18 km at T of about 500°C. However, the actual depth could have been lower if F overpressures took place in the shear zone. The circulation of H_2O-rich and N_2-rich F probably of meteoric origin took place in the shear zone during the late brittle deformation. (From authors' text by H.E.B.)

HÒA, T.T., THANH, H.H., PHUÓNG, N.T. and **ANH, T.T.,** 1997, Mineralization characteristics and forming conditions of lamproite of Viêt Nam: J. Geol. (Viet Nam) [Tap Chi Dia Chat], 1997, Ser. B, no. 9-10, p. 63-68. Authors at Inst. of Geological Sci., Nat'l. Centre for Natural Sci. and Tech., Ngh˜ia Dô, Tù Liêm, Hà Nôi, Viêt Nam.

Paleogene mafic-ultrapotassic rocks of northwestern Viêt Nam (cocites) have been compared with low titanium lamproite of Mediterranean type on the basis of mineralization and geochemical features. Research on distribution features of Mg, Cr, Ti, Ni in olivine, diopside, phlogopite as well as the composition of their silicate-M I allows us to confirm a lamproitic magmatic origin and the nature of differentiation in the formation of the northwestern Viêt Nam rocks. (Authors' abstract)

HOBSON, G.D., 1997, Petroleum geology; two decades of change: J. of Petroleum Geol., v. 20, no. 2, p. 245-247.

Indexed under FI (E.R.)

HODSON, Mark, 1997, Post-crystallisation modification of the igneous layering in the Nunarssuit and West Kungnat syenites, south Greenland: Mineralogical Magazine, v. 61, no. 4, p. 467-483.

The chemistry and textures of the minerals in the layered syenites of Nunarssuit and West Kungnat record a complex post-crystallisation history. Olivines and pyroxenes re-equilibrated with intercumulus M. Pyroxenes reacted with either intercumulus or deuteric F to form amphibole. In West Kungnat pyroxene and amphibole re-equilibrated via later F. Olivines reacted with deuteric F to produce biotites, probably at T<550 °C. After crystallisation alkali feldspars exsolved, the exsolution textures coarsened in the presence of deuteric F with a magmatic origin, possibly at T as low as 450°C. Zoning patterns of apatites and zircons were modified during interactions with either, or both intercumulus or deuteric F. Leucocratic layers underwent more modification than melanocratic ones, probably due to the higher concentration of intercumulus M in the former leading to a higher concentration of deuteric F as water exsolved from the magma during cooling. The syenites underwent little compaction during solidification. (From authors' abstract by E.R.)

HOLL, Albert, ALTHAUS, Egon, LEMPP, Christof and **NATAU, Otfried,** 1997, The petrophysical behaviour of crustal rocks under the influence of fluids: Tectonophysics, v. 275, no. 1-3, p. 253-260.

Experiments of the "triaxial deformation cell" type were performed with two typical basement rocks, a monzogranite and a two-mica-granite. The presence of F generally caused a strong reduction in rock strength. (From authors' abstract by E.R.)

HÖLLER, W. and **GANDHI, S.M.,** 1997, Origin of tourmaline and oxide minerals from the metamorphosed Rampura Agucha Zn-Pb-(Ag) deposit, Rajasthan, India: Mineral. and Petrol., 1997, v. 60, p. 99-119. First author at Inst. of Geosci., Univ. of Leoben, Austria.

The sediment-hosted exhalative Rampura Agucha Zn-Pb-(Ag) deposit in Rajasthan, India, contains a number of oxide minerals which have been formed as a result of high-grade metamorphism, including gahnite, pyrophanite-ilmenite, and rutile. Dravite-rich tourmaline occurs intergrown with the ore minerals. It is argued that dravite-rich tourmaline (or another B-rich precursor mineral) is of premetamorphic origin. This dravite-rich tourmaline recrystallized during high-grade metamorphism when the metamorphic F, represented by H_2O-CO_2±CH_4-N_2 I, was trapped. (From authors' abstract by E.R.)

HOLLMANN, G., KLUG, B., SCHMITZ, J., STAHL, E. and **WELLENS, M.,** 1997, Fractured Carboniferous proved as prolific exploration target in northern Germany (abst.): AAPG Bull., v. 81, no. 8, p. 1383.

The naturally fractured reservoir rocks are Westphalian in age and contained within a thrust-bounded horst block underlying a Zechstein salt plug in the central Lower Saxony Basin. The relative timing of fracture generation is supported by FI analyses that specify the trapping mechanisms. Hence, the structure is considered a classical example of a highly productive naturally fractured G reservoir in porous but low permeability sandstone facies. (From authors' abstract by E.R.)

HOLMGREN, C., 1987, Antecedentes para un modelo genético del yacimiento El Soldado, V Regíon de Valparaiso, Chile: Revist Geol. de Chile, v. 30, p. 13-18 (in Spanish).

Zentilli et al (this volume) quotes FI data from El Soldado (E.R.).

HOLNESS, M.B. and **LEWIS, Stephanie,** 1997, The structure of the halite-brine interface inferred from pressure and temperature variations of equilibrium dihedral angles in the halite-H_2O-CO_2 system: Geochim. Cosmo. Acta, v. 61, no. 4, p. 795-804. Authors at Dept. of Geol. and Geophys., Univ. of Edinburgh, King's Buildings, West Mains Rd., Edinburgh EH9 3JW, Scotland.

The equilibrium F-solid dihedral angle has been determined for H_2O-CO_2 F and Ar in halite polycrystals at 1-2000 bars and 300-600°C. The H_2O-halite angle is a sensitive function of P and T and decreases monotonically with both parameters. The CO_2-halite angle is higher than the H_2O-halite angle at all P and T examined, shows no significant P dependence, and is indistinguishable within error from the argon-halite angle. Simple thermodynamic analysis of the variation of dihedral angle with P and T shows that the surface activity of H_2O molecules on halite is significant and results in a negative excess entropy for the halite-brine interface. The variation of H_2O-halite dihedral angle with P shows that the excess thickness of the interface is negative in the V field and positive in the L field. From this, we constrain the adsorption density of H_2O on halite to between 1.0-2.4 molecules of H_2O per surface unit cell of halite. This is in agreement both with possible hydration numbers for NaCl under these conditions and with observations of the adsorption density of H_2O on halite surfaces at low T in a partial vacuum. (Authors' abstract)

HOLZHEY, G., 1997, Sherry wine coloured topaz from Thomas Range, Utah, USA: Z. Dt. Gemmol. Ges v, 46, no. 2, p. 85-92 (in German; Engl. Abst.). Microscopical studies predominantly reveal quartz I and syngenetic-secondary FI. (From author's abstract by E.R.)

HONDA, M. and **McDOUGALL, I.,**1997, Primordial helium and neon in the Earth - A speculation on early degassing (abst.) The Australian National Univ. Research School of Earth Sci., Annual Report 1997, p. 154-156.

The isotopic compositions of neon trapped in Loihi OIBs and MORBs differ in systematic ways from the atmospheric composition and from each other. They show remarkable correlations with helium isotopic compositions. The correlated neon and helium isotopic compositions provide powerful evidence in favour of a primordial solar component within the Earth.

The enrichment by a factor of two of ^{3}He with respect to ^{22}Ne in MORBs and Loihi OIBs could be explained by a solubility controlled process. As the noble G naturally partition into a G phase, if present, the amounts of noble G dissolved in silicate M are expected to be small. Thus, if a magma ocean existed at an early stage after the Earth's formation, solar noble G originally trapped in the primitive Earth would outgas from the magma ocean to the primitive atmosphere. As the solubility constant of helium is about twice that of neon, the solar helium and neon that remain in the magma ocean would be enriched in helium with respect to neon by a factor of about two. If this explanation is valid, it would further imply that, like the MORB source, the Loihi OIB source may also have experienced significant degassing, as the primordial ^{3}He/^{22}Ne ratios in the Loihi OIBs are also higher than the solar value. Alternatively, if the average value of primordial ^{3}He/^{22}Ne ratios in Hawaiian OIBs (= 6.0), slightly lower than in MORBs (=9.4), is taken at face value, this may indicate that the source for the Loihi OIBs was partly degassed or consists of a mixture of undegassed and fully degasssed components. (From authors' abstract by E.R.)

HU, Ruizhong, BI, Xiangwu, TURNER, G., and **BURNARD, P.,** 1997, Researches on He and Ar isotope systematics of several solid ore deposits in China: Acta Geoscientia Sinica (Diqiu Xuebao), v. 18, Suppl., p. 170-172.

Indexed under FI (E.R.)

HU, Shumin and **ZHANG, Ronghua,** 1997, Critical state phenomena of NaCl-H_2O binary system at elevated temperatures and pressures: *in* Proceedings of the Fifth Int'l. Symposium on Hydrothermal Reactions, Palmer, D.A. and Wesolowski, D.J., eds., 1997, Gatlinburg, TN USA, p. 214-219. Authors at Open Research Lab. of Geochem. Kinetics, Chinese Acad. of Geol. Sci., Inst. of Mineral Deposits, Baiwanzhuang Road 26, Beijing 100037, China.

HU, X., MURAO, S. and **HUANG, X.**, 1996, Genetic model of gold-antimony-tungsten mineralization: Evidence from geology and mineralization of the Wuxi deposit, Hunan, China: Bulletin of the Geological Survey of Japan, v. 47, no. 11.

HUANG, Guicheng, 1997, Discussion on genetic relation between the Naozhi gold deposit and the Mesozoic volcanic rock series in Naozhi, Jilin Province: Mineral Resources and Geol. [Kuangchan yu Dizhi], v. 11, no. 1, p. 32-38.

The Naozhi gold deposit is a volcanic-subvolcanic hydrothermal ore deposit related to the Mesozoic volcanic rock series. Ores occur in a concentration area of subvolcanic rock veins distributed as a group ore belt. Both of them are controlled by structural fissures in the same system. The geochemical characteristics of isotopes, rare-earth elements and FI suggest that the ore-forming materials are mainly from magmatic hydrothermal solutions. (Author's abstract)

HUANG, Z, WILLIAMSON, M.A., YANG, C., QING, H. and **STASIUK, D.L.**, 1997, Petroleum migration history in the Terra Nova area, Jeanne d'Arc Basin, offshore Newfoundland; evidence from fluid inclusions (abst.): Annual Meeting Abstracts - American Assoc. of Petroleum Geologists and Soc. of Economic Paleontologists and Mineralogists, v. 6, p. 53.

The diagenetic history, composition of diagenetic F, the role of major faults and the time of diagenetic events and oil migration in the Jeanne d'Arc Formation of the Terra Nova area, the Jeanne d'Arc Basin, were investigated using FI data. Aq, CO_2-rich and hydrocarbon FI co-occur in the same FI assemblages (FIAs). The Th, which are interpreted to be reliable estimates of Tt, of P aq FI in quartz overgrowth/cements range from 82-135°C. Sal varies in these I from 0.17 to 12.86 wt.%, with an average Pt of 317 bars. Th variations among wells seem to be related to burial depth and especially the proximity to major faults. Where the Jeanne d'Arc formation was cut by fault(s) the Th are higher and show increased variations. A comparison of different habits of oils in their wavelength at the maximum intensity and RIG quotients suggested that the reservoirs were charged at least twice. The hydrocarbon I that occur in the same FAIs with the aq FI are of lower maturity than those in annealed fractured quartz and in late diagenetic clays. The crude oils show intermediate maturity between the two, suggesting mixture of oils. Decompacted burial curves indicate that the first charging event occurred at around 70 Ma, when the sandstones were under quartz overgrowth and cementation, and the second one happened at around 30 Ma. (Authors' abstract)

HUFF, W.D., KOLATA, D.R. and **BERGSTRÖM, S.M.**, 1997, The Ordovician Deicke, Millbrig, and Kinnekulle K-bentonites: Volume and mass balance calculations (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 151. First author at Dept. of Geol., Univ. of Cincinnati, Cincinnati, OH 45221.

We conclude that the preserved portions of these three K-bentonites represent co-ignimbrite accumulations. MI SiO_2 values are in the range 73-75% indicating a rhyolitic composition. Mass balance calculations were made by normalizing the glass and rock chemical data to aluminum. Converting on the basis of total Al_2O_3, the glass: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 half of the original SiO_2 and K_2O was removed during devitrification and subsequent diagenesis. (From authors' abstract by H.E.B.)

HUGHES, R.W., 1997, Ruby and Sapphire: RWH Publishing, Boulder CO, 511 pp.

Chapter 5 discusses the occurrence and significance of F and solid I. (H.E.B.)

HUNER, M.A., VANKO, D.A. and **DOWLING, S.M.**, 1997, A history of fluid-rock interaction in vein minerals (calcite and quartz) from the Savannah River site, South Carolina (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 3, p. 25. Authors at Dept. of Geol., Georgia State Univ., Atlanta, GA 30303; email (dvanko@gsu.edu).

Drill cores from the Savannah River Site provide samples of the local Paleozoic crystalline basement, which consists primarily of greenschist facies metavolcanic rocks and amphibolite facies schist and gneiss. The metamorphic basement rocks are covered by a wedge of Cretaceous sediments 700 to 1200 ft. thick. Veins in the basement rocks yield evidence of a prolonged history of F-rock interaction and suggest the possibility that vein minerals exert thermodynamic controls on groundwater chemistry.

Early vein types are characterized by quartz, epidote, calcite, chlorite, apatite, and K-spar, largely conforming to the structure and mineralogy of the host metamorphic rocks. Later vein types contain drusy quartz, calcite, zeolite, gypsum, pyrite, hematite and clay. Two rarities are kutnahorite and barite. The history of F rock interaction is revealed through vein mineralogy, texture, CL, stable isotope chemistry, and FI characteristics.

CL reveals at least two types of calcite veins: those that exhibit fine CL color banding, and others composed of calcite with a homogeneous luminescence.

FI observed in one calcite vein include a population of 3-phase FI with aq and carbonic L that have Tm ice=-5.6 °C and Th[CO_2 L-V (L)]=26-29°C. Also present are 2-phase FI that have a melting T of 7°C, indicating the presence of a clathrate, and Th ranging from 170 to 200°C. Another calcite vein contains 2-phase FI having lower Th, from 70 to 110°C, and Tm ice ranging from -2 to +0.4°C. FI in quartz have Th=280-370°C and Tm ice ranging from -2.2 to 0°C.

Isotope data for calcite revealed $\partial^{13}C_{PDB}$ ranging from -3.7 to -10.5‰ and $\partial^{18}O_{PDB}$ ranging from -11.1 to -25.5‰. The $\partial^{18}O_{SMOW}$ values of quartz range from 5.3 to 12.0‰. In general, calcite and quartz occurring together cannot be in isotopic equilibrium.

Isotope, FI and CL data point to multiple generations of calcite±quartz. There appears to be a high T (>200°C) generation that formed from moderate to low sal waters in the presence of mixed H_2O-CO_2 F. A second generation formed at lower T (<100°C) with low sal $H_2O \pm CO_2$ F. Present day basement groundwater is in equilibrium with calcite and quartz, as well as laumontite and feldspar, at ambient T. (Authors' abstract)

HUNNS, S.R. and **KHIN Zaw,** 1997, Mount Chalmers - A shallow water exhalative VMS deposit (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A70. Authors at Geol. Dept., Univ. of Tasmania, GPO Box 252-79, Hobart 7001, Tasmania, Australia.

The Mt. Chalmers mine is a gold and copper dominated volcanogenic massive sulphide (VMS) deposit hosted within the Early Permian Berserker beds of central Queensland, Australia.

P FI up to 20 microns in quartz from the stringer mineralisation yielded Th in the range 160-268°C and sal of 5-8 NaCl eq. wt.%. No evidence for boiling has been detected within the FI. For a hydrothermal F at 231°C (mode) and 6.3 NaCl eq. wt.% (mode) the boiling curves of Haas (1971) indicate that a water depth of approximately 280 m is required to prevent the F from boiling. Therefore, the minimum depth of 280 m as indicated by the FI is in strong agreement with the range in water depth of 50-300 m indicated by the fossil evidence.

Studies to date on modern and ancient VMS deposits have indicated that a minimum water depth in the range of 1000-1500 m is required to prevent boiling of hydrothermal F and therefore concentrate metal deposition on the seafloor. However, these minimum water depths are in strong disagreement with the minimum water depth as suggested by the palaeontological and FI evidence for the Mt. Chalmers VMS deposit. (From authors' abstract by H.E.B.)

HURAI, Vratislav, SIMON, Klaus and **BEZÁK, Vladimír,** 1997, Contrasting chemistry and H, O, C isotope composition of greenschist-facies, Hercynian and Alpine metamorphic fluids (Western Carpathians): Chem. Geol., v. 136, p. 281-293. First author at Geological Survey, Mlynská dolina 1, 817 04 Bratislava, Slovak Republic.

Microthermometry and stable isotope data enable us to distinguish between two contrasting sets of F involved in the Hercynian and Alpine metamorphic events in the Western Carpathians. High-T smoky quartz (450-500°C) was probably formed during the syn-kinematic phase of the Hercynian metamorphism, when chemical and isotopic equilibrium had been established between aq solutions and the surrounding rocks. This is indicated by fixed Na/Ca ratios and narrow ranges of δD and $\delta^{18}O$ values in the I F (-59±5‰ and +7 to +7.5‰ SMOW, respectively). In contrast, Alpine quartz precipitating at T between 300 and 400°C in extension-related structures displayed a non-equilibrium signature characterized by a much larger compositional and isotopic variability. Presence of CO_2 in quartz from granitoid-hosted shear zones indicates externally derived F with $\delta^{13}C$ values between -11.9 to -7.7‰ PDB. These values can be interpreted to reflect an admixture of a lighter CO_2 generated by decomposition of organic matter in underlying low- to medium-grade sediments. The essentially identical isotopic composition of the I CO_2 from the presumably Hercynian as well as Alpine metamorphic quartzes supports the concept of Hercynian overthrusting of granitoids into metamorphites in the crystalline basement of the Western Carpathians. (Authors' abstract)

HURAI, Vratislav, SIMON, Klaus, WIECHERT, Uwe, HURAIOVÁ, Monika, KONECNY, Patrik and **PIRONON, Jacques,** 1997, Late-stage immiscible separation of Ni, Cu, Zn-rich, Fe-oxide melt from evolved alkali basalt: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 147-148. First author at Geological Survey, 817 04 Bratislava, Slovakia; email (hurai@guds.sanet.sk).

Immiscible separation of two compositionally contrasting M has been observed in anorthoclasite xenoliths rapidly quenched during basaltic phreato-magmatic eruptions dated at 6.4-7.2 My from Slovakia.

The $\delta^{18}O$ values of the anorthoclasite zircon determined by laser fluorination technique varied between 5.2-5.6‰ (V-SMOW), overlapping those of all rock-forming minerals, including calcic plagioclase, in the gabbroic cumulates (4.9-5.9‰). This is suggestive of a common mantle source for the anorthoclasite and gabbroic xenoliths. Hydrogen isotope ratios between -61 and -86‰ in the postcumulus kaersutite from the gabbroic cumulates are also consistent with the δD range commonly accepted for P magmatic water.

Glass in the anorthoclasite xenoliths is present as thin films along plagioclase grain boundaries, or as rounded and elongated pockets, 0.5-5 mm in diameter. The glass is homogeneous, transparent, vesicular, rarely slightly devitrified. The Si-rich matrix contains brown, translucent spherules of high-iron M (HIM), up to 5 μm in diameter. The HIMs are frequently trapped as isolated droplets, up to 100μ in diameter, along growth planes in the plagioclase and zircon.

Composition of the Si-rich matrix [and in MI in zircon] corresponds to trachyte or trachyandesite in the TAS diagram. The HIM spherules contain 16% normative magnetite, 24-29% hypersthene and 31-37% wüstite, with the total $FeO+Fe_2O_3$ between 60-66 wt.%. Low totals on the conjugate M are due to presence of water and CO_2 confirmed by FTIR.

The late-stage, two-L immiscibility observed during differentiation of the alkali basalts might imply some recent genetic models, pertaining to the formation of massive magnetite (kiruna-type) ores, which are believed to represent an immiscible L fraction exsolved from a mantle-derived mafic magma. (From authors' abstract by E.R.)

HURAIOVÁ, Monika, DUBESSY, Jean and **KONECNY, Patrik,** 1997, Temperatures, pressures, fluid composition and oxygen fugacities in a deep-crustal magmatic reservoir (southern Slovakia, western Carpathians): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 149-150. First author at Dept. of Mineral. and Petrol., Comenius Univ., 84105 Bratislava, Slovakia; email (huraiova@fns.uniba.sk).

Anorthoclasite, tonalite-trondhjemite, hornblendite and pyroxenite fragments have been ejected by basaltic lapilli tuffs during phreato-magmatic eruptions. Gabbroic xenoliths (pyroxenite and hornblendite) associated with the anorthoclasite fragments are igneous cumulates, exhibiting highly varying modal composition.

Formation PT conditions of the gabbroic cumulates have been derived from clinopyroxene thermobarometry and FI. Peak conditions [were] 1230°C and 10 kbar

(33km). Isochores for the most dense cpx-hosted CO_2 I intersected the PT estimates from pyroxene thermobarometry at 5.3-6.8 kbar (19.5-23.9 km).

Preliminary Raman microprobe analyses of I from quartz, K-feldspar, plagioclase, hornblende, and clinopyroxene revealed small amounts of carbon monoxide, methane, hydrogen, hydrogen sulphide and nitrogen in the CO_2 I. (From authors' abstract by E.R.)

HUSSAIN, N., 1997, Flux of ^{4}He from Carnmenellis granite: Modelling of an HDR geothermal reservoir: Applied Geochem., v. 12, p. 1-8. Author at College of Marine Studies, Univ. of Delaware, Robinson Hall, Newark, DE 19716.

T variation of the diffusion coefficient D fits an Arrhenius plot, but yields an activation energy for He release from rock significantly lower than the value for feldspar or quartz, suggesting that most of the He in the reservoir granite resides within grain boundaries and jointing cement and may be easily released. (From author's abstract by E.R.)

ICENHOWER, J.P. and **LONDON, David**, 1997, Partitioning of fluorine and chlorine between biotite and granitic melt: Experimental calibration at 200 MPa H_2O: Contrib. Mineral. Petrol., 1997, no. 127, p. 17-29.

ILCHIK, R.P. and **BARTON, M.D.**, 1997, An amagmatic origin of Carlin-type gold deposits: Economic Geol., v. 92, no. 3, p. 269-288. Authors at Center for Mineral Resources, Dept. of Geosci., Univ. of Arizona, Tucson, AZ 85721.

Carlin-type deposits are major sources of gold, yet their origins are enigmatic. Suggested genetic models make connections to magmatism, regional metamorphism, or regional extension. Depositional mechanisms are uncertain as well. We propose on the basis of geologic, physical, and chemical reasoning, a genetic model in which meteoric F were circulated by heat released during crustal extension. These F interacted at depth with the sedimentary rock pile and scavenged gold. Upon upwelling, these F interacted with various lithologies and/or other F and produced the characteristic alteration and metal suites of these deposits. To test the viability of this amagmatic model, we have investigated certain physical and chemical constraints implicit to the model. (From authors' abstract by E.R.)

INVERNIZZI, N.de S.C. and **VITYK, M.O.**, 1997, Textural and microthermometrical studies of fluid inclusions in metamorphic rocks: A comparison of natural and experimental data for reconstruction of the P-T path: Boll. Soc. Geol. It., v. 116, p. 253-265 (in Italian). First author at Dipartimento di Scienze della Terra, via Gentile III da Varano, Univ. di Camerino (62032, Italy).

The Diamante-Terranova unit (D-T) is a part of an ophiolitic sequence which was involved in a HP/LT event (P = 8 kb; T = 400°C), followed by re-equilibration in greenschist facies conditions (P = 3 kb; T = 300°C). In this paper we present data on textural analysis and microthermometry of FI found in quartz veins from metabasalts formed as extension veins during the first deformation event. Most of the I appear to be S (i.e. related to healed fractures). A large percentage of the I (about 40%) were destroyed after entrapment. The "destroyed" I contain no visible F, and display a distinctive, highly irregular "dendritic-like" texture. The observed "dendritic" texture is similar to that produced experimentally during laboratory-induced deformation of synthethic aq I in natural quartz. This texture was obtained only under conditions of internal underpressure (ca. 5 kbar), that were simulated during either isobaric cooling (IBC) or isothermal compression (ITC) experiments, carried out at high confining P (5 kbars) and relatively low T (300-400°C). Internal underpressure at high P and low T for I in quartz from the D-T unit can be generated if the veins were involved with nearly isothermal compressional events during underplating. Quartz samples from the D-T unit also contain a large number of low sal (0-5 wt.% NaCl) aq 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 in the same fractures, and were trapped during the uplift of the HP rocks, when greenschist facies conditions were reached. Explanation for the one-phase I might involve simple metastability from absence of bubble nucleation. (Authors' abstract)

ISHIYAMA, T., KIMURA, J., SATO, H., WOOD, S.A. and **MIZUTA, T.**, 1997, Analytical study on chemical composition of an individual fluid inclusion using laser ablation (LA)-ICP-MS: A preliminary study, (abst.): Abstracts of the 47th Ann. Meeting of the Soc. of Resource Geol., June 4-6, 1997, Tokyo, Japan (in Japanese; translation courtesy T. Sawaki).

The authors preliminarily analyzed synthetic FI in quartz and natural I in sphalerite from Jokoku mine, using LA-ICP-MS. Cl was detected by an individual I analysis for the synthetic I. Sr, Rb, Ba, La, Ce and Eu were semi-quantitatively detected in I of sphalerite. (Authors' abstract)

IVANOVA, G.F., 1997, Mineral composition and formation conditions of the Piaotang tin-tungsten deposit, South China: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 637-639. Author at Vernadsky Inst. of Geochem. and Analytical Chem. of the Russian Acad. of Sci., Moscow, Russia.

The conditions of formation of the Piaotang tin-tungsten deposit (South China) were investigated. The existence of a homogeneous source of mineral-forming F responsible for the deposit formation was demonstrated by data on mineral compositions of the ore-bearing zones, chemical compositions of individual minerals, distribution of rare-earth elements and estimation of the T and chemical composition of the F ore-bearing systems. (Author's abstract)

IXER, R.A.F., PATTRICK, R.A.D. and **STANLEY, C.J.**, 1997, Geology, mineralogy and genesis of gold mineralization at Calliachar-Urlar Burn, Scotland: in Trans. Instn. Min. Metall. (Sect. B: Appl. Earth Sci.), v. 106, May-August 1997, p. B99-B108.

At Calliachar Burn quartz - sulphide±gold veins infill master joints that crosscut gently dipping metasediments and metabasics. FI data suggest that the mineralization took place over the range 320-140°C from F containing significant CO_2 and 2-13 wt.% eq. NaCl. Isotopic and noble G studies indicate a magmatic (mantle-derived) source for the F with input from meteoric water. The mineralization appears to have been initiated by mantle-derived F, generated during the late Caledonian. (From authors' abstract by E.R.)

IZQUIERDO M., Georgina, ARELLANO,

V.M. and **CATHELINEAU, Michel,** 1997, P-T-X conditions of formation of zeolites, clays and calc-silicates in the Los Azufres geothermal field: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 151-152. First author at Inst. de Investigaciones Electricas, Unidad de Geotermia, Apdo. Postal 1-475, CP 62001, Cuernavaca, Mor. Mexico; email (gim@iie.org.mx).

Most common S minerals in Los Azufres are: clay minerals, calcite, quartz, epidote, pyrite. Less common are zeolites, prehnite and anhydrite among others. Zeolites identified include lesser amounts of mordenite-clinoptilolite and laumontite, and relatively more abundant wairakite.

FI were analyzed from quartz, epidote, calcite and anhydrite. In summary, from the surface to the deepest levels a regular mineralogical sequence of three [four?] thermal zones has been established:

alunite – amorphous silica – gypsum – native sulfur (80°C <T <150°C); kaolinite – smectite – clinoptilolite – laumontite (100-180°C); illite-chlorite – calcite – pyrite – wairakite – anhydrite (190-250°C) and chlorite – K-mica-quartz – epidote – hematite – diopside – prehnite – adularia (220-320°C). (From authors' abstract by E.R.)

JAMTVEIT, B. and **YARDLEY, B.W.D., editors,** 1997, Fluid flow and transport in rocks: Mechanics and effects: book review in Lithos, v. 40, p. 341-342.

Contains many chapters that are pertinent to FI studies, but FI data are mentioned only rather briefly. (E.R.)

JANG, B.-A., 1997, The Mesozoic paleostress from healed microcracks and fluid inclusions in granites of Korea: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F699-F700. Author at Dept. of Geophys., Kangwon Nat'l. Univ., 192-1 Hyoja-dong, Chuncheon, Kangwon-do, 200-701, Republic of Korea; email (bajang@cc.kangwon.ac.kr)

Healed microcrack orientations and the S FI within healed microcracks in Mesozoic granites of Korea were examined. The Tt of FI were determined from Th. The age of healed microcrack formations were estimated by comparing the Tt of FI with cooling history of granites. The Mesozoic paleostress at the time of healed microcrack formations were determined based on the orientations and the age for formation of healed microcracks. These results indicate that stress rotations had occurred at least three times during the Mesozoic. (From author's abstract by E.R.)

JANSSEN, C., MICHEL, G.W., BAU, M., LUEDERS, V. and **MUEHLE, K.,** 1997, The North Anatolian fault zone and the role of fluids in seismogenic deformation: J. of Geol., v. 105 no. 3, p. 387-403. A study of the North Anatolian Fault Zone (Turkey) indicates significant spatial variations of deformation mechanisms and F flow along and across a major active strike-slip fault. Trace element distribution, isotopic data, and FI suggest that F were derived from the adjacent limestones and that hydrostatic F P was dominant during fault development. We suggest that meteoric water circulates through the fault zone, causing solution transfer and compaction, which allows frictional failure at lowered shear stress. (From authors' abstract by E.R.)

JARMOLOWICZ, S.K., 1997a, Microscope studies of hydrocarbon fluid inclusion fluorescence in sedimentary rock cement: Przeglad Geologiczny, v. 45, no. 9, p. 865-867 (in Polish).

JARMOLOWICZ, S.K., 1997b, Fluid inclusion research for study of reservoir rock diagenesis and reconstruction of hydrocarbon migration: Nafta Gaz., v. 53, no. 5, p. 165-172 (in Polish).

JEAN-BAPTISTE, P., CHARLOU, J.L. and **STIEVENARD, M.,** 1997, Oxygen isotope study of mid-ocean ridge hydrothermal fluids: Implication for the oxygen-18 budget of the oceans: Geochim. Cosmo. Acta, v. 61, no. 13, p. 2669-2677. First author at Laboratoire de Modélisation du Climat et de l'Environnement, DSM/LMCE, CEA-Saclay, F-91191 Gif-sur-Yvette cedex, France.

Mid-ocean ridge hydrothermal vents are a major source of ^{18}O to the ocean. Ocean water may have had a rather constant ^{18}O composition over most of the Earth's history and $\delta^{18}O$ measurements in ancient cherts and carbonates may primarily record the evolution of the ocean T. (From authors' abstract by E.R.)

JENDRZEJEWSKI, Nathalie, TRULL, T.W., PINEAU, Françoise and **JAVOY, Marc,** 1997, Carbon solubility in Mid-Ocean Ridge basaltic melt at low pressures (250-1950 bar): Chem. Geol., v. 138, p. 81-92. First author at Univ. Paris 7, Laboratoire de Géochimie des Isotopes Stbles, URA 1762, Tour 54-64 1er étage, 2 place Jussieu, 75 251, Paris, cedex 05 France.

The carbon solubility in a Mid-Ocean Ridge Basaltic (MORB) M was determined by equilibrating natural glass with CO_2 produced by decomposition of silver oxalate. These experiments were performed in closed platinum capsules in an internally heated P vessel at 1200 and 1300°C, at oxygen fugacity close to the QFM buffer and at P between 250 and 1950 bar. The results yield a best fit minimum solubility of 0.137±0.004 ppm C/bar. Many MORB glasses are supersaturated at eruption as a result of slow kinetics of degassing, while a few others are undersaturated because of either C loss during degassing of water-rich M or generation from carbon-poor sources. (From authors' abstract by E.R.)

JENKIN, Gawen, O'REILLY, Cian, FEELY, Martin and **FALLICK, Tony,** 1997, Fluid inclusion and stable isotope evidence for Triassic fluid mixing forming base-metal veins in Connemara, Ireland (abst.): Mineral Deposits Study Group Annual General Meeting, Glasgow Univ., 1997, Programme and Abstracts Volume, p. xxx. First author at Scottish Univ. Research & Reactor Centre, East Kilbride, G75 0QF, Scotland.

Mineralisation is frequently spatially associated with granite intrusions. However, there are a growing number of examples where this mineralisation is clearly much later than the age of intrusion, and therefore cannot be the result of magmatic heat (e.g. cross-course mineralisation in Cornwall; Scrivener et al, 1994). What causes this mineralisation to be spatially related to the granite?

In Connemara, western Ireland, the Caledonian (~400 Ma) Galway Granite exhibits a number of styles of mineralisation (O'Reilly et al, 1997). Mo mineralisation is clearly related to separation of magmatic F from the magma at the end-stages of crystallization. This was followed by a major influx of meteoric F, probably in a meteoric convection system. The last phase of mineralisation (base metal, quartz, fluorite, calcite, barite), however, is tentatively dated at ~210 Ma; U. Triassic (Halliday & Mitchell, 1983; O'Connor et al, 1993; Menuge et al, 1996; Jenkin et al, 1997), and is therefore not the result of magmatic heat.

Combined FI and stable isotope studies show that the F depositing the base metal veins fluctuated in sal, T, $\delta^{18}O$, δD, $\delta^{13}C$ and $\delta^{34}S$. Variations in these parameters are correlated, so that the veins are thought to be the result of mixing of two F end-members, *within the vein system.*

EM1 is interpreted [as] Triassic meteoric water that has gained sal, either by dissolution of Triassic evaporites, or mixing with evaporated Triassic seawater, or probably both. EM $\delta^{34}S$ and $\delta^{13}C$ are consistent with Triassic marine values.

EM2 is interpreted to be a basinal brine from the adjacent or overlying L. Carboniferous sediments. The low δD and $\delta^{13}C$ values are attributed to a component of "organic water". The high $\delta^{34}S$ values suggest the F dissolved L. Carboniferous evaporites.

Given these origins, the higher T of the surface-derived EM1I must be explained by this F travelling a path to the mixing zone that allowed it to heat up more, either by deep penetration beneath the area, or by traversing Permo-Triassic basins offshore, in which concurrent volcanism took place (Tate & Dobson, 1989). Thus is it suggested that EM1 was rising into the zone of mixing. The cause of F mixing is probably incipient North Atlantic opening at this time (Mitchell & Halliday, 1976; Halliday & Mitchell, 1984; O'Connor et al, 1993). The reason why this mineralisation is concentrated around the granite is probably related to a number of features of granites in general, such as higher heat flow, greater permeability, source of mineralising constituents (e.g. F) and spatial relation to basins. (From authors' abstract by E.R.) *See table on page 233.*

JI, Jinsheng, XUE, Chunji, ZENG, Zhangren and **YANG, Xingke,** 1997, Study on the Kanggur Tag gold zone in the eastern Tianshan Mountains: Geological Review (Dizhi Lunping), v. 43, no. 1, p. 69-77. Authors at Xi'an College of Geol., Xi'an, Shaanxi.

In the Kanggur Tag gold ore zone, isotopic and FI studies show that there are three type of gold deposits, i.e.: (1) shallow low-T hydrothermal type, (2) ductile shear belt altered rock type and (3) magmatic hydrothermal quartz vein type. The three had the same metallogenic source and the initial $^{87}Sr/^{86}Sr$ ratio ranges from 0.7053 to 0.7061 and the variation is small. The metallogenic F are similar in composition, all belonging to Na-K-Cl type with less Ca and Mg and reductive gases CH_4, C_2H_6 and CO. But the three types of gold deposits also have some [minor] differences. (From authors' abstract by E.R.)

JIANG, Neng, 1997, Fluid inclusion evidence for meteoric water involved in hydrothermal fluid evolution at Wenyu gold deposit: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 7 (in English). Author at Inst. of Geol., Chinese Acad. of Sci., Beijing, 100029.

FI are investigated on quartz of stage I, II, and III from vein 530 of Wenyu mine. CO_2-H_2O I are dominant in both stage I and II vein quartz whereas aq I dominant in stage III vein quartz. According to FI microthermometry data, CO_2-H_2O I from stage I through II to III indicate an evolving CO_2-H_2O-NaCl system. However, aq I in stage III vein quartz are not the evolving result of CO_2-H_2O-NaCl system. FI data, combined with isotopic data, support that the aq I are most likely derived from meteoric water. The ore-forming F are CO_2-rich in the earlier stages and H_2O-rich in the latest stage. (Author's abstract)

JIN, Mingxia and **SHEN, Su,** 1997, Fluid features and metallogenic conditions in Lala Cu deposit, Huili, Sichuan: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 5 (in English). Authors at Chengdu Inst. of Geol. and Mineral Resources, Chengdu, 610082.

According to the research on the F generations, ore-forming T, sal, system, density and P of Lala copper deposit, Huili, it is considered that the F may be divided into five generations from magmatic stage – rock-forming stage – metallogenic stage – post-metallogenic stage. First to fourth generations are related to mineralization. Ore-forming F belong to NaCl-H_2O system. The best ore-forming T ranges in 420 ~240°C, sal w(NaCl) 13% ~17%, density 0.82 ~0.97 g/cm^3 and ore-forming P are in the range of 20.0 ~42.5 MPa, which are attributed to anatectic – hypabyssal – hydrothermal deposit reformed by multiphase thermo-dynamics. [sic] (Authors' abstract)

JOHNSON, K.T. and **NAKAMURA, Eizo,** 1997, Compositional variation of primitive Kilauea magmas over the last 100,000 years from melt inclusions in the SOH-4 deep core (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 5, p. 21. First author at Dept. of Natural Sci., Bishop Museum, 1525 Bernice St., Honolulu, HI 96817; email (kevinj@soest.hawaii.edu).

One of the more controversial issues related to the Kilauea and Mauna Loa magma systems is the degree to which they may be connected. This issue has traditionally been addressed by bulk analysis of lavas sampled from each edifice. Lavas exposed on the surface however, represent only a very small percentage of the magmas erupted and have seen extensive fractionation and mixing, processes that can mask the differences between the magma types.

We present initial results of a study to: 1) develop a technique for recovering the composition of L trapped as I in primitive olivines, and 2) to understand the chemical variability of primitive M of Kilauea over time. P MI represent L trapped during growth of their host crystals. I with compositions more primitive than their host lavas are common and often represent magmatic components from deeper in the plumbing system than erupted lavas, and are less affected by shallow-level modification by mixing and fractional crystallization.

We analyzed 30 primitive MI, ranging in size from 30μ-150μ, in olivines from nine picritic horizons in SOH-4 a ~2000 m drill core from Kilauea's lower East Rift Zone. Analyses were done by ion and electron probes after remelting the I at their nominal Tt to eliminate post-entrapment crystal growth and devitrification products. The sample depth range was 270-1951 m in the core.

In general, I major element compositions are similar to lava compositions, but Zr/Nb and La/Yb in MI from the upper core resemble Kilauea compositions, while I from the middle and lower parts of the core are similar to Mauna Loa compositions. Also notable is the difference in REE compositions between the erupted lavas and the remelted MI. While the overall compositional trends in both lavas and I are similar, the I show greater compositional diversity and uniformly lower La/Yb values that are more "Mauna Loa-like" than those of the lavas. (Authors' abstract)

JUHÁSZ-BODNÁR, Katalin, BÜKER, Carsten, RAMSEYER, Karl and **MATTER, Albert,** 1997, Changes of fluid composition during quartz cementation: evidence from fluid inclusions, Upper Palaeozoic Haushi Group sandstones, Sultanate of Oman: GAEA 3, 18th IAS, Regional European Meeting of Sedimentology, Heidelberg, Sept. 2-4, 1997, Abstracts, p. 183-184. Authors at Geologisches Institut, Univ. Bern, Baltzerstrasse 1, CH-3012 Bern, Switzerland.

The wide present day depth range of the interior Oman sedimentary basin provides a unique setting for studying burial-related diagenesis, including quartz cementation and pore-water evolution.

Intense quartz cementation is the most important reservoir-quality-reducing process. Authigenic quartz formed as multiphase, zoned syntaxial overgrowths on detrital quartz grains. It varies from trace amounts in outcrop samples to almost 25 vol.% in sandstones buried over 4000 m. Four processes provide silica for quartz cementation: dissolution of unstable aluminosilicate minerals due to meteoric mixing, transformation of smectite to illite in mixed layer clay minerals (I/S), P solution and illitisation of kaolinite and feldspars (Hartmann et al., 1997).

Extensive FI microthermometric studies of quartz cements in samples from surface to 4000 m in depth show that P, water-rich, mainly two-phase FI are located on detrital grain-cement boundaries and rarely in the cement itself. The presence of CO_2 or CH_4 G in the measured I could not be detected by microthermometry.

Th of FI within quartz cements are higher than those present on the boundaries between the detrital quartz grains and overgrowths. Precipitation of quartz cement thus occurred during a phase of increasing T, e.g. increasing burial and/or heat flow. The timing of quartz precipitation was constrained on the base of the modelled burial and T histories for each well.

On a basin-wide scale, sal deduced from the final ice melting T increase with increasing precipitation T, showing generally lower values (6.4-11.5 wt.% NaCl eq.) from samples of shallower depth in the SE than those from the deeply buried samples in the NW (9.5-23.6 wt.% NaCl eq.). This difference can be attributed to the influence of meteoric water during shallow burial in sandstones from the southeast and the increasing influence of highly saline brines derived from the Ara salt during deep burial common in the northwest. Within individual highly-cemented samples from the central and northwest parts of the basin, however, a decrease of sal during ongoing quartz precipitation is observed. This indicates a decrease in pore-F sal during precipitation of quartz cement with ongoing burial. (From authors' abstract by E.R.)

KAGI, H., LU, R., HEMLEY, R.J. and **MAO, H.-k.,** 1997, Discovery of IceVI as an inclusion of natural diamonds: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F731. First author at CHiPR and Dept. of Geosci., SUNY at Stony Brook, Stony Brook, NY 11794-2100; email (kagi@sbmp04.ess.sunysb.edu)

Natural diamonds contain mantle-derived FI. Previous studies showed that some diamonds retain high P in order of GPa inside of diamond crystals judging from the spectral shifts observed for I. These high P are high enough to crystallize water as ice VI or VII at room T. So far, however, water in natural diamonds has been believed to exist as L in a supercooled state due to smallness of water I or high solute concentration.

In this study, a high P phase of ice was found in a morphologically cubic diamond by near infrared spectroscopy. We observed a combination band between stretching and bending vibrations of water I in the diamond at room T. The combination band revealed the presence of a shoulder absorption around 5000 cm^{-1} in addition to the main peak at 5180 cm^{-1} due to L water. The shoulder absorption declined by heating at 100°C. The P dependence of frequency of the combination band was determined by an in-situ observation of ice VI and VII using a diamond anvil cell. Obtained IR spectra demonstrated that ice VI at 1.9 GPa gives rise to the absorption at 5000 cm^{-1}. The spectral change by heating corresponded to melting of ice VI, because ice VI at 1.9 GPa melts at around 70°C. The spectral observation of ice VI enables us to directly estimate the residual P of mantle F encapsulated in natural diamonds. (Authors' abstract)

KAINDL, R., ABART, R. and **HOINKES, G.,** 1997, Microthermometry and geobarometry of singly and polymetamorphic crystalline rocks from the Ostal Alps crystallines: Austrian Fluid Info Workshop, extended abstracts, Mitt. Osterr. Miner. Ges., v. 142, p. 7-8 (in German).

KALYUZHNYI, V.A., 1997, On the effect of the quartz beta-alpha inversion on the behaviour and temperature of homogenization of the fluid inclusions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 153. Author at Inst. of Geol. and Geochem. of Combustible Minerals, Naukova Str., 3a, 290053 Lviv, Ukraine.

Usually in thermometric analysis the influence of volume changes in the host mineral is neglected. However, the peculiarities of quartz have to be taken into account. As an example; phenocrystals of quartz from liparite tuff contain magmatic glass I of two types: two-phase type (20% V), and one-phase type (all glass). On heating, the two-phase type have Th>1400°C. One-phase I show a solitary point-like gas bubbles at 560°C. At 565-575°C there is an intensive G bubble production, and the I become semitransparent; at 650°C the G phase volume begin to reduce; at 770-780°C there is a homogenization into the M. On cooling, the phase changes occur in the opposite sequence.

Magmatic quartz from breccia tuff contains MI with 2% V. On heating, at 20-400°C the G bubble gradually decreases; at 400-420°C the G bubble disappears (first homogenization); at 420-430°C there is a heterogenization; at 500-650°C the volume of the G phase increases greatly; at 830-840°C the second homogenization occurs. On cooling, at 680°C there is a F heterogenization; at 680-610°C the G phase increases to its maximum; at 610-520°C there is a gradual decrease and disappearance of the G phase (homogenization); at 520-20°C I is still homogeneous, recovering to the initial two-phase state after several days. Under high magnification, it is possible to distinguish G and L phases in the bubble, which finally appears. The existence of the two phases can be noticed sometimes in the G bubble before the thermoanalysis.

Without thermometric analysis of magmatic I, wrong conclusions about the T conditions of quartz crystallization are possible. For example, the one-phase property is explained usually by the metastable solidification ("quenching") of the glass due to rapid cooling, which is not a universal case. Lowering of the homogenization T of the I saturated by volatiles do not correspond to the crystallization conditions. (From author's abstract by E.R.)

KAMENETSKY, V.S., CRAWFORD, A.J., EGGINS, Stephen and **MÜHE, Richard,** 1997, Phenocryst and melt inclusion chemistry of near-axis seamounts, Valu Fa Ridge, Lau Basin: Insight into mantle wedge melting and the addition of subduction components: Earth and Planetary Sci. Letters, v. 151, p. 205-223. First author at SRC for Ore Deposit Research, Univ. of Tasmania, GPO Box 252-79, Hobart, Tasmania 7001, Australia.

Phenocryst assemblages, and mineral and M I compositions of magmas erupted at near-axis seamounts on either side of Valu Fa Ridge provide a hitherto unprecedented insight into the complexity of magma generation in this back-arc basin tectonic setting. Two fundamentally different primitive P M compositions are identified based on M I compositions, olivine phenocryst chemistry, and the early co-crystallisation of either magnesian clinopyroxene or magnesian orthopyroxene with magnesian olivine and Cr-rich spinel. One magma type is a H_2O-rich (~2.5 wt.%), high-CaO (~14 wt.%), low-Al_2O_3 (~8 wt.%) magnesian basalt, variants of which occur in both the eastern and western seamounts. The other is a low-Ca boninite-like magma that only occurs as a component of the western seamount magmas.

Large and systematic variations in incompatible trace-element compositions of M I trapped in primitive olivine phenocrysts reflect an integration of diverse but geochemically related M fractions to produce the magmas at each seamount. Trace-element systematics require the variable addition of a LILE-, Pb-, and Cl-rich component to the mantle wedge source with increased influence toward the Tofua arc. (From authors' abstract by E.R.)

KANEV, Kamen, IKEUCHI, Jun, KIMURA, Shigeo and **OKAJIMA, Atsushi,** 1997, Heat loss to the surrounding rock formation from a geothermal wellbore: Pergamon Press, Oxford, New York, International.

Indexed under FI (E.R.)

KANG, Xianji and **HUANG, Huilan,** 1997, Genetic mineralogical study of quartz from the Shizhuyuan deposit in southern Hunan: Geology and Mineral Resources of South China (Huanan Dizhi Yu Kuangchan), 1997, no. 3, p. 60-69 (in Chinese; Engl. abst.). Authors at Yichang Inst. of Geol. and Mineral Resources, Yichang 443003.

The Qianlishan granite, which [is] closely related to mineralization, was the product of magma from the remelting of crustal silica-alumina layer, and the metallogenic F came from magma fractionation; the mineralization mainly occurred in the pneumatogenic-high T hydrothermal F stages, the mineral-bearing liquor was of medium sal and density of weak acidic pneumatolitic solution with a little more fugitive constituent of CO_2, F and Cl. The mineralization system was a semi-closed state in the main metallogenic stage. It is obvious that the decrease of outside P and [some] deep-cycled meteoric water infiltration were two major important factors for mineralization. The kind and high content of main mineralization elements in quartz formed in metallogenesis simply indicate the geochemistry type of the ore-deposit. Therefore, the trace metal elements in quartz could be regarded as a sensitive indicator of mineralization.

Extensive FI data presented (H.E.B.).

KASHIMA, T. and **TSUNOGAE, T.,** 1997, Fluid inclusion study of pelitic gneisses around Choshi and Oku rivers, Oki-Dogo Island (abst.): Abstracts of 1997 Japan Earth and Planetary Sci. Joint Meeting, March 25-28, 1997 at Nagoya Univ., (in Japanese, translated by T. Sawaki).

Oki metamorphic rocks, which are exposed in the northeastern part of the Oki-Dogo Island, southwestern Japan, consist of pelitic-psammitic, mafic and calcareous gneisses and granites. Mineral assemblages of the gneisses suggest that the metamorphic grade reached the upper amphibolite to granulite facies. The authors studied FI of quartz in leucocratic and melanocratic parts of pelitic gneisses from the Choshi and Oku rivers, to elucidate the relation between the metamorphic history and F activity.

Almost all the studied I are S, of 0.5-1.8 mm in size [sic]. Freezing experiments show that two types of I occur; one is H_2O-rich (NaCl eq. wt.% = 0.12-3.8), and the other is CO_2-rich (Tm=-56.6°C). In melanocratic parts, these I coexist, or only H_2O-rich I occur, while few CO_2-rich I are observed in leucocratic parts. Th of H_2O-rich I in both leucocratic and melanocratic parts are 240-280°C, and those of CO_2-rich I are 10-25°C. Based on the results, estimated formation T of H_2O-and CO_2-rich I are 450-540°C and 540-860°C at 3 kbars, respectively. These estimates and previous work on the Oki metamorphic rocks suggest that H_2O-rich I were formed at the final stage of retrogressive metamorphism. On the other hand, CO_2-rich I were thought to be formed at the peak to retrogressive stage of metamorphism. CO_2 was probably derived from decomposition of graphite in pelitic gneisses because occurrence of CO_2-rich I is correlated with existence of graphite. (Authors' abstract)

KASIMOVA, F.I., 1995, Meaning of carbon's isotopes of hydrocarbon inclusions at minerals-sputnic from Kimberlite pipe Mir: Sixth Internat'l. Kimberlite Conference, Extended Abstracts, Russia, 1995, p. 705. Author at Azerbaidzan Geological Inst., SA.

Hydro-carbon I were determined in zircon from concentrate from kimberlite pipe Mir. With the method of low T and spectrofluorimetry their consistence was studied. Consistence of hydro-carbon I in zircon is close to hydrocarbons which were studied earlier in mineral-indicator olivine from pipe Udachnaya (Daldino-Alkitaiskii region) and in garnets from pipe Mir (Malo-Botoubinskii region). Aromatic hydrocarbons with molecular structure of alkinnaphtaline, alkinfenatren and piren prevail. (Author's abstract) See also FIR 27, p. 62-63 (E.R.).

KASIMOVA, F.I., 1997, Temperature conditions of zircon's crystallization from kimberlite pipe Mir: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 154. Author at Azerbaidjan Geological Inst. SA, 117234 Russia Moscow Vorobjori Hills, MGU Geol. Dept.

Zircon occurs as color zoned crystals up to 15 mm. ZrO_2 is to 65 wt.% HfO_2 [sic] from 0.8 till 1.6 wt.% FeO=0.00-0.14 wt.% Zr/Hf=55.33-137.14, ZrO_2/HfO_2=1.93-2.07. Min. T of zircon crystallization 850-921°C at 10, 20, 30 kbar (general P) was determined. I of restored hydrocarbon by method of low T spectrofluorimetry were determined in zircon for the first time. Aromatic hydrocarbons with molecular structure of alkinnaphtaline, alkinfenatren and pirene prevail [sic] as in minerals-sputniks garnets from pipe Mir and in olivines from pipe Udachnaya, which were determined earlier. Their presence indicates that situation of crystallization of minerals-sputiks is full of hydrocarbons.

Meaning of isotopes C13 hydrocarbons from I at zircon are close to the meaning C13 hydrocarbons in olivines from pipe Udachnaya and in garnets from pipe Mir; they occupy field of meanings of isotopes hydrocarbons of diamond of eclogite paragenesis. According to consistence of mineral I (olivine, clinopyroxene–CrDi, Spl) zircons from kimberlite pipe Mir are concerned to be ultrabasic magnesial paragenesis [sic]. (From author's abstract by E.R.)

KAWAKAMI, K., GROVE, M. and **HARRISON, T.M.**, 1997, Argon solubility in mid-crustal fluids: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F787. Authors at Dept. Earth and Space Sci., UCLA, Los Angeles, CA 90024; email (marty@argon.ess.uc.a.edu)

Knowledge of the solubility of Ar in crustal F is key to understanding both the sources of excess radiogenic ^{40}Ar (^{40}Ar^{xs}) trapped by minerals and how Ar concentrations evolve within the crust. A survey of ^{40}Ar^{xs}/Cl ratios calculated for I-hosted F in nearly 100 alkali feldspars analyzed in ^{40}Ar/^{39}Ar step-heating experiments reveals variation of over three orders of magnitude with an upper maximum of ~10^{-3}. Based upon plausible sal for these F, corresponding Ar/H_2O ratios are expected to fall below ~$5\text{x}10^{-4}$. Whether this upper bound reflects Ar saturation or other factor(s) is unclear. For example, the value is well below that indicated experimentally for Ar solubility in pure H_2O extrapolated to middle crustal conditions. To test whether NaCl significantly depresses Ar solubility at elevated P and T, we have refined an experimental technique in which Ar- and NaCl-bearing hydrothermal F are trapped in synthetic FI. Decrepitation of these I via in vacuo crushing in an Ar extraction line allows determination of Ar/H_2O from the measured ratio of ^{40}Ar to Cl-derived ^{38}Ar and the known sal in the F. Experiments undertaken at 2000 bar, 350°C and 0.0-0.3 mole fraction NaCl yielded Ar/H_2O values between 2-$8\text{x}10^{-4}$ for F with bulk Ar/H_2O~10^{-3}. Although dependence of the results upon sal were equivocal, more recent experiments with bulk Ar/H_2O>0.1 that yield similar Ar/H_2O values from FI appear to confirm that the F were Ar-saturated. Based upon these preliminary results, it seems likely that Ar/H_2O saturation in saline solutions at 2000 bar, 350°C is <10^{-3}. This in turn implies that the highest ^{40}Ar^{xs}/Cl values determined for I-hosted F in K-feldspars may represent Ar saturation in nature. (Authors' abstract)

KAWAMOTO, Tatsuhiko and **HOLLOWAY, J.R.**, 1997, Melting temperature and partial melt chemistry of H_2O-saturated mantle peridotite to 11 gigapascals: Science, v. 276, p. 240-243.

KENNEDY, B.M., KHARAKA, Y.K., EVANS, W.C., ELLWOOD, A., DePAOLO, D.J., THORDSEN, J., AMBATS, G. and **MARINER, R.H.**, 1997, Mantle fluids in the San Andreas fault system, California: Science, v. 278, p. 1278-1281. First author at Center for Isotope Geochemistry, Lawrence Berkeley Nat'l. Laboratory, Berkeley, CA 94720.

F associated with the San Andreas and companion faults in central and south-central California have high ^{3}He/^{4}He ratios. The lack of correlation between helium isotopes and F chemistry or local geology requires that F enter the fault system from the mantle. Mantle F passing through the ductile lower crust must enter the brittle fault zone at or near lithostatic P; estimates of F flux based on helium isotopes suggest that they may thus contribute directly to fault-weakening high-F P at seismogenic depths. (Authors' abstract)

KENT, A.J.R. and **McCUAIG, T.C.**, 1997, Disturbed ^{40}Ar-^{39}Ar systematics in hydrothermal biotite and hornblende at the Scotia gold mine, Western Australia: Evidence for argon loss associated with post-mineralisation fluid movement: Geochim. Cosmo. Acta, v. 61, no. 21, p. 4655-4669. First author at Research School of Earth Sci., The Australian Nat'l. Univ., Canberra 0200, Australia.

Hornblende and biotite that formed during gold mineralisation at the Scotia mine, Western Australia, have erratic ^{40}Ar-^{39}Ar release spectra and total gas ages that are ~200-900 million years younger than the ca. 2600-2620 Ma minimum age of gold mineralisation, as given by ^{40}Ar-^{39}Ar plateau (muscovite) ages of crosscutting pegmatite dykes. It is suggested that argon loss occurred during mineral-F interaction during movement of a retrograde F along the mineralised lode structures and that this occurred at ambient T below the blocking T of pegmatite muscovite. (From authors' abstract by E.R.)

KENT, A.J.R., NORMAN, M.D., HUTCHEON, I.D. and **STOLPER, E.M.**, 1997, High water contents of glasses and melt inclusions from the Loihi seamount: Evidence for assimilation of a modified seawater component: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 111-112, Lunar and Planetary Inst., Houston. First author at Div. of Geological and Planetary Sci., MS 170-25, California Inst. of Tech., Pasadena CA 91125, U.S.A.; email (adam@expet.gps.caltech.edu)

MI and submarine glasses are frequently analyzed for H_2O and CO_2 contents in an effort to characterize pre-eruptive volatile contents of magmas. It is usually assumed that volatile contents have been influenced primarily by processes such as crystal fractionation or degassing (and thus, for basaltic magmas, can be used to set limits on the volatile contents of primitive magmas); however, care must be taken to rule out the influence of assimilation of volatile-rich material. This can be an important process: e.g., incorporation of a modified seawater component is thought to have significantly altered the H_2O and Cl compositions of some MORB. Here we report a case of pre-eruptive incorporation of a volatile-rich component, probably derived from modified seawater, into Hawai'ian magma.

We have analyzed two samples from Loihi seamount, Hawai'i, using SIMS (H, Li, Be, B), FTIR (H_2O, OH^-, CO_2), and the electron microprobe (major and minor elements, including Cl and S). Both samples consist primarily of glass plus olivine phenocrysts with glass I. Host glasses from both samples have similar major-element compositions with average MgO and K_2O contents of 8.90 and 0.55 wt.%. MI have compositions indicating that they represent relatively unevolved M samples (MgO contents of 9.4-12.6 wt.%).

The observations strongly suggest that the high H_2O, Cl, and B contents result neither from concentration in residual L as a result of crystallization nor from significantly lower degrees of melting.

The elevated H_2O contents of these samples probably reflect addition of a H_2O- (and B+Cl-) bearing component within the magma chamber environments in which the olivine phenocrysts grew and trapped MI, and from which the M now quenched to the host glasses were erupted. High-T brines and/or seawater-altered basaltic material from within the volcanic edifice are possible candidates for the assimilated component. Assimilation of seawater or seawater-altered basalt has been suggested previously to account for B and H isotope systematics of some Hawai'ian basalts. (From authors' abstract by E.R.)

KERKHOF, Alfons Van Den, KOOI, Eline, SCHOUTEN, Jan, ISTRATE, George and ALTHAUS, E., 1997, The system CO_2-N_2 at high pressures: Applications to fluid inclusions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 335-336. First author at IGDL, Univ. of Göttingen, Goldschmidtstr. 3, D-37 077 Göttingen; email (akerkho@gwdg.de).

High-P experiments (P=1 to 40 kbar; T=-70 to 130°C) were performed with 49.6 and 50.3 mol.% N_2 mixtures in a diamond-anvil cell at different T and P. The experiments show that F-F immiscibility is not realistic for this system below 33 kbar. As a consequence, the model of Kreglewski & Hall (1983) cannot be valid at high P.

High-density CO_2-N_2 FI in charnockite from Rundvågshetta, Lützow-Bay, Antarctica (760-830°C/7-8 kbar), mainly occur in garnet, but also in plagioclase, cordierite, orthopyroxene, apatite and quartz. They contain about equal amounts of CO_2 and N_2. They offer the unique possibility to study the (sub) critical F characteristics in this compositional range. A TX-projection of the system CO_2-N_2 is used to clarify the combination of the I data with the diamond anvil cell data. (From authors' abstract by E.R.)

KESLER, S.E., FRIEDMAN, G.M., KRSTIC, Dragan, 1997, Mississipi Valley-type mineralization in the Silurian paleoaquifer, central Appalachians: Chemical Geol., v. 138, p. 127-134. First author at Dept. of Geological Sci., Univ. of Michigan, Ann Arbor, MI 48109.

This study used lead and sulfur isotope tracers to determine the nature and geometry of MVT-related brine flow in the Silurian paleoaquifer of the central Appalachians. These relations, in combination with Na-Cl-Br compositions of FI leachates, suggest that MVT deposits in the lower part of the paleoaquifer formed when rising metal-bearing brines intersected reduced sulfur of probable thermogenic origin, whereas deposits in the upper part of the paleoaquifer (Lockport Dolomite) formed where metal-bearing brines intersected reduced sulfur of biogenic origin that was dissolved from sulfate evaporites in the overlying Salina Group and transported downward into the Lockport. (From authors' abstract by E.R.)

KESLER, S.E., VENNEMANN, T.W., FREDERICKSON, Christian, BREITHAUPT, Angela, VAZQUEZ, Rodrigo and FURMAN, F.C., 1997, Hydrogen and oxygen isotope evidence for origin of MVT-forming brines, southern Appalachians: Geochim. Cosmo. Acta, v. 61, no. 7, p. 1513-1523. First author at Dept. of Geological Sci., Univ. of Michigan, Ann Arbor, Michigan 48109-1063.

Hydrogen and oxygen isotope compositions of FI hosted brines [in sphalerite, fluorite, and barite] from Mississippi Valley type (MVT) deposits in the southern Appalachians were analyzed to test whether the dominant water in the brines was seawater as suggested by previously reported Na-Cl-Br relations. These data permit, but do not require, the interpretation that the mineralizing brines contain seawater with hydrogen and oxygen isotope compositions that were modified by reaction with country rocks, particularly with organic matter and/or hydrocarbon gas. Consideration of published isotopic compositions of brines from other MVT deposits suggests that interaction with organic matter and/or gas may be an important process in the evolution of ore-forming brines. (From authors' abstract by E.R.)

KHIN Zaw, 1997, Microprobing of VHMS ore fluids: Implications for the role of seawater leaching vs. magmatic processes: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 357. Author at Special Research Centre for Ore deposits, Geol., Dept., Univ. of Tasmania, Hobart, Tasmania, Australia 7001; email (zaw@postoffice.utas.edu.au).

The Hellyer and Mt. Chalmers deposits are mound-style volcanic-hosted massive sulphide (VHMS) deposits in Australia. Textural, petrographic and microthermometric investigations of FI in the Hellyer stringer system indicate that Type I, P, L-V I are 10-15 µm in size, and yield Th of 170-220°C in early 2A veins, 165-322°C in main-stage 2B veins and 190-256°C in late-stage 2C veins. These data suggest a waxing and waning thermal history. However, the average sal remained between 8-11 NaCl eq. wt.% in all Stage 2 veins. At Mt. Chalmers, Type I inclusions 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 (<1 mol.%) in the Hellyer and Mt. Chalmers VHMS systems.

Semi-quantitative SEM/WDS microprobe analyses of FI decrepitates indicate that the Hellyer and Mt. Chalmers ore F were enriched in potassium and calcium but depleted in magnesium relative to seawater. PIXE analysis of FI in quartz from the mineralised zones 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. (From author's abstract by E.R.)

KHIN Zaw, GEMMELL, J.B., HUNNS, S.R., MERNAGH, T.P., RYAN, C.G., LARGE, R.R. and BOTH, R.A., 1995, Composition of fluid inclusions from the Hellyer and Mt. Chalmers VHMS deposits, Australia: Implications for source of ore-forming fluids: Geol., Soc. New Zealand 1995 Annual Conference, Nov. 22-24, 1997, Auckland Univ., Programme and Abstracts, published in Geological Soc. of New Zealand Miscellaneous Publication 81A ISBN 0-908678-49-5, p. 51. First author at CODES Key Centre, Univ. of Tasmania, Hobart, Tasmania, Australia 7001.

See Khin Zaw, 1995, FIR v. 28, p. 72-73. (E.R.)

KHMELEVSKA, E.V., 1997, Upper Jurassic evaporites of the southwestern slope of east European platform: Slovak Geol. Mag. 3, no. 3, p. 213-216. Author at Inst. of Geol. and Geochem. of Combustible Minerals, Nat'l. Acad. of Sci. of Ukraine, Naukova 3a, 290053 Lviv, Ukraine.

Upper Jurassic evaporite sequences along the southwestern slopes of East European Platform consist of interbedded dolomites, dolomitic limestones, anhydrite and siliciclastic rocks, and in Predobrogea also of gypsum and rock salt. The rock salt contains chevron and recrystallized halite with specific FI in each type. The I have a chloride chemical composition, with the ratios of sodium, potassium and magnesium chlorides similar to those in the modern seawater saturated to the corresponding stage, and differed only by $CaCl_2$ content. Maximum potassium content in brine I in halite is 15.5 g/l and indicates that the concentration of brine in the basin did not reach the stage of potash sedimentation. (Author's abstract)

KHOLODNOV, V.V. and **YAZEVA, R.G.**, 1997, Halogen systematics of rock and ore formation in divergent paleogeodynamic environments as exemplified by the Urals: Geokhimiya, 1997, no. 12, p. 1255-1261 (in Russian, translated in Geochem. Internat'l., v. 35, no. 12, p. 1116-1121). Authors at Zavaritskii Inst. of Geol. and Geochem., Ural Div., RAS, Pochtovyi per. 7, Yekaterinburg, 620150 Russia.

Connects the variations in the Cl/F ratio in minerals of igneous rocks with their relation to crustal environments (E.R.).

KIGAI, I.N. and **KOVALENKER, V.A.**, 1997, Evolution of structures of mineral aggregates in ore veins and its relationship to fluidal regime (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 192-193 (In Russian; Engl. translation from: English Version of the Abstracts of the Oral Presentations of the Papers of the Russian Participants, p. 36-37). ISBN 5-88918-002-9. Authors at IGEM RAS, Moscow, Russia.

The authors propose a rule or law concerning the sequence of appearance of filling veins and greisenization. Metasomatic veins are first, then filling veins and open space filling styles. At lower T in various deposits, abundant particles of native gold were found along with the globules of amorphous silica of the same size. This is suggestive of initial gold precipitation also as colloidal globules. (From authors' abstract by E.R.)

KILIAS, S., CHELIOTIS, I., CONSTANDINIDOU, E., CROSSING, J., NADEN, J., SHEPHERD, T.J. and **SIMOS, I.**, 1997, Epithermal gold mineralization in the Aegean: The Profitis Ilias deposit, Milos Island, Greece: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 155-156. First author at Nat'l. Univ. of Athens, Dept. of Geol., Section of Economic Geol. and Geochem., Panepistimiopolis, Ano Ilisia, 157 84 Athens, Greece; email (skilias@atlas.uoa.gr).

The Profitis Ilias gold deposit is classified as an adularia-sericite type epithermal deposit. Aq L- and V-rich I occur in ore and post-ore quartz, sphalerite, and barite. Quartz and sphalerite contain predominantly L-rich P, 20% V, I. Barite contains relatively more V-rich I in comparison with quartz and sphalerite.

P L-rich I have Th L varying by stage: ore stage 145-399°C (median 230°C); post-ore stage 112-263°C (median 175°C). Sal of L-rich I range between 0.1 and 11.4 wt.% NaCl eq. in ore-stage quartz and sphalerite, and between 0.93 and 8.5 wt.% NaCl eq. in post-ore barite. V-rich I in ore-stage quartz homogenize between 368 and 399°C (three measurements). Th vs sal relationships suggest two different evolution trends. First, L-rich I in Au-bearing quartz indicate a distinct boiling L trend to higher salt contents (0.1 to 9.5 wt.% NaCl eq.) with falling Th (399-210°C). This is followed by, or evolves to, a flat dilution trend with a sal decrease to about 2 wt.% NaCl eq. This occurs over a very narrow T interval between 210 and 200°C. L-rich I in barren post-ore barite exhibit only dilution. Stronger evidence for boiling is shown by a plot of sample elevation vs Th (Fig. 2). Two distinct distributions are evident. Below 450 m FI Th are tightly clustered and vary only by 20 to 50°C However, above this level Th show extreme variation (sometimes over 150°C), and this is attributed to the heterogeneous trapping of a boiling hydrothermal F above this zone. The transition between the two distributions at 450 m is interpreted as the base of boiling. Moreover, samples containing high gold values (>12 ppm) or visible gold are exclusively located above this level.

The FI data strongly suggest that boiling was a major control on Au deposition. Moreover, this conclusion was only made possible by combining the FI data with the spatial and an analytical information provided by drill-core and gold assay. (From authors' abstract by E.R.) *See figure on page 235.*

KILIAS, S.P. and **KONNERUP-MADSEN, J.**, 1997, Fluid inclusion and stable isotope evidence for the genesis of quartz-scheelite veins, Metaggitsi area, central Chalkidiki Peninsula, N. Greece: Mineralium Deposita, v. 32, p. 581-595. First author at Nat'l. Univ. of Athens, Dept. of Geol., Section of Economic Geol. and Geochem., Panepistimiopolis, Ano Ilissia, 15 784 Athens, Greece; email (skilias@atlas.uoa.gr).

Three types of P FI coexist in quartz and scheelite: type 1, the most abundant, consists of mixed H_2O-CO_2 I with highly variable (20-90 vol.%) CO_2 contents and sal between 0.2 and 8.3 eq. wt.% NaCl. Densities range from 0.79 to 0.99 g/cc; type 1 I contain also traces (<2 mol.%) of CH_4. Type 2 I are nearly 100 vol.% L CO_2, with traces of CH_4, and densities between 0.75 and 0.8 g/cc. Type 3 I, the least abundant, contain an aq L of low sal (0.5 to 8.5 eq. wt.% NaCl) with 10-30 vol.% H_2O gas infrequently containing also small amounts of CO_2 (<2 mol.%); densities range from 0.72 to 0.99 g/cc. The wide range of coexisting FI compositions is interpreted as a result of F immiscibility during entrapment. Immiscibility is documented by the partitioning of CH_4 and CO_2, into gas-rich (CO_2-rich) type 1 I, and the conformity of end-member compositions trapped in type 1 I to chemical equilibrium fractionation at the minimum measured Th, and calculated homogenization P. Minimum measured Th of aq and gas-rich type 1 I of 220-250°C, either to the H_2O, or to the CO_2 phase, is considered the best estimate of T of formation of the veins, and T of scheelite deposition. Corresponding F P were between 1.2 and 2.6 kbar. Oxygen fugacities during mineralization varied from 10^{-35} to 10^{-31} bar and were slightly above the synthetic Ni-NiO buffer values. The

FI data combined with $\delta^{18}O$ and $\delta^{13}C$ CO_2 data, together with geologic data, indicate generation of mineralizing F primarily by late- to post-metamorphic devolatilization reactions.

(From authors' abstract by E.R.)

KIRSTE, D., DESROCHER, S., SPENCE, B., HOYNE, B., TSANG, B. and HUTCHEON, I., 1997, Fluid flow, water chemistry, gas chemistry and diagenesis in the subsurface Triassic in Alberta and British Columbia: Bulletin of Canadian Petroleum Geol., v. 45, no. 4, p. 742-764.

KLEMD, R. and OTT, S., 1997, Compositional characteristics of fluid inclusions as exploration tool for Au-mineralization at Larafella, Burkina Faso: J. of Geochemical Exploration, v. 59, p. 251-258. Authors at FB-Geowissenschaften, Univ. Bremen, P.O. Box 330440, 28334, Bremen, Germany.

The Larafella Au-prospect (Burkina Faso) lies within dacitic greenstone rocks and zones of cataclastic deformation. Lode-vein mineralization is closely associated with CO_2-rich FI and increased As, but the barren quartz veins are characterized by $H_2O\pm$salt-bearing I. Consequently, FI studies of quartz veins and As-anomalies constitute important exploration tools for mesothermal gold mineralization. (From authors' abstract by E.R.)

KLING, M., 1997a, Genesis of the ankerite-siderite-sulphide-barite deposit of Kamsdorf (Thuringia, Germany): Fluid inclusion, Sr- and stable isotope constraints: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 535-537. Author at Institut für Allgemeine und Angewandte Geologie, München, Germany.

At Kamsdorf/Thuringia a metasomatic ankerite-siderite-sulfide mineralization hosted in carbonates is exposed. It is intersected by barite veins. The mineralization is regionally bound to the faults at the southern border of the Thuringian basin. T of ore formation ranges from 170 to 70°C. Isotope data point to the activity of several different F during mineralization, at least one derived from the basement, others from the Thuringian basin. (Author's abstract)

KLING, Michael, 1997b, Estimation of age and formation conditions of copper veins at Brenntal/Austria using microthermometric data and a P-T-t path: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 157-158. Author at Inst. für Allgemeine und Angewandte Geologie, Luisenstr. 37, D-80333 München; email (mike.kling@iaag.geo.uni-muenchen.de).

The Brenntal area is in the central part of the Tauern Window. Quartz veins with copper ores and ankerite are hosted by alpine shear zones. The quartz veinlets contain P FI. The composition of the F is aq, no separate G phase could be detected [sic]. No signs for boiling or F unmixing exist. Sal is between 8 and 11 wt.% NaCl eq.; Th is between 160 and 210°C. About 10% of the I contain opaque dxls interpreted as heterogeneous trapped sulfide minerals.

Combination of the microthermometric data and P-T-t path considerations lead to the following conclusions: T of vein formation was about 210-230°C; P ranged from 25 to 1200 bar; and age of formation is about 15 million years. The copper veins were formed during the young uplift of the area after Alpine thrusting and metamorphism. Deposition of quartz and ore minerals took place at significantly lower T than the formation of the hosting shear zones. The age of 15 Ma for this mineralization is also a hint on regional extension tectonics at this time. (From author's abstract by E.R.)

KLOHN, E., HOLMGREN, C. and RUGE, H., 1986, El Soldado, a peculiar copper deposit associated with anomalous alkaline volcanism in the Central Chilean Coastal Range: Proc. 115th Annual Meeting, Soc., Mining Eng.: New Orleans, AIME, 8 pp.

FI data reviewed by Zentilli et al (this volume (E.R.).

KNOLL, P., PRESSL, M., ABART, R. and KAINDL, R.A., 1997, Quantitative analysis of fluid inclusions with Raman spectroscopy: Austrian Fluid Info Workshop, extended abstracts, Mitt. Osterr. Miner. Ges., v. 142, p. 9-10. First author at Inst. of Experimental Physics, Karl-Franzens Univ., Universitätsplatz 5, A-8010 Graz, Austria.

We developed an algorithm that accounts for nonlinear Raman behavior within a consistent framework using only the measured Raman efficiency $S_a(\omega_a)$, the differential Raman scattering cross section of a molecule $\sigma_a(\omega_a)$, and the number of molecules per volume n_a. Values of the differential Raman scattering cross sections for the Q branch of N_2 and CH_4 at standard conditions (760 Torr, 298 K, 514.5 nm laser excitation) are: σ_{N_2} (2331 cm^{-1})=43 x 10^{-32} cm^2 sr^{-1}, σ_{CH_4} (2917 cm^{-1})=3.2 x 10^{-30} cm^2 sr^{-1} (Schrötter 1979).

Our proposed algorithm for nonlinear Raman response works as follows: first the relative compositions x_i are determined by Raman analysis with a first guess of the absolute concentrations n_i of the I. (It is assumed that the Raman investigations are performed at a T above the Th with the same density of the I as at Th. For most cases this will be true for room-T Raman analyses.) Secondly, the Th is determined by microthermometric measurements. With the help of the relations $d(x_i, Th)$ for the specific binary subsystems the density ρ of the I is determined. Then the absolute concentrations $n_i=\rho x_i$ are obtained and enter into the next iteration step for the Raman analysis.

The relevant question for the application of this method on geological problems is how the accuracy can be improved. In order to estimate the error of the Raman analysis we consider the N_2-CH_4 subsystem and take the nonlinear Raman response as obtained by Seitz (1996) and Wang (1973). As long as the density of the I is lower than around 0.005 mole/cm^3 the linear approximation will work with an error <20% and slightly better than our proposed nonlinear method. At higher densities the error of the linear interpretation raises significantly and is far above 100% at 0.02 mole/cm^3. For this high density I the error of our nonlinear method is down at 7% which is the statistical limit for an estimated Raman accuracy of 10%. (From authors' abstract by H.E.B.)

KNOX, Kimberly and LEES, B.K., 1997, Gem rhodochrosite from the Sweet Home mine, Colorado: Gems & Gemology, v. 33, no. 2, p. 122-133. First author at Golden Pacific Arts, 520 Fifth Ave., San Diego, Ca 92101.

Characteristic FI are illustrated and discussed. (H.E.B.)

KNUPP, R.L. and **METCALF, R.V.**, 1997, Hydrothermal alteration associated with the Miocene Devil Peak intrusion, Clark County, Nevada (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-157. Authors at Dept. of Geosci., Univ. of Nevada, Las Vegas, 4505 S. Maryland Parkway, Las Vegas, NV 89154-4010; email (metcalf@ccmail.nevada.edu).

The Devil Peak rhyolite plug intrudes Paleozoic carbonate rocks. Two altered areas provide evidence for a small hydrothermal system. O and C stable isotope values decrease with increasing alteration of the limestone. Modeling indicates that Rayleigh decarbonation was not entirely responsible for the isotopic changes. Infiltration of the limestone by a hydrothermal F with a different isotopic composition best explains the lower isotope values. Modeling of F sources suggests that the infiltrating F was likely a mixture of meteoric, magmatic, and metamorphic F.

T-XCO_2 diagrams for the system MgO-CaO-SiO_2-H_2O-CO_2 show that brucite is stable only at XCO_2 values of 0.04 and lower. No CO_2 is visible in FI in calcite, and phase changes that denote a significant presence of CO_2, such as melting or freezing of CO_2 or clathrate, did not occur during FI analysis. Measured freezing point depressions of ice in FI were 0.2°C or less, indicating a sal of <0.36%. Thus the hydrothermal F was water-rich, with a very low CO_2 and NaCl content. (From authors' abstract by H.E.B.).

KODERA, Peter, RANKIN, A.H. and **LEXA, Jaroslav**, 1997, Evolution of fluids responsible for iron skarn mineralisation: Example from the Vyhne-Klokoc Deposit (Western Carpathians, Slovakia): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 159-160. First author at Geological Survey of the Slovak Republic, Mlynská dolina 1, 817 or Bratislava, Slovakia; email (kodera@guds.sanet.sk).

Vyhne-Klokoc, the largest and the best-known Fe-skarn deposit in the Western Carpathians, is related to the emplacement of a subvolcanic granodiorite pluton in the central zone of a large Neogene andesite stratovolcano. Skarn mineralisation is developed in places, where apophyses of the granodiorite invaded Triassic carbonates of the basement. Granodiorite in the apophyses grades into rocks of granitic composition. Ca-magnetite exoskarns developed during three paragenetic stages (initial, metasomatic, retrograde).

FI from garnets showed a large variation in sal (4-23 wt.% NaCl eq.) and Th (220-370°C), independent of the garnet types, probably caused by variable interactions with low sal meteoric waters. The composition of these F is probably a mixture of Na, Fe, Ca, K, and Mg chlorides. Later FI (captured in quartz, calcite, sphalerite) showed progressively more dilute (0-4 wt.% NaCl eq.) and cooler (Th 215-380°C), dominantly meteoric F with evidence for boiling. The P calculation for this boiling F corresponds to a depth of 800 m under hydrostatic conditions. Chlorite crystallization T, calculated from the chlorite geothermometer (Cathelineau, 1988), are in good agreement with the Th data for I in associated skarn minerals.

The preliminary FI data for the quartz in granodiorite apophyses showed the existence of very saline L-rich FI (up to 67 wt.% NaCl eq.), composed mainly of $NaCl+KCl+FeCl_2$ with with cogenetic V-rich FI, homogenizing over the T range 450 to 570°C. These provide strong evidence for aq F immiscibility during the late magmatic or early hydrothermal stages. The presence of Fe-chloride dm in saline FI suggests very high iron contents (>10 wt.%). Less saline lower Th FI (1-24 wt.% NaCl eq.), composed mainly of $NaCl+CaCl_2+FeCl_2$, Th 188-277°C) form the other end-member type. These FI usually appear S and their data are very similar to those obtained from the skarn.

Immiscible to aq F, exsolved from the crystallising granodiorite intrusion, accumulated along the roof and reacted with pre-existing mineral phases, replacing mafic minerals and plagioclase by chlorite, quartz and dominant K-feldspar. According to the experimental studies of Whitney et al. (1985) subsolidus F-mineral interactions will further add to the iron already concentrated in the ponded magmatic aq phase. This very high sal F is the P source of iron for the skarn.

Evolved lower saline and cooler metasomatic F form Fe-rich exoskarn mineralisation (with dominant magnetite and andradite) in response to neutralisation of these F, on contact with limestones and dolomitic limestones. A progressive influx of meteoric F into the skarn viroment resulted in simultaneous boiling and dilution process with precipitation of retrograde and retrograde hydrothermal mineralizations. (From authors' abstract by E.R.)

KOEHLER, G., KYSER, T.K., ENKIN, R. and **IRVING, E.**, 1997, Paleomagnetic and isotopic evidence for the diagenesis and alteration of evaporites in the Paleozoic Elk Point Basin, Saskatchewan, Canada: Canadian J. of Earth Sciences (J. Canadien des Sciences de la Terre), v. 34, no. 12, p. 1619-1629.

In the Paleozoic Elk Point Basin, Saskatchewan, Canada, hematite in evaporite rocks of the Middle Devonian Prairie Formation records two magnetizations that are very different from those expected when the evaporite were originally deposited. Stable isotopic compositions of FI in halite and the associated hematite in the Prairie Formation indicate that the hematite carrying the X magnetization formed at low T (about 60°C) by F similar to those currently resident in overlying formations. The hematite carrying the inferred late Paleozoic magnetization was also formed at low T by F having δD and $\delta^{18}O$ values significantly lower than Paleozoic seawater. Paleomagnetic, petrographic, and isotopic data, and K-Ar ages indicate that evaporites in the Elk Point Basin have been affected by major F events that occurred during the late Paleozoic and Cretaceous-Cenozoic. These F are most probably related to brines that have their origins within the basin, which were mobilized by major tectonic events. (From authors' abstract by E.R.)

KOGARKO, L.M., 1997, Ore-forming systems of high alkalinity (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 45-46 (In Russian; Engl. translation from: English Version of the Abstracts of the Oral Presentations of the Papers of the Russian Participants, p. 12-13). ISBN 5-88918-002-9. Author at Vernadskiy Inst. of Geochem. and Analytical Chem., RAS, Moscow, 19 Kosygin Street, Moscow, 117975, Russia.

An important feature of the geochemistry of alkaline agpaitic magmas is their capacity to hold and to accumulate volatile components including water until the latest stages of the differentiation. According to our calculations (Kogarko, 1996) high activities of alkaline oxides inhibited the separation of volatile components into L phase. In spite of the significant enrichment of agpaitic nepheline syenites in chlorine and fluorine, HF and HCl contents in equilibrium G phase are extremely low by comparison with silicic rocks. It is this feature of systems with high alkalinity which causes the absence of greisenisation and pneumatolitic mobilization of ore metals and volatile components in agpaitic nepheline syenites. Experimentally measured significant solubility of water in alkaline M (Kogarko, 1989) permits gradual transition of magmatic M into hydrothermal solution during the cooling of peralkaline rocks. Rare metal deposits are in the main related to magmatic process. The comparison of petrological and geochemical data and results of microthermometric studies of M I with experimentally investigated phase diagrams for systems with ore minerals imply that the formation of supergigantic and rare metal agpaitic complexes took place at the magmatic stage during fractional crystallization parallel to the effect of convective stirring (Kogargo, 1996). The principle of cotectic saturation of alkaline magmas as the necessary condition for the formation of ore deposit which [sic] is the basis of forecasting of alkaline magmatic formations for rare metal ores.

High alkalinity of agpaitic nepheline syenites caused the absence of cryolite mineralisation in spite of high contents of Na, Al, and F in these rocks by comparison with other rocks of earth's crust.

High contents of volatile components in alkaline agpaitic magmas and their accumulation in M due to high alkalinity of the environment created conditions for the appearance of immiscible L at the late stages of crystallization of agpaitic nepheline syenites. (From author's abstract by E.R.)

KOGARKO, L.N., 1997, Role of CO_2 on differentiation of ultramafic alkaline series: Liquid immiscibility in carbonate-bearing phonolitic dykes (Polar Siberia): Mineralogical Magazine, v. 61, p. 549-556. Author at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, 19 Kosygin Street, Moscow, 117975, Russia.

The Maimecha-Kotui province in the north of Siberian platform is the largest province of ultramafic alkaline rocks in the world. The province comprises thirty-seven central-type complexes together with numerous dykes. The majority of dykes are radially disposed around the ultramafic alkaline massifs. Data are presented for dykes of the Dolbykha carbonatite complex, which comprises olivine and melilite nephelinites; nosean, calcite and cancrinite phonolites; calcite trachytes and calcite carbonatites.

Some peralkaline phonolitic dykes contain carbonate-bearing globules with sizes of 1-2 mm to 17-20 mm. Analysis of these materials in the light of experimental data on the L immiscibility in carbonate-silicate systems suggests that separation of carbonatite from phonolitic M took place due to immiscibility in the L state.

The generation of the carbonatites was probably controlled by the depth (and P_{CO_2}) of the crustal magma chamber where differentiation took place and probably also by the alkalinity of M, and the rapidity of magma ascent to the surface. (From authors' abstract by E.R.)

KOGARKO, L.N., KURAT, G. and NTAFLOS, T., 1997, Intense carbonate metasomatism of oceanic mantle beneath the Fernando de Noronha Island: (abst): MAEGS, 10th Meeting Association of European Geological Societies, Sept. 1-5, 1997, Carlsbad, Abstracts: J. Czech Geol. Soc., v. 42, no. 3, p. 12. First author at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, Kosygin str., 19, 117975, Moscow, Russia.

Petrologic and geochemical study of lherzolitic and harzburgitic xenoliths from basanites of the Fernando de Noronha Island revealed that oceanic mantle of this region has been affected by very strong carbonate metasomatism. Olivine encloses abundant polyphase, glass-rich I consisting of trachytic glass, monosulphide of Fe, Ni, and Cu, Ca-rich carbonate and dense CO_2. All major silicate phases of the rocks are rich in CO_2 I. The relationships between glass, sulphide and carbonate I permit to speculate that silicate and sulphide in the Ca-rich carbonatite M were in equilibrium with each other and originated by partial melting of metasomatized and wehrlitized mantle of the Fernando de Noronha Island.

We have experimentally investigated, with a piston-cylinder apparatus, the immiscibility relationships in the system Ca-rich carbonate-Fe, Ni sulphide-F-bearing silicate M of phonolitic composition. Experiments were conducted at 1250°C and 4-15 kbar. The double-Pt capsule method has been employed in order to control the oxygen fugacity. Immiscibility has been observed in the investigated system as a complete separation of carbonate and silicate L, with sulphide M present in the form of small globules in both L.

The results permit a two-stage model of Ca-rich carbonatite formation: 1st stage – metasomatic wehrlitization and carbonatisation of mantle rocks; 2nd stage – partial melting of the wehrlitic substrate containing carbonates, resulting in two L and the generation of calciocarbonatites.

Comparison of these data with our observations on Montana Clara xenoliths (Kogarko et al., 1995) demonstrates that the carbonatization processes are widespread in the oceanic mantle and partial melting of wehrlitized mantle, containing carbonate, could result in generation of Ca-rich carbonatitic M. (From authors' abstract by E.R.)

KOGISO, Tetsu, TATSUMI, Yoshiyuki and NAKANO, Satoshi, 1997, Trace element transport during dehydration processes in the subducted oceanic crust: 1. Experiments and implications for the origin of ocean island basalts: Earth and Planet. Sci. Letters, v. 148, no. 1-2, p. 207-221. First author at Dept. of Earth and Planetary Sci., Tokyo Inst. of Tech., Ookayama 2-12-1, Meguro, Tokyo 152, Japan.

Dehydration experiments on natural amphibolite have been carried out under upper mantle P/T conditions, in order to examine transportation of trace elements during dehydration processes in the subducted oceanic lithosphere. Pb, Nd, and Rb are more readily transported by aq F during amphibolite dehydration than U-Th, Sm, and Sr, respectively. (From authors' abstract by E.R.)

KOH, S.M. and CHANG, H. W., 1997, Geological and geochemical characteristics of the Bukok hydrothermal clay deposits in the Haenam area, Korea: Resource Geol., v. 47, no. 1, p. 29-40. First author at Korea Inst. of Geol., Mining and Materials, Taejon 305-350, Korea.

The Bukok hydrothermal deposits consist of acid pyroclastics with "acid sulfate type" alteration, and the enrichment of Au, Ag, As and Sb. The $\delta^{34}S$ values for sulfide (pyrite) and sulfates (alunite and barite) indicate that the acid sulfate alteration is a P hypogene origin. The $\delta^{18}O_{H_2O}$ and δD_{H_2O} values estimated from the data of dickite and illite represent a mixture of magmatic and meteoric water. The Th and sal of FI for quartz ranges from 127 to 361°C and from 0.33 to 7.87 wt.% NaCl, respectively. (From authors' abstract by E.R.)

KOLONIN, G.R., PAL'YANOVA, G.A., SHIRONOSOVA, G.P. and **MORGUNOV, K.G.,** 1997, The effect of carbon dioxide on internal equilibria in the fluid during the formation of hydrothermal gold deposits: Geokhimiya, 1997, no. 1, p. 46-57 (in Russian, translated in Geochem. Internat'l., v. 35 no. 1, p. 40-50). Authors at Inst. of Mineral. and Petrog. (IMP), Siberian Div., RAS, Univ. pr. 3, Novosibirsk, 630090 Russia.

Multistep thermodynamic calculations were performed to determine the effect of the increase in the saturation concentration of CO_2 (as a nonpolar component) of an ore-forming F on the dissociation constants of the principal components of the F (H_2O, H_2CO_3, H_2S and NaCl), the products of hydrolysis of NaCl (HCl and NaOH) and the dominant gold-transporting and -depositing solute species ($AuCl_2^-$, $AuOH^0$, $AuHS^0$, and $Au(HS)_2^-$) at a P of 1 kbar and at an NaCl concentration of 1 mol/kg H_2O in the T range 100-400°C. T dependencies were calculated for the possible gold concentrations within this T range for F in equilibrium with the hematite-magnetite and pyrite-pyrrhotite-magnetite redox buffers. As expected, CO_2 has a negative effect on the gold solubility, primarily due to increasing pH of the F with increasing T, as well as some other factors. The influence of the initial NaCl concentration and the presence of additional (free) HCl on the theoretical solubility of gold was evaluated. (Authors' abstract)

KOMNINOU, A. and **YARDLEY, B.W.D.,** 1997, Fluid-rock interactions in the Rhine Graben: A thermodynamic model of the hydrothermal alteration observed in deep drilling: Geochim. Cosmo. Acta, v. 61, no. 3, p. 515-531.

KONNERUP-MADSEN, Jens, 1997a, H_2O-CO_2-CH_4-NaCl fluids associated with metamorphism and partial remobilization of massive sulfides (the Black Angel mine, Greenland): Formation and Metamorphism of Massive Sulphides—Frank M. Vokes 70 Year Anniversary Symposium March 16-19, 1997, Norwegian Univ. of Sci. and Tech. in Trondheim, Norway, Abstracts (unpaginated). Author at Geological Inst. Copenhagen Univ., Øster Voldgade 10, DK-1350, Denmark.

The stratabound massive Fe-Zn-Pb sulfide ores of the Black Angel mine show three types of FI, primarily in quartz from the various ore types: (1) aqueous I. These vary in sal from about 1-45 eq. wt.% NaCl and have total Th and densities between 175 and 300°C and up to 1.19 g/cm^3, respectively. (2) CO_2-CH_4 I. These vary in composition from pure CO_2 to more than 80 mol% CH_4. Molar volumes range between 40 and 50 cm^3/mole, irrespective of the CO_2/CH_4 ratio. (3) CO_2-CH_4-aq I. These have CO_2-CH_4 compositions similar to the pure CO_2-CH_4 I but slightly higher molar volumes of the CO_2-CH_4 F.

The FI data suggest the simultaneous existence and entrapment of a highly saline aq F (low in carbonic component) and a CO_2-CH_4 dominated F during metamorphism, deformation and partial remobilization of the ores. General conditions of 350-500°C and about 2-3 kbars are indicated. More CH_4-rich carbonic F prevailed during stages of shearing and porphyroclastic deformation of the sulfide ores and may have been influential in overthrusting of the ore bodies. The CO_2/CH_4 ratios of the F and their composition in general reflect decomposition of kerogeneous materials, carbonates and hydrous minerals during prograde metamorphism. Remobilization of more mobile components of the sulfides occurred in the presence simultaneously of CO_2-dominated and highly saline aq F. (From author's abstract by E.R.)

KONNERUP-MADSEN, J., 1997b, Fluid inclusions in minerals: Constraints on magmatic and metamorphic fluids in the Earth's crust (abst.): Mineral Equilibria and Databases, Abstracts of the Meeting of the Mineral Equilibria Working Group of the Internat'l. Mineralogical Association in Espoo, Finland, August 19-20, 1997, p. 42. Author at Geological Inst., Univ. of Copenhagen, Øster Volgade 10, DK-1350 Copenhagen, Denmark; email (jenskm@geo.geol.ku.dk)

A review, using examples from the Gardar continental rift province, South Greenland, and the Black Angel metamorphosed massive sulfide deposit, West Greenland. (E.R.)

KONNIKOV, E.G., NERUCHEV, S.S., PRASOLOV, E.M., KISLOV, E.V. and **ORSOEV, D.A.,** 1997, Fluid regime of PGE and Au bearing reef formation in the Dovyren Mafic Layered Complex, East Siberia, Russia: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 449-451. First author at Inst. of Experimental Mineral., Chernolovka, Russia.

The distribution of G phase within microinclusions and intergranular pore spaces of the Dovyren layered dunite-troctolite-gabbro intrusive rocks, characterized by a precious metal mineralization related to disseminated sulphides (Stillwater type), has been investigated [for] the first time. Previously such studies had only been undertaken on the trap or peridotite-pyroxenite-norite intrusions related to sulphide copper-nickel deposits. (Authors' abstract)

Gas analyses were made by crushing samples in high vacuum at room T, using a modified approach to mass-spectrometry. Reduced gases (CH_4 and H_2) prevail amongst those gases trapped by silicate minerals during the growth within the silicate magma, and it is also clearly evident that the abundances of reduced gases (H_2, N_2, CH_4, CO) increase upwards through the Dovyren massif. A similar trend is observed in enrichment with mantle-produced He, radiogeneous Ar and C_2H_6. (From authors' text by E.R.)

KONTAK, D.J. and **ANDERSON, A.J.,** 1997, The origin of crack-seal – textured quartz in auriferous quartz veins of the Meguma group, Nova Scotia: A combined hydraulic fracture-replacement model (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A80. First author at Nova Scotia Dept. of Natural Resources, P.O. Box 698, Halifax, Nova Scotia, Canada B3J 2T9.

Crack-seal (cs) or ribbon-textured quartz, common in mesothermal quartz veins hosted by slate-belt sequences, are characterized by numerous parallel bands/laminae of mainly silicate minerals. In the Meguma Group deposits, southern Nova Scotia, such veins have been the focus of gold mining for over a century, hence, numerous suggestions have been advanced for their origin (e.g., exhalative, organic mounts, cs I bands, water sills). A new model for cs quartz is presented based on detailed macro- and micro-scale analysis of the veins hosted by greenschist facies metaturbiditic rocks of the Meguma Group.

Critical to our interpretation is that cs quartz occurs in discordant veins as well as in the dominant bedding concordant veins and that the veins containing cs quartz are composite (i.e., contain two distinct quartz types). In addition, the [10] features are inconsistent with previous interpretations of vein-formation where cs-textured quartz occurs, including the following: optical continuity is preserved across the abrupt interface separating cs and homogeneous milky quartz; mineral I bands are 0.01-1 mm thick, thus 104-105 bands occur in some cs-textured quartz; FI in milky quartz proximal to cs quartz contain abundant solid phases vs. simple L-V types more distal; and overgrowths of milky quartz about polygonal-shaped cs domains terminate at triple junctions. The following model is proposed for the composite veins: an initial phase of bedding-parallel dilatancy producing polygonal columns of wallrock material with subsequent infilling of void space during opening and concomitant silicification of wallrock columns to generate cs-textured quartz. (From authors' abstract by E.R.)

KONTAK, D.J. and **CLARK, A.H.**, 1997a, The Minastira peraluminous granite, Puno, southeastern Peru; a quenched, hypabyssal intrusion recording magma comingling and mixing: Mineralogical Magazine, v. 61, no. 6, p. 743-764.

The Minastira granite has preserved textures indicative of a history involving mixing of at least two magmas, felsic and mafic. The felsic component is represented by variably fractured, altered and embayed crystals of quartz, feldspar, biotite with minor coarse-grained M- and F-I rich apatite, and possible cordierite, whereas the mafic component is represented by calcic plagioclase. The process of magma mixing occurred in an underlying magma chamber. (From authors' abstract by E.R.)

KONTAK, D.J. and **CLARK, A.H.**, 1997b, The roles of magmatic and meteoric fluids in the formation of the giant, high-grade, San Rafael Sn deposit, SE Peru (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A80. First author at Nova Scotia Dept. of Natural Resources, P.O. Box 698, Halifax, Nova Scotia, Canada B3J 2T9.

The San Rafael Sn(-Cu) deposit occurs within a 25 Ma peraluminous cordierite-biotite granodiorite-monzogranite, hypabyssal stock hosted by sub-greenschist facies metaturbidites. Petrographic relationships document extreme alkali metasomatism in large but irregular zones of the granite. The presence of abundant S FI in magmatic quartz retain evidence of the metasomatising F. FI types are: (1) L-V; (2) V-rich (>95% V); (3) L-V-halite; (4) L-V-H-sylvite; (5) L-V-multiple solids. Coexistence of all I types suggests F unmixing. Thermometric measurements reveal: (1) bimodality of sal with 35-63 and 0-25 wt.% eq. NaCl; (2) the presence of $CaCl_2$ in solution and NaCl/(NaCl + $CaCl_2$) = 0.4-1.0; (3) halite-sylvite dissolution define a bulk F composition with NaCl/(NaCl + KCl) = 0.47 to 0.63 and ratios (in wt.%) 35:35:30 for H_2O:Na_2O:KCl; (4) Th of 250-525°C and 207-295°C for high- and low-sal groups, respectively. EMPA analysis of decrepitate mounds and preliminary micro-PIXE analysis of unopened I indicate that the F are Na-dominant with significant K, Fe, Mn and Ca. The high-sal F, indicating entrapment P of 200-700 bars, predated tin deposition, whereas the lower-sal, lower-T F are similar to those from which the tin lodes formed. The data indicate that F evolution commenced with early generation of a hypersaline F from a moderately saline, plausibly magmatogene, F through effervescence, followed by incursion of meteoric water which mixed with and diluted the high-sal F. (From authors' abstract by E.R.)

KONTAK, D.J., HALTER, W., WILLIAMS-JONES, A.E., MARTIN, R.F., ANSDELL, K. and **DOSTAL, J.**, 1997, A geochemical, isotopic and fluid inclusion study of pegmatite formation in a fluorine-rich environment: The East Kemptville Sn deposit, Nova Scotia, Canada (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A80-A81. First author at Nova Scotia Dept. of Natural Resources, P.O. Box 698, Halifax, Nova Scotia, Canada B3J 2T9.

The east Kemptville topaz-muscovite leucogranite (EKL) represents the end product of extreme crystal-L fractionation of the 370 Ma Davis Lake pluton part of the South Mountain Batholith. Infiltration of orthomagmatic, F-rich F with ^{18}Owater = +7 to +8 formed Sn-Fe-Cu-Zn-rich quartz-topaz greisens at T = 480°C and Pfluid = 4 kbars. Within the deposit, ovoid pegmatite pods (1-2 m^2) occur within a few m of the paleo-roof of the magma chamber where the EKL is texturally heterogeneous and contains: (1) crenulate and comb quartz layering, (2) muscovite- and feldspar-rich amoeboid-shaped pods (1 m^2), (3) rare miarolitic cavities; these features suggest local F exsolution occurred with concomitant quenching of the M. Pegmatites are dominated by quartz (morphology) and K- and Na-rich alkali feldspar (AF), trace muscovite and rare topaz, cassiterite and molybdenite. The K-rich AF is triclinic (=0.89±0.04), but grid twinning is absent. Geochemical data, including REE, indicate the EKL marginal to pegmatites is identical to the main leucogranite in the deposit, whereas analysis of pegmatitic AF indicates: (1) bulk compositions of Or45Ab55 to Or75Ab25 and Ab95Or5, (2) to 1 wt.% P_2O_5 [sic] (EMPA), (3) the following abundances (ppm) for K-rich AF-Rb = 700-1165, Sr = 100-250, Ba = 110-225 and K/Rb = 90-120; (4) REE and patterns similar to those of EKL, except HREE are depleted and Eu/Eu* = 0.2-1.2. Pegmatitic muscovite is depleted in F compared to EKL muscovite (2.0 wt.% vs. 4-5 wt.%). Stable isotopic analysis (^{18}O) of quartz and AF indicate equilibrium fractionation (T = 425±40°C) and ^{18}Owater = +7.5 (450°C). A T of 300-325°C is indicated for qtz-cass and qtz-ms isotopic fractionation in a miarolitic cavity. Preliminary FI data in pegmatitic quartz indicate Th = 240-260°C and sal of 32-42 wt.% eq. NaCl (enrichment of Na, Fe, Mn, K, Ca, Sr, P from decrepitate analysis), which are similar to the greisen F and therefore may not be representative of pegmatitic F. Collectively, the data indicate pegmatite formation due to localized exsolution of volatile-rich M from the magma as a result of fluctuations in Pfluid. (Authors' abstract)

KONTAK, D.J. and **KERRICH, Robert**, 1997, An isotopic (C, O, Sr) study of vein gold deposits in the Meguma Terrane, Nova Scotia; implication for source reservoirs: Econ. Geol., v. 92, no. 2, p. 161-180.

Vein quartz, carbonate, and tourmaline from 19 Meguma gold deposits in the Meguma terrane of Nova Scotia have been analyzed for stable $\delta^{18}O$, $\delta^{13}C$ and radiogenic $^{87}Sr/^{86}Sr$ isotopes in order to assess the nature and origin of the vein-forming F. Vein quartz is of uniform isotopic composition. Vein carbonate $\delta^{18}O$ values reflect exchange with low-T F. Vein carbonate has $\delta^{13}C$ values, indicating a reduced, biogenic source for the carbon. Oxidation of the reduced carbon, as indicated by CO_2 in FI, may have occurred via hydrolysis of graphite or dissolution of carbonate minerals. Collectively, the data indicate that a P F of metamorphic origin has had its isotopic signature variably modified due to interaction with different reservoirs. The most affected isotopic systems are C and S (based on earlier work on $\delta^{34}S$ values) which are abundant as graphite carbonate and sulfides in the Meguma wall rock, respectively. The range in $^{87}Sr/^{86}Sr$ values of the F also reflects contamination, but this was quite variable. The uniform $\delta^{18}O_{water}$ value for the F indicates that this was the least affected isotopic system, except for the later exchange of carbonate at low T. (From authors' abstract by E.R.)

KORMUSHIN, V.A., 1997, The feeler for the thermal influence on fluid inclusions: p. 38. Author at Scientific Soc. of Ore-forming Fluid Research in Inclusions of Minerals of Uzbekistan.

It is well known that the thermal influence causes to move gas bubbles in FI (1). The nature of this motion is not studied yet. The feeler (2) had been contrived for the thermal pointed influence on micro-objects 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 FI 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 phisico-chemical features of ore forming F [sic]. (Author's abstract)

KOROTEEV, V.A., CHASHCHUKHIN, I.S., and VOLCHENKO, Yr.A., 1997, The advancement of A.G. Betehtin's views about the origin of the chromite deposits in the alpine-type ultramafites (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 272-273 (In Russian; Engl. translation from: English Version of the Abstracts of the Oral Presentations of the Papers of the Russian Participants, p. 55-56). ISBN 5-88918-002-9. First author at Inst. of Geol. and Geochem., Urals Branch RAS, Ekaterinburg, Pochtovy per., 7

Oxygen fugacity of the low chromium chromitites and enclosing dunites is more than [that] of the high chromium chromitites by a factor of 10,000. It is meant that the ore-forming F were saturated by CO_2. (From authors' abstract by E.R.)

KOSS, Stefan and GÖTZINGER, M.A., 1997, Fluid inclusion research on fluorite from Weissecks (Salzburg) and the problem of trace element data from inclusion-rich minerals: Austrian Fluid Info Workshop, extended abstracts, Mitt. Osterr. Miner. Ges., v. 142, p. 11-12 (in German).

KOSTINA, R.I., 1997, Fluid-magmatic model of Ural's cupriferreous pyrites ore deposits formation: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 161-162. Author at Geological Fac., Lomonosov Moscow State Univ., Russia, 119899 Moscow.

Proposes that a F melt-brine separates as an immiscible F from magmatic systems and is responsible for formation of ore deposits–not hydrothermal solutions (E.R.).

KOTEL'NIKOVA, Z.A. and KOTEL'NIKOV, A.R., 1997, Phase boundary in the system H_2O-CO_2-NaCl at 700°C and a pressure of 5 kbar: Evidence from synthetic fluid inclusion data: Dokl. Ross. Akad. Nauk, v. 357A, no. 9, p. 1352-1353 (in Russian, translated in Trans. (Dokl.) of the RAS/Earth Sci. Sections, v. 357, no. 4, p. 535-536. First author at Inst. of Lithosphere, RAS, Staromonetnyi per. 22, Moscow, 109108 Russia.

See figure on page 234.

KOVALENKER, V.A. and JELEN, Stanislav, 1997, Physical-chemical problems of the genesis of the hydrothermal mineralization in the central zone of the Banská Stiavnica stratovolcano (Slovak Republic) (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 41-42 (in English), ISBN 5-88918-002-9. First author at Inst. of Geol. of Ore Deposits, Petrog., Mineral. and Geochem., RAS, Staromonetny pereulok 35, 109017 Moscow, Russia.

The Banská Stiavnica-Hodrusa ore district has been well known in Central Europe since the Middle Ages particularly by its long mining history. It is a classical example of the hydrothermal precious/base metal vein mineralization within a caldera structure.

During last few years a great deal of information about thermodynamic parameters of the ore-forming processes (T, P, composition, sal and pH of mineral-forming F, oxygen and sulphur activity, depth and age of ore formation) have been obtained.

FI data on minerals from the earliest, quartz-carbonate infillings of the Svetozár vein system imply the presence of higher T, homogeneous F of probably deeper crustal origin incidental to precipitation of these gold-bearing "lensoid oreshoots". Th span the interval between 290-395°C. Sal of the aq solutions ranges 0.4 to 7.7 wt.% NaCl eq. and characteristic is also sporadic presence of CO_2. The composition of hydrothermal F from which Au was transported as chloride complexes during the mesothermal phase indicate: reduced less acidic conditions with log a_{O_2}-32 pH 4.5, T>350°C.

Based on microthermometry data, Prokofyev and Naumov (in Jelen 1988, Kovalenker et al. 1991) estimated that crystallization of quartz and sphalerite of the 2nd stage has taken place at T 240-380°C, while minerals of the 4th stage, of similar characteristics to those of the 2nd stage, have precipitated at T between 190-310°C. These minerals have crystallised from aq solutions enriched eq. Different eutectic T estimated in the upper portions of the veins indicate mixed sulphate-carbonate composition of the mineral-forming solutions.

The three trajectories have been discerned in Th vs. sal diagrams at decreasing T: increasing sal from 1 to 11 wt.% NaCl eq. (characteristic of upper portions of the veins), decreasing sal from 11.5 to as low as 0.5 wt.% NaCl eq. (typical of deeper parts of the veins) and random sal changes (observed in middle portions of the veins).

P data determined from I of boiling F vary within the range of 15-200 bars at T 198-336°C. Low amounts of CO_2 are also present.

It was pointed out that F of the 2nd stage have circulated in greater depths (0.75-1.60 km) than those responsible for precipitation of minerals in the 4th stage (0.40-1.10 km). This is explained by a substantial uplift, taking place in the period between both mineralization stages. Vertical geothermal gradient may have reached 8-15°C/100 m. Minerals of the 5th stage have crystallised at T between 50-225°C from the aq solutions of similar sal and composition.

The following data, pertaining to metal contents in F, have been obtained from quartz of the Terézia vein (values correspond to concentrations in mol/kg solution): Cu (0.16-820) x 10^{-4}, Pb (2.0-2.9) x 10^{-2}, Ag (0.11-7.1) x 10^{-2}, Fe (0.025-1.0), Zn (0.3). Quartz and sphalerite from Bieber vein have yielded the following concentrations: Cu (0.15-40) x 10^{-2} and Fe (0.08) (Kovalenker et al. 1992). Anion composition in the I F has corroborated the assumptions about the important role of F^- and SO_4^{2-}, apart from the normally occurring Cl- anions.

It has been recognized that the granodiorite M contained high proportions of dissolved water (5.6 to 6.3 wt.%) and chlorine (0.37-0.39 wt.%), which permits the M to be suspected as one of the possible sources of ore forming F. Prokofyev et al. (1992) supposed that excess water and chlorine have been expelled from the M, extracting and concentrating ore components on cooling in the stage of magmatic distillation. With decreasing T, salt concentration in the F has initially increased. The opposite trend has been established during fracture extension accompanied by influx of diluted meteoric waters and by creating a convective F system. During this stage, the thermodynamic parameters, enabling ore precipitation, have been attained.

The obtained isotope data indicate that most of the $\delta^{34}S$ values in sulphides can be attributed to the F expelled from the uncontaminated granitic magmas with $\delta^{34}S$ values between -3 and +3‰. Such magma-derived F have initially been characteristic of high oxidation potential. In the other hand, a portion of the $\delta^{34}S$ in sulphides and sulphates indicate a sulphur contamination caused by leaching evaporites of the pre-volcanic basement rocks.

Isotopic composition of I F indicates that crystallization of the latest carbonates and barite from the Banská Stiavnica deposit, as well as quartz and carbonates from the Hodrusa deposit occurred in aq solutions of predominantly meteoric origin, substantially depleted in deuterium (δD = -94 to -113‰ SMOW). Contrary to this, quartz and sphalerite from the earlier stages developed a the Banská Stiavnica deposit precipitated from the F with δD values ranging -52 to -67‰ SMOW, which suggests an important role of magma-derived waters of deep circulation. This is corroborated also by the δD values (-75‰) of chlorite and kaolinite precipitating during the 3rd and 4th mineralization stage.

Calculated oxygen isotope composition of water in equilibrium with carbonate and barite vary between -3 and -11‰, yielding thus the further evidence for presence of meteoric waters in mineral-forming solutions. On the other hand, equilibrium isotopic composition of CO_2 coexisting with carbonates 2nd stage ($\delta^{13}C$ = -8.4 to -11.8‰ PDB) and 4th and 5th stages ($\delta^{13}C$ = 0.2 to -13.3‰) do not rule out its partially magmatic origin. Oxygen isotope composition of quartz, scheelite, barite and carbonates, hydrogen isotope composition of OH-bearing minerals (kaolinite, chlorite) as well as those of the F trapped in quartz, sphalerite, barite unequivocally indicate progressively increasing proportion of the meteoric waters from earlier to later stages of mineral formation. (Authors' abstract)

KOVALENKER, Vladimir and **NAUMOV, Vladimir,** 1997, Epithermal fluids: Chemical and isotopic composition: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 163-165. First author at Inst. of Geol. of Ore Deposits, Petrog., Mineral. and Geochem., Staromonetnyi per. 35, Moscow 109017, Russia.

The problems of meteoric and juvenile component contribution in ore-forming solutions as well as the origin of water, metals and ligands are still considered as an object of discussion. We discuss a model of epithermal F-magmatic systems based on a study of a great number of epithermal deposits of different age, scale and type. The data on $\delta^{18}O$ and δD indicate broad variations of magmatic and meteoric component. The relatively deep seated gold-sulfide-quartz deposits (Megradzor type) are characterised by dominant Na and Cl and subordinate HCO_3 (Na/K~9). The gaseous phase dominant has CO_2 and CH_4 with ratios CO_2/CH_4 ranging from 1 to 38. Physico-chemical parameters of the solution were found to vary in different stages of their evolution as well as within any certain stage: T=380-120°C, pH=3.8-6.4, $\lg fS_2$= -9/-16.2, $\lg fO_2$=-32.8/-48.8, $\lg fTe_2$=<-15/-13.6.

The Au-Ag-Pb-Zn deposits of adular-sericite type (Banska-Stiavnica) have a significant vertical scale (up to 1-1.5 km) and form in the hydrostatic conditions. The ore-forming solutions characterised with wide range of anion composition, vary widely from dominantly chlorine to fluorine and sulfate with Na/K ratio (1-0.5). The gaseous composition is mostly comprised of N_2 with subordinate CO_2 (P_{CO_2}<4 bar) and sporadic low CH_4 content. Physico-chemical parameters of the solution are highly variable in different ore-forming stages: T=400-100°C, pH=3.6-6.6, $\lg fS_2$=-8.8/-16.6, $\lg fO_2$=-32/-46.

The combined properties of adular-sericite and acidic-sulfate epithermal mineralisation are peculiar to the gold-sulfosalt-telluride deposits (Kochbulak type). The composition and concentration are also greatly variable from Cl-Na-Ca to Cl-Na-K, with major SO_4 and F in same. Na/K ratio is in the range of 1-0.1. The gaseous phase is represented with dominant CO_2 and N_2 with subordinate CH_4. The T range was within the 100-400°C interval, pH from 2-3 up to 6-6.5, aS_2 values were within the equilibria Py/Po-Bo/Py, aO_2 were located at the parallel of Ni-NiO buffer. (From authors' abstract by E.R.)

KOVALENKER, V.A., RUSINOV, V.L., SAFONOV, Yu.G., CHERNYSHEV, I.V. and **NAUMOV, V.B.,** 1997, Epithermal ore-forming fluid-magmatic systems (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 39-40. (In Russian; Engl. translation from: English Version of the Abstracts of the Oral Presentations of the Papers of the Russian Participants, p. 8-9). ISBN 5-88918-002-9. First author at Inst. of Geol. of Ore Deposits, Petrog., Mineral. and Geochem. RAS, 109017, Staromonetnyi, 35, Moscow, Russia.

Epithermal ore-forming systems were derived by the evolution of some specific ore-bearing deep-rooted F-magmatic systems. The REE evolution trend confirms the single source of F and magmas. Some evidences were obtained from F and M I in quartz and feldspar phenocrysts from granite-porphyry and rhyolites confirming that most of ore metals (especially Au, Cu, Te, Se, V, Cr, REE, Sr, Ba) were succeeded [sic] by ore solutions to salt M derived by liquidation of magma due to F-magmatic interaction. The F and M I data gave as well some evidences of coexistence of salt M, silicate M and F in magma. However, some metals in part are mobilized from host rocks. At least two sources of water for ore solutions occur: magmatic and meteoric mixing in various proportions. Due to these variations salt concentration of ore solutions also vary. (From authors' abstract by E.R.)

KOVALENKER, V.A., SAFONOV, Yu.G., NAUMOV, V.B. and RUSINOV, V.L., 1997, The epithermal gold-telluride Kochbulak deposit (Uzbekistan): Geologiya Rudnykh Mestorozhdenii, v. 39, no. 2, p. 127-152 (trans. in Geol. of Ore Deposits, v. 39, no. 2, p. 107-128). First author at Inst. of Geol. of Ore Deposits, Petrog., Mineral. and Geochem., RAS, Staromonetnyi per. 35, Moscow, 109017 Russia.

The Paleozoic epithermal gold-telluride Kochbulak deposit contains a great diversity of ore-forming sulfides, sulphosalts, tellurides, and selenides, several of which were first found there. The deposit has features of epithermal mineralization of both the adularia-sericite and acid-sulfate genetic types and mesothermal gold mineralization. Our study of mineral assemblages, FI, sulfur, oxygen, and hydrogen isotopes, and thermodynamic calculations show that the Kochbulak deposit was formed during a cyclic multistage process with periodic alternation of sealing along with tectonic and explosive opening of the F channel ways. The ore-forming process is subdivided into the preore, I to III ore, and postore stages related to fracture opening. Three types of solutions took part in the formation of gold-sulfide-sulphosalt-telluride mineralization. They were distinct in T, composition, sal, and proportion of meteoric and magmatic water and other volatile components. The T generally decreased from 465 to <100°C, and slightly increased at the beginning of each stage of the ore-forming process. P, sal, ion and gas composition of solutions, and the oxygen isotope composition of water varied as well. The deposition of gold-productive mineral assemblages was caused by changes in pH, Eh, activities of S_2, O_2, and Te_2. (From authors' abstract by E.R.) *See figure on page 239.*

KOVALENKO, V.I., and NAUMOV, V.B., 1997, Magmatic volatiles and their part in ore-forming fluids generation (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 43-44 (In Russian; Engl. translation from: English Version of the Abstracts of the Oral Presentations of the Papers of the Russian Participants, p. 10-11). ISBN 5-88918-002-9. First author at Inst. of Geol. of Ore Deposits, Petrog., Mineral., and Geochem., RAS., Staromonetnyi per. 35, Moscow, 109017 Russia.

To estimate mean abundances of the volatiles most common in the crust and the upper mantle, numerous original and published data on H_2O, CO_2, Cl, F, and S concentrations in M I and quenched volcanic glasses from the ocean floor were generalized. The data were obtained by various methods, the main of which were the high-T mass-spectrometry (H_2O, CO_2), IR spectroscopy (H_2O, CO_2), electron microprobe (Cl, F, S), and ion microprobe (H_2O, F). Representativeness of the data generalized in this work is as follows: H_2O, 1365 analyses (77 works); Cl, 1357 analyses (122 works); F, 770 analyses (69 works); S, 665 analyses (67 works); and CO_2, 338 analyses (26 works). The results are given in the table below.

Analysis of the data given in the table suggests that basaltic magmas are probably the main source of such volatiles as CO_2 and S, whereas H_2O, Cl, and F are characteristic of acid magmas.

The numerous (>650) data on F T and P in magmatic systems, presently available from the studies of M I in minerals, indicate regular development of much higher than normal supracrustal gradients (30°C/km and 270 bar/km) even at the igneous stage of ore field evolution. Water and water-carbon dioxide F mostly occur in magma under high P and therefore show high densities and high dissolution capabilities with respect to many elements. Undoubtedly the ensuing extra P gradients may mobilize hydrothermal solutions giving rise to hydrothermal ore deposits. (From authors' abstract by E.R.) *See table on page 233.*

KOVALENKO, Vyacheslav, TSARYEVA, Galina, HERVIG, Richard, NEWMAN, Sally and CUNEY, Michel, 1997, Magma compositions of pegmatites, ongonites, rare metal granites, determined by magmatic inclusion studies: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 165-166. First author at Inst. of Geol. of Ore Deposits RAS, 35 Staromonetny, Moscow 109017, Russia; email (vik@igem.msk.su).

We have studied composition, content of trace and volatile elements, PT conditions of magmas, entrapped as MI in quartz and topaz of various rare metal acid peraluminous rocks: Spor-Mountain topaz rhyolites (USA), Ongon-Khaerhan ongonites (Mongolia), Yugodzir W-bearing Li-F granites (Mongolia), Zapadniy (Transbaikalie) and Beauvoir (France) Ta-bearing Li-F granites, and Volyn chambered pegmatites (Ukraine). We have used optical and thermobarometric methods, X-ray and ion microprobes.

All studied rocks are rich in Li (to 4,360 ppm in ongonite and granite magmas), Rb (to 2,000), Cs (to 555), B (to 740), Sn (to 100), Be (to 300 ppm in pegmatite magma), but poor in Sr, Ba, Zr (1-76 ppm). They have low Nb/Ta and Zr/Hf ratios, but a high U/Th ratio. REE contents are low, REE patterns are flat with huge negative Eu anomalies in P-poor magmas or weak Eu anomalies in P-rich magmas (Beauvoir granite).

Solidus T of the all-rock magmas is 510-530°C, liquidus T vary from 650-700°C (pegmatite) up to 700°C (topaz rhyolite, ongonite, Li-F granite), sometimes up to 750°C (Yugodzir granite). The aq phase in MI and the P aq I in minerals from all rocks have sal from 3.5 up to 10 wt.% NaCl eq. and the density 0.6-1 g/cm^3. The calculated F P is 1.6-5.7 (topaz rhyolite), 2.4-2.7 (ongonite, L-F [Li-F?] granite), 2.8-3 kb (pegmatite) at corresponding liquidus T.

We have found many minerals which are the dm in MI or the crystalline I, coexisting with MI. Thus, we have fixed crystallization of rock-forming and ore minerals from rare metal Li-F rock magmas. (From authors' abstract by E.R.)

KOVALEVICH, Volodymyr, 1997, Fluid inclusions in Badenian halite from Bochnia: Przeglad Geologiczny, v. 45, no. 8, p. 822-825 (in Polish).

KOVALEVICH, V.M., JARMOLOWICZ-SZULC, Katarzyna, PERYT, T.M. and POBEREGSKI, A.V., 1997a, Red Sea chevron halite: Fluid inclusion temperatures and composition: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 167-168. First author at Inst. of Geol. and Geochem. of Combustible Materials, Nat'l. Acad of Sci. of Ukraine, Naukova 3A, 290053, Lviv, Ukraine.

FI were studied in chevron halite from near the Atlantis II Deep in the Red Sea (sites 225 and 227). The present FI study of the Messinian chevron halite from sites 225 and 227 has the aim to provide an information on chemical composition and T of brines from which halite precipitated.

Halite core samples were taken from intercalations of transparent and light grey medium to coarse grained salts. Individual grains show zones with FI in chevron halite and display hopper structures.

For a detailed study analytical samples were taken along the halite cleavage. It is possible to observe morphology and structure of sedimentary forms of halite in such oriented plates. Twelve samples from both the sites were chosen for FI studies. They were heated aiming at the homogenization of the I. Heating runs were performed at Fluid Inc. heating-freezing stage (USA) with an accuracy of 0.1°C. FI from each salt plate were stepwise heated until homogenization at low T ranges. In each experiment usually ten I were taken into account, at least in the samples where two or more phases were observed.

The size of FI in the individual chevron crystals reaches tens of micrometers, being at maximum 200 µm.

Homogenization was generally done on I<<40 µm, while chemical analyses were made on the bigger ones (using the Petrichenko (1973) glass capillary method). This part of research was to provide the chemical composition of the brines. The contents of K, Mg and SO_4 were determined. The content of Na and Cl ions was calculated considering the data on concentration of modern marine waters.

Salts from two sites under discussion displayed slightly variable Th of their FI, generally in the range of 37-44°C and 58-86°C for site 225 and 227, respectively.

In site 225 the first two samples were mostly one phase and clearly point to the formation conditions below 50°C. The results of a few two-phase I there support this suggestion and were 39.2°C and 41.8-44.9°C, respectively. Next three samples showed a slight increase in mean Th (from 38.5 to 42-43°C). Generally-large I had higher Th than those smaller ones. At site 227 the Th behaved similarly but at higher T (>60°C). The Th obtained for same cores remain in reasonable concordance with downhole T.

Chemical composition of I brines indicates a relatively good connection with evaporation of sea water. It is concluded that two-phase FI in zoned crystals of the Red Sea halite may be a good tool for determination of T at the corresponding depths and for reconstruction of chemical composition of the brines in the evaporite basin. (From authors' abstract by E.R.)

KOVALEVICH, V.M., JARMOLOWICZ-SZULC, Katarzyna, PERYT, T.M. and **POBEREGSKI, A.V.,** 1997b, Messinian chevron halite from the Red Sea (DSDP sites 225 and 227): Fluid inclusion study: N. Jb. Miner. Mh., 1997, no. 10, p. 433-450.

In the Messinian halite from DSDP sites 225 and 227 FI are present in zonal relics of chevron and/or hopper halite crystals. Microthermometric examination indicates the existence of differences in Th of FI in halite coming from both studied wells. The appearance of gas phase in studied I due to their partial stretching because of overheating is indicated by a correlation of Th with sampling depth and the present T at a given depth. The study of chemical composition of brine I indicates that basin brines were similar to modern marine water concentrated to the beginning of halite precipitation. We suppose that the two-phase I in zoned crystals of Red Sea halite may be used not only for approximate determination of T at the corresponding depth but also for the reconstruction of chemical composition of brines in an evaporite basin. (Authors' abstract)

KOVALEVICH, V.M. and **PETRICHENKO, O.I.,** 1997, Chemical composition of brines in Miocene evaporite basins of the Carpathian region: Slovak Geol. Mag. 3, no. 3, p. 173-180. Authors at Inst. of Geol. and Geochem. of Combustible Minerals, Nat'l. Acad. of Sci. of Ukraine, Naukova 3a, 290053 Lviv, Ukraine.

The chemical composition of brines in P I of P halite from Miocene evaporite formations in the Carpathian region including the Carpathian Foredeep, East Slovakian, Transcarpathian, and Transylvanian basins, have been studied in order to determine the similarities and differences in composition of basin brines. The chemical compositions of FI indicate that brines from all basins studied belong to the Na-K-Mg-Cl-SO_4 type and the proportion of the ions was close to modern seawater saturated with NaCl. The slightly decreased content of SO_4 is found in all basins, that is probably caused by the inflow of continental water. An especially low content of SO_4 was typical for evaporite formations in the smallest, East Slovakian basin. The geochemical data on Miocene evaporites of the Carpathian region confirm the idea that seawater was the main source of the salts and had the composition close to modern seawater. (Authors' abstract)

KOZLOV, A.V., and **MARIN, Yu.B.,** 1997, Genetic interpretation of isotopic composition of inert gases from fluid inclusions in minerals of pegmatites: Proceedings of the Russian Mineralogical Society, 1997, no. 5, p. 28-45 (in Russian; Engl. abst.).

On the base of data on isotope composition of inert G in the present day hydrothermal systems it is shown that their F-dynamic regime made an important influence upon the ratio of mantle, crustal (radiogenic) and atmospheric Ar and He in thermal springs. Obtained in this way results are used for the genetic interpretation of published data on isotope composition of Ar and He from FI in quartz and some other minerals from chambered pegmatites of Volyn', Kazakhstan, and greisens of Akchatau deposit. The chambered pegmatites of these two regions are characterized by close values of the ratio $^3He/^4He = (22\text{-}24)10^{-8}$ in the mineral-forming media I within quartz and topaz, which is an order [of magnitude] higher than values typical for crustal rocks and may be considered as a result of participation of the mantle originated F within the formation of the pegmatite-bearing granites and the mere pegmatites [sic]. Isotopic ratios $^{40}Ar/^{36}Ar$ in the same F testify to significant part of an atmospheric component (about 90%) in Kazakhstan pegmatites along with its low participation (about 10%) in pegmatites of Volyn'. This phenomenon could be connected with formation of the pegmatite-bearing granites in Kazakhstan within the more open system relatively to the system of the Korostensky granite pluton formation. Comparison of ontogenetic peculiarities of quartz crystals from pegmatites of two regions, as well as the study of FI in them have shown an increase of the openness degree along with dynamism of corresponding F systems in a row: chambered pegmatites of Volyn' - Kazakhstan chambered pegmatites - Akchatau greisens. (Authors' abstract)

KOZLOV, A.V., and MARIN, Yu.B., 1997, Genetic interpretation of isotopic composition of inert gases from fluid inclusions in minerals of pegmatites: Proceedings of the Russian Mineralogical Society, 1997, no. 5, p. 28-45 (in Russian; Engl. abst.).

On the base of data on isotope composition of inert G in the present day hydrothermal systems it is shown that their F-dynamic regime made an important influence upon the ratio of mantle, crustal (radiogenic) and atmospheric Ar and He in thermal springs. Obtained in this way results are used for the genetic interpretation of published data on isotope composition of Ar and He from FI in quartz and some other minerals from chambered pegmatites of Volyn', Kazakhstan, and greisens of Akchatau deposit. The chambered pegmatites of these two regions are characterized by close values of the ratio ^{3}He/^{4}He = (22-24)10^{-8} in the mineral-forming media I within quartz and topaz, which is an order [of magnitude] higher than values typical for crustal rocks and may be considered as a result of participation of the mantle originated F within the formation of the pegmatite-bearing granites and the mere pegmatites [sic]. Isotopic ratios ^{40}Ar/^{36}Ar in the same F testify to significant part of an atmospheric component (about 90%) in Kazakhstan pegmatites along with its low participation (about 10%) in pegmatites of Volyn'. This phenomenon could be connected with formation of the pegmatite-bearing granites in Kazakhstan within the more open system relatively to the system of the Korostensky granite pluton formation. Comparison of ontogenetic peculiarities of quartz crystals from pegmatites of two regions, as well as the study of FI in them have shown an increase of the openness degree along with dynamism of corresponding F systems in a row: chambered pegmatites of Volyn'-Kazakhstan chambered pegmatites-Akchatau greisens. (Authors' abstract)

KOZLOWSKI, Andrzej, LEACH, D. L. and VIETS, J.G., 1996, Genetic characteristics of fluid inclusions in sphalerite from the Silesian-Cracow ores, Poland: Carbonate-hosted zinc-lead deposits in the Silesian-Cracow area, Poland, Ewa Górecka, D.L. Leach and Andrzej Kozlowski, eds, p. 73-84. First author at Inst. of Geochem., Mineral. and Petrog., Fac. 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 S I, the I refilling phenomena, their formation on recrystallization of ores, and Th distribution in single fissure fillings were considered. The ore-forming F were liquid-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)

KOZLOWSKI, Andrzej and METZ, Paul, 1997, Melt and carbon dioxide inclusions in olivines from melilitites of Schwäbische Alb, Germany: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 169-170. First author at Inst. of Geochem., Mineral. and Petrog., Warsaw Univ., al. Zwirki i Wigury 93, PL 02-089 Warszawa.

The Schwäbische Alb include explosive Tertiary breccias with surficial forms of maars, tuffs, basaltoid volcanic conduits and veins. The melilitites bear titanoaugite, salite and olivine henocrysts, and olivine xenocrysts probably of mantle origin.

M and CO$_2$ I were studied in olivine phenocrysts (P and S I) and xenocrysts (S I) from the melilitite samples collected at many locations. The olivine grains in the investigated samples comprise several varieties, recognisable by means of microscope investigations.

Th for P MI ranged from 1250 to 1100°C and for S ones, from 1140 to 980°C. Most of the Th values of the P I refer to the early stage of the magmatic olivine crystallization. The high density FI consist generally of almost pure CO$_2$, as indicated by triple point T equal or close to -56.6°C. CO$_2$ densities, calculated from Th values indicated P of magmatic olivine crystallization from 11.7 to 6.4 kbar, that refers to the depth of 40 to 22 km. The higher value means that magmatic olivine started to crystallise below the mantle-crust border. S I indicated three intervals of olivine phenocryst disintegration in the depth of 20 to 4 km. Water was not found in FI in the studied samples, though its presence was evidenced by the occurrence of biotite in M I. (From authors' abstract by E.R.)

KOZLOWSKI, A., MIKULSKI, S.Z. and METZ, P., 1997, Fluid inclusions in detritic scheelite from lower Silesian alluvia: Austrian Fluid Info Workshop, extended abstracts, Mitt. Osterr. Miner. Ges., v. 142, p. 13-15. First author at Inst. of Geochem., Mineral. & Petrog., Faculty of Geol., Warsaw Univ., al. Zwirki i Wigury 93, PL 02-089 Warszawa, Poland.

The studied area is situated in the northern margin of the Bohemian massif in central Sudetes and represents the eastern part of the European Variscan belt. A recent exploration program carried out by Polish Geological Survey showed that scheelite prospects occur in several areas of Sudetes (Mikulski, 1997a). For location of P scheelite, in addition to the ultraviolet (UV) luminescence observations, the detailed heavy minerals sampling of gravel sediment and thermobarometric studies were also made.

FI were investigated in scheelite grains both from the in situ mineralization and in detritic samples. I were small, usually not exceeding 10 µm in length. In all samples only P I were considered for this study. They were frequently euhedral (negative crystals), that, when I were isometric, caused serious problems during the investigations, because they were almost completely opaque due to complete internal reflection of light. Thus, the study is based mostly on the I of tabular habit. The routine heating and freezing methods for I studies were applied. Both from massive and from grain samples doubled-polished preparations were prepared.

The scheelite grains contained aq solution I as well as apparently pure carbon dioxide and mixed carbon dioxide-aq I. This allowed to determine not only Th of the I (250-300°C), but also P (0.8-0.9 kbar and crystallization T 350-460°C. Total salt concentrations in I solutions ranged from 2 to 7 wt.%. The FI data from the detritic scheelite split in two groups: those similar to the in situ scheelite and other differing distinctly. This made possible to indicate the parent areas for some alluvial scheelite accumulations. (From authors' abstract by H.E.B.)

KOZLOWSKI, A., MYSTOWSKA-MAZUR, M. and **METZ, P.**, 1997, "Prenatal" and "posthumous" fluid inclusions of metasomatizing solutions: Austrian Fluid Info Workshop, extended abstracts, Mitt. Osterr. Miner. Ges., v. 142, p. 16-17. First author at Inst. of Geochem., Mineral. & Petrog., Faculty of Geol. Warsaw Univ., al. Zwirki Wigury 93, PL 02-089 Warszawa, Poland.

Metasomatic phenomena affect minerals, causing their partial or complete alteration or removal. On the other hand, some types of metasomatizing F remain certain minerals, e.g. quartz, partly or completely unaffected. FI offer a chance to investigate metasomatizing F from the very early stages of the process to its last signs. The recent study was performed in the Izera area.

Gneissic-schistose complex of the Izera area in Lower Silesia hosts metasomatic rocks of the origin, usually bound to the neighbouring Karkonosze granitoid of Variscan age (Karwowski, 1977; Kozlowski, 1978). The metasomatites comprise albitites and greisens. Moreover, small patches of so-called tourmaline- and fluorite quartzites associate with the above listed metasomatites. The "quartzites" formed from fine-grained gneiss ("leptinite") by dissolution of all components but quartz from the parent rock. Presently the quartz grains "float" in tourmaline or fluorite cement, which replaced the removed rock components. "Fluorite quartzite" was cut by at least two generations of fluorite veinlets c. 1-5 mm thick.

Metasomatizing solutions were investigated by means of FI methods (heating and freezing) in the minerals of the albitite, greisens and in the "fluorite quartzite" cement. Fluorite bears three kinds of P FI: 1) two-phase aq, 2) two-phase carbon dioxide, 3) three-phase aq solution+carbon dioxide+gas bubble. The fluorite "cement" contain type (1) I that homogenized in L phase at 306-211°C, the filling is a solution of 4.1-9.9 wt.% eq. NaCl, 0.0-3.5 wt.% KCl and 0.0-3.8 wt. % $CaCl_2$; type (2) I in the "cement" homogenized in gas phase at 30.8-31.0°C. Type (1) I in the earlier veinlets yielded Th 232-178°C and in the later ones 183-132°C, the solution compositions (in wt.%) 9.9-5.4 NaCl, 3.9-2.0 $CaCl_2$ and 5.7-3.9 NaCl, 0.0 $CaCl_2$, respectively; KCl was not found, Th of the type (2) I were in the veinlets 30.9-30.0°C in gas phase. The type (3) I were either of heterogeneous or homogeneous trapping and they yielded data consistent with the data obtained from the first two types. Quartz grains bear S I typical of fluorite, but also high-T I (Th 380-370°C, filling of essentially sodium chloride solution) that are characteristic for albitite minerals. Thus, "fluorite quartzite" passed the stage of albitization before metasomatic removal of feldspars by the parent solutions of fluorite. The latter I are the only "posthumous" signs of this process. Respectively, similar set of I was found in some "tourmaline quartzites." Gneiss quartz in the zones surrounding albitites bears I of Th 380-360°C, filled with sodic solution, thus typical of albitization, although any albitization was not observed in these zones. These are the remnants of the first infiltration stage of the metasomatizing solutions ("prenatal") that did not cause changes of the mineral compositions yet. (Authors' abstract)

KRAYNOV, S.P. and **RYZHENKO, B.N.**, 1997, Origin of chloride groundwaters and brines in crystalline massifs: Evidence from thermodynamic modeling of geochemical processes in water-granite systems: Geokhimiya, 1997, no. 10, p. 1035-1057 (in Russian, translated in Geochem. Internat'l., v. 35 no. 10, p. 913-933). First author at All-Russia Research Inst. of Hydrogeology and Engineering Geol., pos. Zelenyi, Noginsk raion, Moscow oblast, 142452 Russia.

Thermodyamic modeling of geochemical processes involved in interactions betwen waters of varying chemistry and granite was conducted. The results indicate that interactions between pure water and granite that has normal abundances of chlorine can produce mineralized (containing up to 50-100 g/l total dissolved solids [TDS]) Cl-Na(Ca) waters and brines owing to (1) an increase in solid : liquid ratios and the reworking of large amounts of crystalline rocks by groundwaters and (2) concentration of water in the process of S mineral formation. This explains the occurrence of chloride waters of the first continental type (with a sal of up to 100 g/l TDS) within most massifs of crystalline rocks. Geochemical interactions between pure water and granite are not enough to account for the formation of high-sal (over 200 g/l TDS) Cl-Ca brines. In order for them to form, there must be an inflow of initial brines (e.g., of Cl-Ca, Cl-Na, and Cl-Mg composition) from the sedimentation basins around that shield. (Authors' abstract)

KRIEGER, F.W. and **EADINGTON, P.J.**, 1997, Tracing oil-leg potential in gas discoveries: Application to gas fields in Papua New Guinea (abst.): AAPG v. 6, Annual Meeting Official Program 1997, p. A65. Authors at CSIRO Petroleum, Australia.

Mapping of palaeo formation water sal and oil charge history in Papua New Guinea has resulted in the development of a model that can be used to constrain the risk associated with drilling for gas displaced oil-legs.

FI evidence indiates that the Juha gas discovery originally contained a gross oil column of at least 160 feet. A GWC has not been established for the Juha field which contains gas at dew point suggesting the potential for an associated down-dip oil leg.

ROI™ measurements suggest oil charge in the Papuan Basin trapped irreducible water with sal of 50,000 to 80,000 ppm. Irreducible water is likely to be shielded by present day high oil saturation from flow of current formation water with sal of 6,000 to 15,000 ppm. ROI™ measurements at Juha indicate that irreducible water sal was also 50,000-80,000 ppm suggesting oil charge to the Juha structure occurred at a similar time to other Papuan Basin oil discoveries.

The presence of low sal F in FI from water zone samples in three PNG oil discoveries is consistent with trapping of current meteoric formation waters. However, the absence of low sal F, representative of current formation waters, in FI from oil zone samples suggests oil charge in this region preceded the introduction of present day meteoric waters.

In contrast the presence of low sal as well as high sal F in FI from the Juha palaeo-oil zone suggests that meteoric water gained access to the reservoir and that loss of oil occurred prior to gas charge. This information indicates that there is limited potential for an oil leg displaced by the current Juha gas charge and has implications for constraining the risk associated with this play type in the Papuan Basin. (Authors' abstract)

KROL, Michael, HODGES, Kip and BODNAR, Robert, 1997, A synthetic fluid inclusion approach to understanding excess argon in silicates (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-451. First author at Dept. of Earth, Atmospheric, and Planet. Sci., MIT, Cambridge, MA 02139; email (makrol@mit.edu).

The presence of excess argon (^{40}ArE) in minerals used for ^{40}Ar/^{39}Ar dating can obscure useful thermal history information. Recent studies suggest that ^{40}ArE can be correlated with Cl-derived ^{38}Ar from decrepitating FI. However, questions remain concerning the extent to which ^{40}ArE is concentrated in FI rather than distributed in crystallographic sites or vacancies. A combination of resistance furnace and laser extraction techniques has been used to investigate the characteristics of samples containing synthetic FI in order to better understand ^{38}Ar release from FI generated under controlled experimental conditions.

Cylindrical cores, ~2 cm in length and 4 mm in diameter, were cut from Brazillian quartz and Eifel sanidine. The cores were fractured using a thermal shock technique and loaded into platinum capsules along with 5-20 wt.% KCl aq solution. The sealed capsules were placed into cold-seal P vessels and held at 700°C and 3 kbar for one week. During this time, the fractures heal and trap aq solution as FI. At the end of the run, the cores containing the I were removed and irradiated for ^{40}Ar/^{39}Ar analysis.

Our first experiments involved furnace step-heating of two quartz samples. A sample with no synthetic I yielded a relatively flat ^{38}Ar vs. %^{39}Ar release spectrum with the exception of the first two increments. These increments, corresponding to ~10% of ^{39}Ar released, yield a higher ^{38}Ar value than all subsequent steps. Roughly coinciding with the ^{38}Ar is an elevation in the ^{40}Ar*/^{39}ArK ratio, suggesting that the quartz contains submicron natural FI with ^{40}ArE that are preferentially degassed at relatively low T. A second sample, containing synthetic FI with 5 wt.% KCl, yielded extremely high ^{38}Ar values over the first 35% of ^{39}Ar released. However, this pulse did not correlate well with the ^{40}Ar*/^{39}ArK. Instead, most of the ^{40}Ar* was evolved at high T along with a second, less intense pulse of ^{38}Ar release. This observation suggests that the excess ^{40}Ar in the natural quartz was remobilized during our experimental runs and became trapped in more retentive sites or I, which are degassed at higher extraction T. (Authors' abstract)

KRYLÓVA, T.L., 1997, The mineral associations of molybdenite and conditions of their deposition in the Bugdaya molybdenite deposit (Eastern Transbaikalia): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 146-147, ISBN 5-88918-002-9 (in Russian; English translation courtesy Dr. D. B. Brown). Author at IGEM, RAS, Moskvá, Russia.

The Bugdaya deposit is localized in a granite-porphyry stock. The orebody is formed by a network of molybdenite-quartz veins and veinlets. The following phases have been recognized in the mineral-forming process: quartzification, pyrite-quartz, molybdenite-quartz, beresitization, quartz-polymetallic, and carbonate (V.A. Strel'tsóv, (unpublished data). The mineral composition of the molybdenite-quartz phase and the FI in the quartz have been studied petrographically using microprobe-analytical methods, thermo- and cryometry, and Ramanóvsky spectroscopy.

The principal vein mineral is quartz, but detailed microscopic investigations have, for the first time, enabled us to define four generations of molybdenite, occurring in association with micro-quantities of other minerals.

1. The molybdenite-anhydrite-Ca-feldspar association has been observed in virtually [all?]gangue quartz and in a number of quartz-molybdenite veins. It consists of separate hexagonal platelets of molybdenite in growths with monocrystals of anhydrite, Ca-feldspar, fluorite, and calcite, measuring 50-100 μm. The monocrystals contain extremely peculiar G vacuoles, occupying 15-50% of their volume at times, containing microcrystals of salt and a small quantity of solution.

2. The molybdenite-tridymite association consists of rare hexagonal platelets of MoS_2 or their intergrowths of veinlet-like form, which are completely or partially localized in hexagonal platelets of quartzose composition, typical of tridymite. The FI in them, often in the form of negative platelets of hexagonal crystals, have a gaseous composition.

The quartz, belonging to the 1st and 2nd associations, contains preferenterially G or essentially G I, sometimes with salt crystallites. Syngenetic I with the composition L + G + S.Ph. [sic] have been observed in places. The Th of the latter form two intervals: 450-410°C and 390-350°C. Homogenization of adjacent I has been terminated by solution of the salt or the G bubble at one and the same T, indicating capture of the saturated F on the curve of three-phase equilibrium L + G + S.Ph. [1]. Concentration of the solutions occurred at 50-48 and 47-42 wt.% in eq. NaCl [2]; CO_2 is absent. The measured Th intervals correspond to P of 250-200 and 180-110 bars [3]. Preferentially gaseous two-phase I have been homogenized into the G phase at 450-400°C. The measured Th are the minimally possible T of mineral formation.

3. The molybdenite-quartz association forms zoned veins. Quartz is marked by gaseous and essentially gaseous, three-phase I (L + G + S.Ph.) with Th = 420-300°C, and G-L I (filling coefficient up to 80%) with Th = 350-300°C. Only two-phase I have been observed in quartz from zones of non-commercial mineralization.

4. The molybdenite-Mn, Fe-carbonate association shows up in veins and intercalations of the 1st and 2nd associations in the form of minute lenses and microstreaks. I in the carbonate, forming a shell around the molybdenite, and measuring <1 (m were inaccessible for study. Individual measurements in the carbonate streaks without molybdenite have given Th values of 350-310°C.

Deposition of the 1st and 2nd associations took place almost simultaneously, and the 3rd later. Formations of the 4th association appeared spasmodically.

In virtually all of the specimens, I were present, indicating the capture of a gaseous F. CO_2 is absent from the gaseous I, and they do not freeze at the T of L nitrogen. Apparently, the main component in their composition is H_2O V. The presence of syngenetic (with G), three-phase (with a salt phase) I, is a sign of capture of a heterogeneous F.

The formation of the ore phase took place at T of not less than 450-300°C and at P of up to 250 bars. The predominance of G vacuoles (sometimes with solid phases) in minerals of the 1st and 2nd associations suggests that their deposition could have occurred at quite high T (up to 870°C) (at P = 1 bar), close to the values of the quartz-tridymite boundary [4].

It is evident that the Mo ores of the deposit were formed in the interval of 800-300°C at a P <250 bars in a near-surface open-fluid system in a pulsating regime. The mineral-forming medium consisted of a water-steam F, passing to a heterogeneous system, where drops of salt brine appeared in the gaseous stream. Typical hydrothermal solutions showed up only in the concluding stages of the ore-forming process These solutions deposited an insignificant portion of the molybdenite, but were manifested during recrystallization and redistribution of the ore material. Transfer of molybdenum in such a system could have been achieved in the V phase in the form of molybdic acid [5]. (Author's abstract)

KRYLOVA, T.L. and **TIMOFEEV, A.V.**, 1997, The conditions of molybdenite formation at the molybdenum deposit Bugdaya (eastern Transbaikalien, Russia): Mineralogical and fluid inclusion study: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 171-172. Authors at Inst. of Geol. of Ore Deposits, Petrog., Mineral., and Geochem., RAS, Staromonetnyi per., 35, 109017 Moscow, Russia; email (alex@igem.msk.su).

The stockwork-type molybdenite-quartz deposit Bugdaya is located within granitoids of Variscan age. Practically the only vein mineral is quartz, but detailed microscope investigation allowed for the first time to distinguish four molybdenite associations based on its close intergrowths with microamounts of other minerals:

1. Molybdenite-anhydrite K-feldspar association occurs in barren quartz and in quartz-molybdenite veins. The gaseous I vacuoles within single crystals or at their boundaries with host quartz are very typical; these occupy up to 50% of the crystal volume and sometimes contain salt microcrystals and a small amount of L phase.

2. Molybdenite-tridymite association shows gaseous FI in the tridymite. The quartz of the 1st and 2nd associations contains some syngenetic FI of L+G+S with Th=450-410°C and 390-350°C. The homogenization of adjacent FI ends with salt or gaseous bubble solution under the same T; this suggests trapping of saturated F on the curve for three-phase (L+G+S) equilibrium and sal of 50-48 and 47-42 eq. wt.% NaCl, with no CO_2. The essentially gaseous FI have Th V at 450-400°C.

3. Molybdenite-quartz association forms zoned veins. For this quartz gaseous, essentially gaseous, three-phase (L+G+S) with Th=420-300°C, gaseous-L with Th=350-300°C are typical.

4. Molybdenite-Fe, Mn-carbonate association occurs in aggregates of the 1st and 3rd associations as microlenses or microveinlets. The FI in this carbonate are too small, but measurements on FI in similar Fe, Mn-carbonate from veinlets without molybdenite gave values of Th=350-310°C.

The formation of ore-bearing stage occurred in range of 450-300°C and under P 7,200 bar. The predominance of gaseous FI (sometimes with dm) in minerals of the 1st and 2nd associations suggests the latter can be formed under rather high T – up to 870°C (under P=1 bar) in accordance with P-T values of quartz-tridymite boundary [4].

The data received do not coincide with those available in literature (e.g., Piznyur A.V. (1981), Dr. Sci. Thesis, L'vov State Univ. (Ukraine)) and therefore oblige us to consider new possible mechanisms of the formation conditions for this type deposits. (From authors' abstract by E.R.)

KUCHA, H., **PROCHASKA, W.** and **STUMPFL, E.F.**, 1997a, Au-oxysulphide inclusions in gold and their meaning for gold transport and deposition, Mitterberg, Austria: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 225-228. First author at Inst. of Geol. and Mineral Deposits, Krakow, Poland.

Gold with Au-Cu-oxysulphide I has a distinct pink hue in reflected light. This gold is rich in Cu and Sb, but has very low contents of Ag and Hg. The oxysulphides are close to Cu-Au thiosulphate in chemical composition, show a double SKβ peak, and the SKα peak shift is of the same value as that observed in the thiosulphate standard. The gold valency measured by microprobe in these oxysulphides is +1. Native gold and Au-Cu thiosulphates are very closely intergrown in microarea, and this suggests direct involvement of oxysulphides in gold transport and deposition. (Authors' abstract)

KUCHA, H., **STUMPFL, E.F.** and **PROCHASKA, W.**, 1997b, Tetrahedrite, a novel gold trap and its meaning for gold metallogeny in the Austrian Alps: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 229-232. First author at Inst. of Geol. and Mineral Deposits, Krakow, Poland.

Sb-fahlore is a major gold carrier in the Austrian Alps. Tetrahedrite separates from five localities show Au content varying between 5 and 52.5 ppm, while other sulphides have the Au content usually below 1 ppm. Native gold is present as I alongside small microfractures in Sb-fahlores. Tetrahedrite is enriched in As and Fe (Hg, Zn), but depleted in Sb directly around gold I and minute fractures. The entrapment of gold by Sb-fahlores is a combination of two factors: i) development of unique, tetrahedrite characteristic microfractures under stress regime, and ii) entrapment of gold from Au-S-As-bearing F as a result of exchange of As for Sb between F and the solid tetrahedrite, and related loss of gold dissolving capacity. In contrast As-fahlores from the Alps do not contain gold. Since Sb-fahlores are widespread in the Austrian Alps, it may indicate a significant gold potential in the area. (Authors' abstract)

KÜSTER, M. and **STÖCKHERT, B.**, 1997, Density changes of fluid inclusions in high-pressure low-temperature metamorphic rocks from Crete: A thermobarometric approach based on the creep strength of the host minerals: Lithos, v. 41, p. 151-167. Authors at Research Group High Pressure Metamorphism, Ruhr-Univ., 44780 Bochum, Germany.

The densities of FI in quartz from high-P, low-T metamorphic rocks are generally inconsistent with the P-T conditions derived from solid-phase equilibria. Therefore, some process of change must regularly have occurred during exhumation. However, evidence of decrepitation is frequently lacking. Consideration of the rates of change of P and T in metamorphic rocks shows that very low strain rates are sufficient for volume adaptation. Dislocation creep appears to be a feasible deformation mechanism, allowing for continuous ballooning driven by a small differential P during compression down to T of about 300°C in quartz. Decrepitation requires a higher differential P. In natural rocks, it is therefore restricted to relatively low T. This concept was tested on I in the Phyllite-Quartzite Unit of Crete. In these rocks, cooling to below ca. 300°C at confining P of 3 to 4 kbar is indicated, corresponding to depths of 10-13 km. It is anticipated that in metamorphic rocks the isochores of all FI in quartz that have been formed at higher T and remain unaffected by decrepitation should intersect close to the 300°C isotherm, thereby defining a point on the P-T paths rarely accessible by other methods. Extension of this concept to other minerals with known mechanical properties is straightforward, and can under favourable circumstances be used to fix several points on P-T paths. (Authors' abstract)

KUZMIN, Dmitry and **CHUPIN, Vladimir,** 1997, Temperatures of crystallization and magma composition of trachybasalt-comendite association (Mogzon area, west Transbaikalia): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 173-174. Authors at Inst. of Mineral. and Petrog., Univ. pr. 3, 630090 Novosibirsk, Russia; email (kuzmin@uiggm.nsc.ru).

Trachybasalt-comendite association of the Mogzon area (P-T) is localized within the Mongolo-Okhotskii volcano-plutonic belt. It is linked with development of large intracontinental rift structure.

P syngenetic M and FI in trachybasalt, essexite and acidic volcanics have been studied. Glasses of both heated and unheated I have been studied. Determination of F, Cl and other volatiles were under a special attention.

P silicate-melt and dms and FI were observed in olivine phenocryst from trachybasalt. Th MI=1320-1280°C. The dms are rhönite [aenigmatite group] and Ti-augite. Compositions of heated I glasses approach those of subalkaline basalt (44-48 wt.% of SiO_2). Some heated glassses are rich in F (up to 0.64 wt.%) and poor in Cl. Residual glasses of unheated I are close in composition to dacite (up to 64 wt.% of SiO_2) and do not contain fluorine. F bubbles in MI are composed of N_2 (40 mol%) and CO_2 (60 mol%), while some bubbles contain N_2 only. Syngenetic FI are CO_2-dominant. Their trapping pressure is 0.8-1 kb.

P silicate-melt I were found in pyroxene and plagioclase from essexite. Th are 1190-1110°C. In composition the heated I glasses are close to subalkaline basalt (up to 53 wt.% of SiO_2) and are rich in F (up to 0.92 wt.%).

Th of quartz-hosted MI fall into two groups: high-T (1110-920°C) and low-T (920-735°C). Heated I glasses from the first group have comendite-pantellerite composition, while those from the second group – comendite composition. All the glasses are characterized by the high F (0.4-0.9 wt.%) and low Cl (up to 0.15 wt.%) and are characterized by the absence of F. G bubbles of MI and FI contain minute F-bearing K-rich crystals. Nitrogen is the sole volatile component in bubbles of silicate-melt and in FI.

The compositional data on heated and unheated I show that M initial of alkaline acidic volcanics are not derived from basalt magma during its differentiation. Residue of this magma was close to dacite in composition. (From authors' abstract by E.R.)

KYLE, J.R. and **MISI, Aroldo,** 1997, Origin of Zn-Pb-Ag sulfide mineralization within Upper Proterozoic phosphate-rich carbonate strata, Irecê Basin, Bahia, Brazil: Internat'l. Geology Review, v. 39, p. 383-399. First author at Dept. of Geological Sci., Univ. of Texas at Austin, Austin, Texas 78712-1101.

Stratabound Zn-Pb-Ag sulfide- and phosphate-rich units occur within a dolomitic limestone. Major Zn-Pb-Ag concentrations appear to be an overprint on the earlier iron sulfide-rich zone. Limited FI data suggest precipitation in the range of 140-200°C from formation waters with sal ranging from 3 to 12 wt.%. Petrographic and F-I data suggest that sulfide mineralization may have occurred within a mixing zone of metal-bearing, high-T basinal brines with meteoric water. Metallic mineralization scavenged sulfur from pre-existing sulfides or from direct reduction of evaporitic sulfate minerals. (From authors' abstract by E.R.)

LAMB, W.M. and **MORRISON,** Jean, 1997, Retrograde fluids in the Archean Shawmere anorthosite, Kapuskasing structural zone, Ontario, Canada: Contrib. Mineral. Petrol., 1997, no. 129, p. 105-119. First author at Dept. of Geol. and Geophys., Texas A & M Univ., College Station, TX 77843-3115.

The anorthosite is crosscut by numerous linear alteration veins containing calcite + quartz±dolomite±zoisite±clinozoisite±margarite±paragonite±chlorite. Vein formation, while clearly retrograde, spanned a range of T, and F compositions evolved from H_2O-rich to CO_2-rich. The calcite in the retrograde veins has $\delta^{18}O$ values that range from 8.4 to 1.2‰ (average = +9.7±0.9‰) and $\delta^{13}C$ values that range from -3.9 to -1.6‰ (average = -3.1±0.6‰). These values indicate that the F from which calcite precipitated underwent extensive exchange with the anorthosite and other crustal lithologies. The F may have been initially derived either from devolatilization of metamorphic rocks or crystallization of igneous rocks in the adjacent Abitibi subprovince. Vein quartz contains CO_2-rich FI (final melting T = -57.0 to -58.7°C) that range in size from 5 to 17 µm. Measured Th range from -44.0 to 14.5°C, however, for most I (46 of Sl), Th = -44.0 to -21.1°C ($CO_2 \approx$ 1.13 to 1.05 g/cm^3). At 400 to 600°C, these densities correspond to P of 3.5 to 7 kbar, which is the best estimate of P of vein formation. The coincidence of entrapment P calculated from FI density mesurements with peak metamorphic P alone should not be considered strong evidence for peak metamorphic I entrapment. All FI results are consistent with an initially semi-isobaric retrograde P-T path. (From authors' abstract by E.R.)

LANG, J.R., THOMPSON, J.F.H., MORTENSEN, J.K., BAKER, T. and **SILLITOE, R.H.,** 1997, Intrusion-related Au mineralization associated with lithophile elements: an under-recognized metallogenic association (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-358. First author at Dept. of Geol., Univ. of Brit. Columbia, Vancouver, BC, Canada V6T 1Z4; email (jlang@eos.ubc.ca).

The principal characteristics of the association are found in the Tombstone Plutonic Suite (TPS), Yukon and Alaska, which formed in a narrow belt 700 km in length between 89 and 95 MA. Intrusions include dikes, plutons and small batholiths, range from simple to composite to zoned, are dominated by syenite, granite and granodiorite with minor gabbro and lamprophyre, and have mineralogical characteristics of both I and S type.

Mineralization is widely developed in the TPS, and includes the Fort Knox and Brewery Creek deposits. The defining metal assemblage is Au-W-Bi, with variable Sn-As-Sb-Mo and minor Pb-Zn-Ag. Interior to intrusions the dominant style is sheeted Au-quartz veins, and near intrusive contacts W skarns and Sn and Au-bearing breccias are common. Peripheral Pb-Zn-Ag veins and Au-bearing disseminated to replacement deposits are found locally. Only minor potassic and sericitic alteration accompanies mineralization. High sal and CO_2-rich F are common, phase immiscibility is indicated, Th are between 200 and 500°C, and P estimates indicate epizonal depths. (From authors' abstract by H.E.B.).

LARRIEU, T.L. and **AYERS, J.C.**, 1997, Measurements of the pressure-volume-temperature properties of fluids to 20 kbar and 1000°C: A new approach demonstrated on H_2O: Geochim. Cosmo. Acta, v. 61, no. 15, p. 3121-3134. Authors at Dept. of Geol., Vanderbilt Univ., Nashville, TN 37235.

A new method for measuring volumes of F in a piston cylinder apparatus has been tested and applied to measuring the molar volume of H_2O V_{H_2O} from 8.5 to 20 kbar and 800 to 1000°C. (From authors' abstract by E.R.)

LARSEN, R.B., POLVE, Mireille, JUVE, Gunnar and **POITRASSON, Franck**, 1997, Composition of volatiles and structural admixtures in quartz in granite pegmatites, Setesdalen, south Norway: Current Research and Development at Geological Survey of Norway, Bulletin 433, p. 38-39. First author at Geological survey of Norway, P.O. Box 3006-Lade, N-7002 Trondheim, Norway.

FI studies were conducted on PFI quartz from the intermediate zone of seven pegmatites. They contain aq saline solutions and a carbonic phase occupying 10-15 vol.% of the I. Initial melting of ice at or close to -21°C implies that NaCl is the dominant salt species in the aq phase, and clathrate melting T document a range in sal from 6.4 to 17.4 wt.% NaCl when comparing the different pegmatites.

Although displaying some scattering, the sal follows a gradually declining trend from 10-12 wt.% NaCl in the north to 6 wt.% in the south. (From the authors' text by H.E.B.)

LASARENKO, Helena, BLAZHKO, Vladimir, FOMIN, Yuriy, DEMIKHOV, Yuriy and **SHIBETSKY, Yuriy**, 1997, The deposition of gold from the redox-fluids in the beresite zone (Mid. Dnieper area): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 175. Authors at State Scientific Center of Environmental Radiogeochemistry, 34, Palladina Ave., Kiev-142, 252142, Ukraine; email (jk@egmont.carrier.kiev.ua).

Quartz-gold sulphide mineralization developed on the contact of the magnetite-chlorite jaspilites with carbonate and metabasites. The ores contain magnetite, pyrrhotite, chalcopyrite, sphalerite, pyrite-marcasite, pyrite, arsenopyrite, ferrotetrahedrite, native gold, quartz, carbonate, sulphides of Bi and Ag.

Oxygen isotopes in quartz and carbonate and Th of gaseous-L I give comparable results. Quartz-magnetite association has the highest T (380-320°C); gold-bearing quartz with pyrite and arsenopyrite is 280-200°C. Late stage sideroplesite [?] has about 260-280°C. The P for quartz-gold-sulphide mineralisation is (8.1-8.6) X 10 Pa.

A variety of I compositions are present, including H_2O CO_2+organic substances, sylvite, halite, etc. Both Cl+F are present in L phase. G phase is CO_2 (80-90) and others such as C_2H_6 and H_2S. In gold-bearing beresites H_2S, N_2 and CO are much higher. Amount of CO_2 and H_2S increases with depth and this is correlated with values.

F water of I is enriched in light oxygen and has a relatively stable ratio ($\delta^{18}O$=-2.7...+2.8‰), but wide variations in δD(-74...+47‰). These variations reach anomalous high values in ore zone. (From authors' abstract by E.R.)

LAVADO, Marcelo and **CARTER, J.L.**, 1997, Genesis of polymetallic mineral deposits along the Mitu-Pucara contact in the Yauli dome region of central Peru (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-209. First author at 1621 Salem Dr., Richardson, TX 75080.

The polymetallic mineralization occurs as: veins, pipe-like deposits, and as a series of elongate lens-shaped deposits known in the district as mantos. The manto ore bodies are not syngenetic massive sulfide as previously thought, but are replacement and open space filling ores that occurred during the same event that produced hydrothermal veins. The overlap of paragenetic sequence in the veins and mantos ores, the FI Th (230 to 300°C) and sal (3.12 to 9.2 wt.% eq. NaCl) similarities for mantos and veins, and the lead isotope evidence indicate that the polymetallic mineralization is hydrothermal in origin and is related to the emplacement of various Tertiary quartz-monzonite to quartz-diorite intrusive plugs. (From authors' abstract by E.R.)

LAVADO, Marcelo and **CARTER, J.L.**, 1997, Genesis of the mineral deposits along the Mitu-Pucara contact and in the lower section of the Pucara group in the Yauli Dome region of central Peru: Boletín de la Sociedad Geológica del Perú, v. 86, p. 57. Authors at Programs in Geosci., FO 21, The Univ. of Texas at Dallas Richardson, Texas 75083-0688.

The polymetallic mineralization occurs as: veins, pipe-like mantos, and as a series of elongated lens-shaped deposits known in the district as mantos. Filling T in FI in quartz crystals from the mantos in the Manuelita mine range from 194 to 321°C with the main population of Th between 270 to 300°C. The salt content of the ore solutions ranged from 3.2 to 7.6 eq. wt.% NaCl. The Carahuacra mantos indicate a T range from 214 to 277°C with the main population of Th between 230 to 270°C and sal of 4.1 to 9.2 eq. wt.% NaCl. The different studies and analyses indicate that the polymetallic mineralization along the Mitu-Pucara contact in the Yauli Dome region is hydrothermal in origin and is related to the emplacement of the Tertiary intrusive plugs. (From the authors' text by H.E.B.)

LAWRIE, K.C., MERNAGH, T.P. and **ELLIS, P.**, 1997, Host rock control on localisation of the Gidginbung epithermal high sulphidation Au deposit (abst.): Geological Society of Australia, Abstracts No. 44, p. 45. First author at Australian Geological Survey Organisation, GPO Box 378, Canberra, ACT 2601.

FI results in quartz fibre veins cutting the silica-pyrite alteration are in good agreement with a previous FI study by Allibone et al. (1995) with a peak in the Th around 120-130°C, and sal around 5% NaCl eq. Note that neither study has found any evidence for boiling. A close association was noted between enargite and barite in both fibre veins and vuggy quartz and the observation of mainly all L I in barite suggests T<50°C. Since V-containing I are quite rare (and are most likely leaked I), these I have not formed by necking down, and thus are indicative of trapping within the low-T, phreatic zone. These results suggest that the massive barite in these samples represents the final paragenetic stage of the vein system and that the barite was precipitated at low P from a low T, low sal aq F. It seems unlikely that a large P correction is warranted (Allibone et al., 1995), and the range of geological and F data point to hydrothermal alteration and mineralisation at shallow crustal levels, not at crustal depths in excess of 4.5 km as proposed previously.

High sulphidation and porphyry deposits are commonly linked in their formation (e.g. Lepanto/FSE and Nena/Frieda River deposits), and recognition of F migration pathways within the high sulphidation environment can assist in targeting porphyry magmatic F sources at depth. At Gidginbung, the hydrothermal F originated at depth, to the south of the current open pit. Although zonation in Au and Cu is commonly observed within high sulphidation systems, the Au-rich character of ore at Gidginbung is attributed more to the Au-rich, (relative to Cu), sulphide-undersaturated nature of Ordovician-Earliest Silurian magmatism in the LFB. (From authors' abstract by H.E.B.)

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 Silesian-Cracow Zn-Pb district, Poland: Carbonate-hosted zinc-lead deposits in the Silesian-Cracow area, Poland, Ewa Górecka, 1996, D.L. Leach and Andrzej Kozlowski, eds, p. 105-112. First author at U.S. Geological Survey, Box 25046, Mail Stop 973, Denver Federal Center, Denver, CO 80225.

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_4 and CO_2-H_2S bearing FI. 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., APODACA, L.E., REPETSKI, J.E., POWELL, J.W. and **ROWAN, E.L.,** 1997, Evidence for hot Mississippi Valley-type brines in the Reelfoot Rift complex, south-central United States, in Late Pennsylvanian-Early Permian: U.S. Geological Survey Professional Paper 1577, 36 pp.

Petrographic and FI studies of sparry dolomite cement from Upper Cambrian to Lower Ordovician rocks and conodont thermal-alteration indices provide evidence that hot Mississippi Valley-type brines were once present in the Reelfoot Rift complex. The CL microstratigraphy of sparry dolomite cement in the Reelfoot Rift resembles that of sparry dolomite cement associated with widespread mississippi valley-type deposition in the Ozark region. If correlative CL zones in the sparry dolomite from the Ozark and Reelfoot Rift regions indicate broadly contemporaneous dolomite deposition, then the results show that the Ozark MVT-type hydrothermal system extended into the Reelfoot region and onto the western flank of the Nashville Dome. Independent evidence supports migration of MVT-type brines into the Ozark region from the Reelfoot Rift complex in late Paleozoic time. (Authors' abstract)

LEE, M.R. and **PARSONS, Ian,** 1997, Dislocation formation and albitization in alkali feldspars from the Shap granite: Amer. Mineral., v. 82, p. 557-570. Authors at Dept. of Geol. and Geophys., Univ. of Edinburgh, West Mains Road, Edinburgh EH9 3JW, U.K.

Orthoclase-rich alkali feldspars in the Lower Devonian Shap granite, northwest England, contain two generations of albite-rich feldspar. The later generation of replacive albite-rich feldspar, which is restricted to grain margins and is compositionally pure ($Ab_{>99}$), was produced by magmatic-hydrothermal F at ~370°C. This generation of albite-rich feldspar does not crosscut exsolution microtextures and has selectively replaced volumes of highly elastically strained feldspar surrounding edge dislocations along semi-coherent albite films. Marked differences in controls of the localization of the two generations of replacive albite-rich feldspar by pre-existing exsolution microtextures indicate that significant numbers of edge dislocations developed along albite films after the first phase of F-feldspar interaction and associated albitization but before the second phase. This relation indicates that edge dislocations formed between 410 and 370°C. These observations have important implications for understanding the factors that control the interaction of alkali feldspars with F both in cooling igneous rocks and in clastic sedimentary rocks during diagenesis. (From authors' abstract by E.R.)

LEE, W.-J. and **WYLIE, P.J.,** 1997a, Liquid immiscibility between nephelinite and carbonatite from 1.0 to 2.5 GPa compared with mantle melt compositions: Contrib. Mineral. Petrol., 1997, no. 127, p. 1-16. Authors at Div. of Geological and Planetary Sci., California Inst. of Tech., Pasadena, CA 91125.

The compositions of the evolved nephelinites and phonolites approach the silicate side of the miscibility gap, confirming the probable generation of immiscible, alkalic carbonate-rich L at crustal P. (From authors' abstract by E.R.)

LEE, W.-J. and **WYLIE, P.J.,** 1997b, Liquid immiscibility in the join $NaAlSiO_4$-$NaAlSi_3O_8$-$CaCO_3$ at 1 GPa: Implications for crustal carbonatites: J. of Petrology, v. 38, no. 9, p. 1113-1135. Authors at Div. of Geological and Planetary Sci., California Inst. of Tech., Pasadena, CA 91125.

The phase diagrams indicate that high-T immiscible carbonate-rich L must be physically separated from parent silicate L before they can precipitate carbonate-rich mineral assemblages. Sövites are readily explained as cumulates, with residual alkali-rich M causing fenitization. We can see no way in phase diagrams for V loss to remove alkalis and change immiscible natrocarbonatite L to $CaCO_3$-rich L. (From authors' abstract by E.R.)

LEE, Y.I. and **KO, H.K.,** 1997, Illite crystallinity and FI analysis across a Paleozoic disconformity in central Korea: Clays and Clay Minerals, v. 45, no. 2, p. 147-157.

Illite crystallinity and FI techniques are used to understand the thermal histories of rocks on either side of the disconformity between the Lower and Upper Paleozoic strata in South Korea. Illite crystallinity studies show that the metamorphic grade of the upper strata of the Lower Paleozoic Joseon Supergroup, platform carbonates with subordinate siliciclastics, belongs to the epizone and that of the lowermost strata of the Upper Paleozoic Pyeongan Supergroup, paralic to nonmarine clastics, belongs to the anchizone. The maximum mode of Th for FI of the uppermost strata of the Joseon Supergroup is 260-270°C and that of the lowermost strata of the Pyeongan Supergroup is 240-250°C. These data reveal a difference in thermal histories of strata below and above the unconformity, suggesting that, in contrast to the previous supposition of a period of non-deposition, at least a 1-km thick section of sediment was removed by erosion during development of the unconformity. Burial and heat flux from a proposed hot spot are suggested as the dominant factors causing differences in a metamorphic grade for the Joseon Supergroup before the deposition of the Upper Paleozoic strata. (Authors' abstract)

LEE, Y.J., WILTSCHKO, D.V., GROSSMAN, E.L., MORSE, J.W. and LAMB, W.M., 1997, Sequential vein growth with fault displacement; an example from the Austin Chalk Formation, Texas: J. of Geophys. Research, B, Solid Earth and Planets, v. 102, no. 10, p. 22,611-22,628.

Indexed under FI (E.R.)

LEGRAND, Michel and MAYEWSKI, Paul, 1997, Glaciochemistry of polar ice cores: A review: Reviews of Geophysics, v. 35, no. 3, p. 219-243. First author at Laboratoire de Glaciologie et Géophysique de l'Environnement, CNRS, St. Martin d'Hères, France.

Human activities have already modified the chemical composition of the natural atmosphere even in very remote regions of the world. The study of chemical parameters stored in solid precipitation and accumulated on polar ice sheets over the last several hundred thousand years provides a unique tool for obtaining information on the composition of the preindustrial atmosphere and its natural variability over the past. This paper deals with the chemistry of polar ice focused on the soluble mineral (Na^+, NH_4^+, K^+, Ca^{++}, Mg^{++}, H^+, F^-, Cl^-, NO_3^-, SO_4^{--}, and H_2O_2) and organic (methanesulfonate ($CH_3SO_3^-$), formate ($HCOO^-$), acetate (CH_3COO^-), and formaldehyde (HCHO)) species and their interpretation in terms of past atmospheric composition (aerosols and water soluble gaseous species). We discuss ice core dating, the difficulties connected with trace measurements, and the significance of the ionic composition of snow. We examine temporal (from the last decades back to the last climatic cycle) and spatial (including examples from coastal as well as central areas of Greenland and Antarctica) variations in the ionic budget of the precipitation and evaluate ice core studies in terms of the chemical composition of our past atmosphere. We review (1) how Greenland and Antarctic ice cores that span the last few centuries have provided information on the impact of human activities and (2) how the chemistry of deep ice cores provides information on various past natural phenomena such as climatic variations (glacial-interglacial changes, El Niño), volcanic eruptions, and large boreal forest fires. (Authors' abstract)

LEHMANN, B., HEINHORST, J., WEISSER, D.J., FEDESEJEV, V. and NEUMANN, M., 1997, Exploration for epithermal gold mineralization in the southern Urals, Russia: The Bereznjakovskoje gold deposit: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 233-236. First author at Technische Univ. Clausthal, Clausthal-Zellerfeld, Germany.

The east Uralian Zone south of Chelyabinsk consists of a Silurian to Early Carboniferous volcanosedimentary sequence on Proterozoic basement, intruded by postorogenic Permian granitic rocks. Dacitic to andesitic volcanic-subvolcanic units of Late Devonian age host a number of low-sulfidation epithermal systems with the metal spectrum of Au-Ag-As-Sb-Cu-Zn-Pb and a characteristic Te component. Precious-metal mineralization is related to a fahlore-telluride stage overprinting earlier barren pyrite. Silicic and sericitic alteration overprints prophylitic assemblages in stockworks and shear zones. A spatial relationship to a copper porphyry system at depth is inferred. (Authors' abstract)

Reconnaissance FI petrography could not find P FI within hydrothermal ore-related quartz (recrystallization fabrics). However, S two-phase aq FI in magmatic quartz phenocrysts of the hydrothermally overprinted host rock show initial melting T of >-21°C, indicating dominance of NaCl. Final melting T are -6 to -2°C, i.e., represent sal of about 3-8 eq. wt.% NaCl. The two-phase I homogenize into the L phase in a T range of 130-220°C; most have Th between 145-185°C. The Th indicate a minimum P of 200 bar. Boiling was not observed. Post-ore hydrothermal quartz contains P aq two-phase FI which homogenize into the L phase at T of 80-105°C. Their sal is ≤ 1 eq. wt.% NaCl (Tm_{ice}>-0.5°C).

The relatively restricted range of ore-stage Th at variable sal suggests F mixing during ore formation, concomitant with cooling and dilution. (From authors' text by E.R.)

LEROY, J.L., BAILLY, Laurent, MILESI, J.-P., MARCOUX, Eric and NEHLIG, Pierre, 1997, Fluid behaviour in the epithermal Au-Cu-Zn-Sb deposits of the Baia Mare district (north Rumania): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 176-177. First author at Univ. Henri Poincaré-Nancy 1, UMR EP578, BP 239, 54506 Vandœuvre-lès-Nancy cedex, France; email (leroy@lpesh.u-nancy.fr).

The Baia Mare district mineralization is related to hydrothermal circulations from the rising of the Baia Mare batholith.

The studied deposits belong to the adularia-sericite (or low-sulfidation) epithermal type, and have five mineralization stages, 1: Fe-W, 2: Bi-Cu, 3: Pb-Zn-Cu-Mn, 4: Sb, 5: Au-Ag-As.

FI in quartz (stages 1 to 5) and in sphalerite (stages 1 and 3), were sampled in the Baia Sprie mine (stages 1 to 4) and in the Sasar mine (stage 5). Whatever their origin, P or S, they are all two-phase purely aq I. The sal and Th fluctuated rapidly during the 5 stages of evolution, from ~0>20% and 150° to 340°C. Boiling occurred repeatedly.

This study clearly indicates that the FI well record both a regional evolution of the T of the F in relation with the rising of the Baia Mare batholith, and local, sudden and momentary falls of this T due to isoenthalpic boiling in relation to the brittle movements and to periods of phreato-magmatic activity. In such deposits, close to the surface, single phase F, boiling F, dilution, V condensation (stage 4) continuously alternate. (From authors' abstract by E.R.)

LESLIE, A.B., HARWOOD, G.M. and **KENDALL, A.C.,** 1997, Geochemical variations within a laminated evaporite deposit: Evidence for brine composition during formation of the Permian Castile Formation, Texas and New Mexico, USA: Sedimentary Geol., v. 110, p. 223-235.

LESPINASSE, Marc and **CATHELINEAU, Michel,** 1997, Paleostress magnitude determination by using fault slip and fluid inclusion planes (FIP) data: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 178-179. First author at Univ. Henri Poincaré-Nancy 1, UMR EP578, BP239, 54506 Vandœuvre-lès-Nancy cedex, France; email (lespinas@lpesh.u-nancy.fr).

This paper shows that quantitative estimation of the lithostatic load and the F P during a tectonic event can be derived from paleofluid analysis in FIP. As the FIP are healed mode I cracks, oriented in a consistent manner relative to regional or local structures, stress and F features may be obtained for a given deformation event. This approach has been applied to a fault system which affects an Hercynian granite of the NW French Massif Central. (From authors' abstract by E.R.)

LESPINASSE, Marc, CATHELINEAU, Michel, BOIRON, M.-C, and **LEROY, Jacques,** 1997, What is the usefulness of fluid inclusion planes (FIP)?: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 180-181. First author at Univ. Henri Poincaré-Nancy 1, UMR EP578, BP239, 54506 Vandœuvre-lès-Nancy cedex, France; email (lespinas@lpesh.u-nancy.fr).

A review of recent studies of FIP and their applications (E.R.).

LEVASSEUR, Randy, 1997, Fluid inclusion studies of rare element pegmatites, South Platte District, Colorado: Master's thesis, Univ. of Windsor, Windsor, Ontario, Canada, 105 pp.

Over fifty granite-hosted pegmatites occur in the South Platte district, located in the northern portion of the 1.01 Ga Pikes Peak batholith in the Rocky Mountain Front Range of central Colorado. Many of these pegmatites are concentrically zoned and enriched in fluorite, REE, Y and Nb, relative to the host granite, and may be classified as NYF pegmatites. Rare-element mineralization principally occurs in a core- margin zone as vein and replacement assemblages comprising albite, fluorite, hematite, muscovite and a variety of rare-element minerals, including samarskite, allanite, monazite, bastnaesite and gadolinite. Laser-excited emission (fluorescence) spectra indicate early, massive, core-margin fluorite (probably magmatic) in many instances contains higher concentration of REE than later hydrothermal white, clear and purple fluorite which replace it. The latter fluorite is associated with rare element minerals which have sequestered the REE released from the massive fluorite during fluid-fluorite interaction. This indicates that at least some of the rare elements in the mineralized zones have been derived from earlier, magmatic concentrations. Some later hydrothermal, rare element mineral-free fluorite contains very high concentrations of REE, possibly requiring intrinsically high rare element contents in the hydrothermal F. FI studies of both magmatic and hydrothermal phases reveal that four compositionally distinct hydrothermal F types have permeated the pegmatites. These are: (1) low sal aq F (0-12 eq. wt.% NaCl + $CaCl_2$); (2) intermediate sal aq F (18-24 eq. wt.%); (3) high sal aq F (26-30 eq. wt.%); and (4) low sal, CO_2-bearing F. Data from P I within hydrothermal fluorite indicate that the rare-element mineralization was formed from low sal (<10 eq. wt.% NaCl $CaCl_2$), orthomagmatic F at T of at least 340-500°C. The other F types occur exclusively in S I, and post-dated the early, low-sal F. The intermediate sal F is present in all the pegmatites studied and likely represents a distinct, district-wide F infiltration event. The high sal and carbonic F are, for the most part, restricted to the same pegmatites and are possibly genetically related to one another through immiscibility. Modelling of the compositions of halite-bearing I in the H_2O-NaCl-$CaCl_2$ system indicates two compositionally-distinct high-sal F; one with around 3 wt.% $CaCl_2$ and another with around 11 wt.% $CaCl_2$. These two F are distributed differently within the pegmatites and their compositional differences possibly reflect separate F-rock interaction histories, the Ca-poor F having interacted with fluorite-rich assemblages. (Author's abstract)

LEVELT SENGERS, J.M.H., 1997, Anomalous behaviour of aqueous systems near the water critical point: *in* Proceedings of the Fifth Int'l. Symposium on Hydrothermal Reactions, Palmer, D.A. and Wesolowski, D.J., eds., 1997, Gatlinburg, TN USA, p. 181-183. Author at Chemical Sci. and Tech. Laboratory, Nat'l. Inst. of Standards and Tech., Gaithersburg, MD 20899.

LEWIS, A.J., PALMER, M.R., STURCHIO, N.C. and **KEMP, A.J.,** 1997, The rare earth element geochemistry of acid-sulphate and acid-sulphate-chloride geothermal systems from Yellowstone National Park, Wyoming, USA: Geochim. Cosmo. Acta, v. 61, no. 4, p. 695-706.

LI, Changcun, HAN, Xiuli and **LIU, Jinxuan,** 1997, Study of fluid inclusions in Cretaceous clastic rocks in the Kashi Depression: J. Mineral. and Petrol., v. 17, no. 1, p. 23-28.

LI, Cunyou and **SHI, Lida,** 1997, Application of α-β peak and other quartz decrepitation parameters to searching gold veins: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 14 (in English). Authors at Shenyang Inst. of Geol. and Mineral Resources, MGMR, Shenyang, 110032.

A decrepitation parameter model for searching gold veins is established from the quartz I decrepitation study in Zhangquanzhuang quartz vein type of gold deposit, namely, α-β peak developed with a high α-β decrepitation peak and appearance ratio at the top of gold veins; the higher the gold content, the lower the decrepitation T; the little decrepitation activity and the low main decrepitation peak height and the high appearance ratio of low multi-peak decrepitation curve are the marks for better gold mineralization. Ore-bearing character of quartz veins is evaluated by this decrepitation parameter model. The mineralization predictions are carried out for the mined veins in depth. Some right conclusions corresponding to the actual conditions and forecasting result of 840 kg gold are obtained. These show that prospecting with quartz decrepitation parameters is feasible and effective. (Authors' abstract)

LI, Guochang and **WANG, Ping,** 1997, Morphological characters of the natural inclusions and their distribution in the Shandong corundum and sapphire: Mineral Resources and Geol. (Kuangchan Yu Dizhi), v. 11, no. 2, p. 104-108 (in Chinese; English abst.). Authors at Shandong College of Building Materials, Zibo 255200.

A large number of crystal I and two-phase or three-phase I are contained in the Shandong corundum and sapphire, which are distributed along specific net planes and parting planes. Micro I in a single crystal number hundreds of millions, in which the shapes of the two-phase and three-phase I are very varied. (Authors' abstract)

LI, Rongxi, JIN, Kuili and **AI, Tianjie,** 1997, Introduction to the research methods of organic inclusions: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 13 (in English). Authors at Beijing Grad. School., China Univ. of Mining and Tech., Beijing, 100083.

The research methods of organic I are briefly introduced in this paper. They are in-situ microanalysis, such as fluorescence spectrometry, Micro-FT-IR, LRM, LMPY–GC/MS and TOF–SIMS. These methods and their application in the research on the organic F are compared. (Authors' abstract)

LI, Wenming, SONG, Zhijie and **ZHANG, Hanwen,** 1996, Geological characteristics and genesis of the Gakehe cupreous silver-arsenic deposits, Qinghai Province: Northwest Geoscience (Xibei Dizhi Kexue), v. 17, no. 2, p. 30-37 (in Chinese; English abst.). Authors at Xi'an Inst. of Geol. and Mineral Resources, CAGS, Xi'an, 710054.

The Gakehe Cu-Ag-As deposits are quartz vein-type deposits that originated from magmatic hydrothermal solution in the Late Indosinian magmatic intrusive activity. (From authors' abstract by H.E.B.)

FI microthermometric and chemical data are presented. (H.E.B.)

LI, Zhaolin, 1997, Study on the silicate melt inclusions in accessory minerals of various igneous rocks in China: Proc. 30th Int'l. Geol. Congr., v. 16, p. 265-276, H. Yunhui and C. Yawen, eds. Author at Dept. of Geol., Zhongshan Univ., Guangzhou, 510275, China.

It is well known that the forming T of magmatite can be determined by means of homogenizing MI in its rock forming minerals. The Th are mainly acquired from high T heating stage homogenization and quenching methods. But the Th thus determined, due to the wide range of T variation during the rock forming process, usually do not perfectly reflect the whole spectrum of the T range, especially in the case where there were no MI in rock forming minerals (e.g. quartz in some granites and diorites) and only G L I that could be found used. Actually the Th of G L I can only represent the low limits of rock forming T. In order to get initial crystallizing T of magmatic rocks, one should determine the Th of MI in accessory minerals that crystallized from magma in the early period of intrusion. From 1979 to 1981, we succeeded in developing the quenching oil immersion method, and homogenization method by means of which Th of MI in the accessory minerals in the magmatic rocks can be obtained and phase change of MI under thermal states may be studied and the effection is good. It provided new technology and had great significance in advancing for the study of rock-forming T of magmatic rocks. (From the author's text by H.E.B.).

See also FIR 29, p. 116 (E.R.).

LI, Zhaolin, GUO, Hongzhong and **LIE, Lihong,** 1997, Organic geochemistry of lead-zinc polymetallic deposits, northern Guangdong: Chinese J. of Geochem., v. 16, no. 4, p. 330-335 (in English). Authors at Dept. of Geol., Zhongshan Univ., Guangzhou, 510275.

The characters of organic matter in rocks and ores in the Fankou and Dabaoshan deposits are systematically studied with regard to their implications for mineralization. The results show that kerogens in this area fall mainly into the plutonism field in Van Krevelen's diagram. Reflectivity of the organic substance was measured to be 3.06% (Fankou) and 1.67% (Dabaoshan), corresponding to the paleo-geotemperatures of 232 and 184°C respectively. The same types of porphyrins and hydrocarbons were recognized in the rocks and ores and hydrocarbon-bearing I are widespread in quartz and calcite, particularly in Dabaoshan. It is thought that the organic matter must have played a critical role in diagenesis and metallization in these deposits and that the hydrothermal solution was most likely to be the type of water-oil hot brine. (Authors' abstract)

LI, Zhaolin, YANG, Rongyong, LI, Wen, ZHAI, Wei and **MAO, Yanhua,** 1997, The forming physico-chemical condition of different genetic pegmatites in China: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 1 (in English). First author at Dept. of Earth Sci., Zhongshan Univ., Guangzhou, 510275.

The study on the pegmatites from Mufushan in Hunan, Ailaoshan in Yunnan, Keketuchai in Xinjiang and Xikeng in Fujian shows that M and/or M-FI in the given minerals in the pegmatites range over 450-1140°C in Th, and G-L I over 180-400°C; but in different areas there are some differences in both the type of I and the range of Th. And the main components are Ca^{2+}, K^+, Na^+, Mg^{2+}, Fe^{3+}, HCO_3^-, SO_4^{2-}, Cl^-, F^- and C_2H_6 in the G-L I, and their content order changes obviously in different pegmatites. It suggests that these pegmatites belong to different genesis respectively. (Authors' abstract)

LIANG, Huaying, XIA, Ping, WANG, Xiuzhang, ZHANG, Hu, CHENG, Jingping, SHAN, Qiang and **ZHANG, Guoheng,** 1997, The isotopic geochemical characteristics and genesis of Changkeng gold deposit in Guangdong: Contributions to Geol. and Mineral Resources Research, v. 12, no. 2, p. 21-26. First author at Guangzhou Inst. of Geochem., Chinese Acad. of Sci., 510640 Wushan Guangzhou.

ChangKeng gold deposit occurs in the silicolites beneath a fault plane. The early mineralization has $\delta^{34}S$‰ value of -35.4 ~-0.3 reflecting sedimentary sulfur, and δD‰ value of -80 ~-59. The late mineralization is antimonite-quartz-gold vein with δD‰ and $\delta^{34}S$‰ of -30 ~-46 and 0.8 ~2.3 respectively. Pb isotope composition of ore body is the same as the underlying rock. (From authors' abstract by E.R.)

LIBOWITZKY, Eugen and **ROSSMAN, G.R.,** 1997, An IR absorption calibration for water in minerals: Amer. Mineral., v. 82, p. 1111-1115.

LIDWIN, Arne, 1997, Fluid induced dehydration during granulite-facies metamorphism: An example from the Bamble shear belt, south Norway: Inst. Geol. Univ. Oslo Rapport nr. 70, p. 23-24 [Thesis, 1994 and 1995], pub. 1997.

The Bamble Shear Belt is one of five segments of the Sveconorwegian province of the Baltic Shield. Studies of the amphibolite to granulite facies metamorphic transition within the Bamble Shear Belt have led to several important contributions to the geochemistry of lower crustal rock.

The island of Tromøy is situated northeast of Arendal on the Skagerrak coast. Tromøy represents the highest grade of metamorphism in a 15 km wide coastal granulite facies zone. The rocks on Tromøy is dominated by LILE and LREE-depleted charnockitic gneisses.

FI studies have been done on FI in quartz in the enderbitic rock. Analyses were made with a multichannel Dilor Microdil-28 laser Raman microprobe, and show two types of P FI, pure CO_2 and CO_2 with 12-14% N_2. No H_2O has been observed, but as much as 10-15% water might stay as, in the microscope, an invisible layer on the inside of the cavities. Microthermometry were made with a Chaixmeca heating/freezing stage, cooled by pre-cooled nitrogen gas, and with a Linkam THM600 stage, attached to a Linkam TMS90 control unit. The melting Tm took place between -56.6 and -60.0°C, with a histogram maximum between -56.0 and -56.9°C. The I homogenized to the L phase, and the Th^L range from -11.8 to +31.4°C with a histogram maximum between 8.0 and 9.9°C. This corresponds to a molar volume histogram maximum of 48 to 51 cm^3/mole.

Isochores for the histogram maximum and for the minimum molar volume indicate P at about 4-6 kb for T from 800-900°C. However, the isochore P is lower than the actual P derived from mineral thermobarometry, due to changes in the I after trapping.

The geochemical data and the petrological observations indicate that the amphibolite is a homogeneous rock, and that the millimeter-sized anhydrous margin is a result of dehydration of the amphibolite. As a result of the dehydration, the margin is now free of hornblende. The dehydration was triggered by CO_2-rich F with low μH_2O, which originated from the enderbitic M which intruded small fissures in the amphibolite. Both the abundance of the trace elements, and the feldspar composition evolve through the margin from the amphibolite to the enderbite. In the margin calcium and aluminum are substituted for by sodium and silicon, in the feldspar. The margin has been depleted in uranium, thorium, rubidium, samarium and neodymium. A consequence of this is that the margin is less radiogenic than the amphibolite.

From the author's abstract by H.E.B.

LINDBLOM, Sten, BROMAN, Curt and **FROGNER, Paul,** 1997, Fluid inclusions and the weathering of historical monuments: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 182-183. Authors at Dept. of Geol. and Geochem., Stockholm Univ, S-106 91 Stockholm, Sweden; email (Sten_AB.Lindblom@geo.su.se).

The dissolution rates of silicates and calcite are dependent on pH, T and electrolytes. Dissolution rates increase with decreasing pH. FI may contain considerable amounts of dissolved components. A saline solution could be very corrosive and effect [affect] the microenvironment of weathering to a considerable degree. FI are present in a number of the rocks used for monuments in Europe. (From authors' abstract by E.R.)

LINDENMAYER, Z.G. and **RONCHI, L.H.,** 1997, Mineralizing hydrothermal fluids in a metagabbro granophyric sill, Igarape Bahia gold mine, Serra dos Carajas, Brazil: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 184-185. Authors at Univ. do Vale do Rio dos Sinos – UNISINOS, Dept. of Geol., Caixa Postal 275, CEP 93022-000 S/o Leopoldo, Rio Grande do Sul, Brazil.

The Igarape Bahia gold mine is situated in the Serra dos Carajas, Amazon region, northern Brazil. This mine is the largest gold producer in Carajas. The metal is extracted from a lateritic zone developed on low grade Cu-Au sulfide ore. In spite of the efforts to study the ore geological controls, since the mine discovery in 1974 (Docego, 1988; Althoff et al., 1994; Zang & Fyfe, 1993, 1995), the origin of the P Cu-Au ores and the evolution of the related F are not yet completely understood. This paper presents new data concerning to the ore-F evolution on the mine area, obtained during a research program, still in progress. A hydrothermally altered volcanosedimentary unit of basalts and sediments hosts the primary sulfide ore [and the lateritic ore-grade soil developed on it]. There is a sill of granophyric gabbro emplaced at the contact between the basalts and the sedimentary rocks. The contacts of the granophiric gabbro are marked by mineralized hydraulic breccias and carbonatized rocks, where the mineralization is concentrated.

Three main types of FI were described in the quartz of the granophyric gabbro: Type S1 – early, multiphase FI, composed by H_2O, a V phase and dm as halite, sylvite, red iron oxide and probably carbonate, together with several unidentified solid phases; Type S_2 – early, multiphase FI composed by H_2O L, V phase and at least two solid phases, halite and/or $CaCl_2$ have Th$\leq$430°C.; Type L – late, two-phase FI, composed by H_2O L and a V phase with Th $\leq$150°C and 6% sal,; Type M – S FI, formed of one F phase. No visible CO_2 phase was observed in any of these I. The highest Th (430°C), corresponds to relicts of the higher metamorphic or hydrothermal T. (From authors' abstract by E.R.)

LIOU, J.G., MARUYAMA, S. and **ERNST, W.G.,** 1997, Seeing a mountain in a grain of garnet: Science, v. 276, p. 48-49.

A discussion of the occurrence of I of low-P minerals in rocks that have been at high P (See Darling et al, this volume) (E.R.)

LITASOV, K.D., SMIRNOV, S.Z. and **LITASOV, Y.D.,** 1997, Fluid and melt inclusions in low-Al clinopyroxenite xenoliths from quaternary basanites of the Vitim Plateau, Siberia: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 186-187. Authors at United Inst. of Geol., Geophys. and Mineral., Univ. pr. 3 630090 Novosibirsk, Russia; email (kostik@uiggm.nsc.ru).

The glass composition of unheated I in cpx from xenoliths ranges from dacite to rhyolite, while the glass of heated I in cpx ranges in composition from basaltic andesite to andesite. Unheated I in ol from basanite have glasses ranging from trachyandesite to phonolite. The initial composition of MI in olivine is expected to be basanitic. The Al_2O_3 contents of glasses from unheated I are 22-23% for ol and 12.3-21.0% for cpx, whereas Al_2O_3 content of glass from heated I in cpx is 7.2-11.5%. The distribution coefficient $D_{Ca/Al}{}^{cpx/glass}$ is unexpectedly high. It was estimated to be 6.1-7.5 by calculations on host cpx/heated I.

CO_2 and N_2 are major components of FI and gas bubbles of MI. There is no evidence for the presence of significant amount of hydrocarbons and water. Considering the CO_2/N_2 ratio, M and FI in cpx were divided to three groups (1) N_2-rich; (2) CO_2-N_2 (with CO_2 predominated); (3) CO_2-rich.

The reconstruction of F evolution during the clinopyroxenite crystallization suggests two-stage formation. The first stage was related to the andesite-like M with low-density nitrogenous F. During the second stage, the M enrichment in CO_2 up to the saturation and boiling occurred due to the influence of the basanitic M volatiles. (From authors' abstract by E.R.)

LIU, Bin and SHEN, Kun, 1997, Application of fluid potential map obtained from fluid inclusion data to research on oil-gas migration: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 9 (in English). First author at Dept. of Underground Construction and Engineering, Tongji Univ., Shanghai, 200092.

This paper deals with the theory of oil-gas migration and the concept of F potential, and introduces a method of calculating F potential and the method of contour potential map drawing. It is shown by an example that using the FI in oil-gas migrating processes of different periods to calculate F potential and drawing the F potential dynamic maps of different periods may quantitatively determine the directions of oil-gas migration in different periods, enclose the positions of oil-gas traps at that time and provide reliable basis for oil-gas exploration and evaluation. (Authors' abstract)

LIU, Guanliang, LU, Qi, ZHAI, Lina and ZHENG, Shu, 1997, Magma melt inclusions in diamonds: Geology and Mineral Resources of South China (Huanan Dizhi Yu Kuangchan), 1997, no. 2, p. 1-5 (in Chinese; Engl. abst.). First author at Yichang Inst. of Geol. and Mineral Resources, Yichang 443003.

The occurrence of magma M materials as I in diamonds has been found from the Fuxian, Monying mines and Dingjiagang diamond placer mine, China.

The I in diamonds are of 30~85 μm in size, with black or deep brown colour and with weak metallic luster. The I materials in diamonds consist of some spheres and groundmass, which are uncommon in diamonds.

The spheres are of ferroball, [sic] silicon-ferroball and mafelsic [mafic-felsic] ball, and the groundmass are high in SiO_2, Al_2O_3, K_2O, SiO_2, FeO, CaO and SiO_2, FeO, MgO in different diamonds.

The authors conclude that a certain material of a quenched or T unequilibrated M was present as I in the diamonds. These I can be deduced to be magma formed after a L immiscibility phase of the M from which diamonds were formed, giving rise to the assumption that the formation of diamonds might be related with volcanic eruption. (Authors' abstract)

LIU, Jiajun, ZHENG, Minghua, LIU, Jianming, ZHOU, Yufeng, GU, Xuexiang and ZHANG, Bin, 1997, Ore-forming material sources of gold deposits in the Cambrian silicalite formation, West Qinling: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 4, p. 330-339 (in Chinese; Engl. abst.). First author at Inst. of Geochem., Chinese Acad. of Sci., Guiyang 550002.

Gold deposits, including the Laerma and Qiongmo deposits and the Yaxiang ore occurrence, are a new type of stratabound gold deposits closely associated with submarine exhalative sedimentation and showing many distinctive features. The gold deposits are clearly controlled by strata, host rock types and structures.

According to the results of gold absorbing and releasing experiments of organic matter and clay minerals and the results of gold leaching rate, the authors conclude that the activated gold can be easily remobilized to take part in the ore-forming process. It is reasonably assumed that the gold deposits have affinity with exhalative-sedimentary silicalite formation. The REE patterns of gold ores are similar to those of the host rocks, with negative Ce and Eu anomalies.

The hydrothermal minerals and ores in the gold deposits have $\delta^{34}S$ values -32.2‰ ~+46.9‰ (sulfides) and +2.4‰ ~+33.3‰ (sulfates), $\delta^{13}C$ values -10.3‰ ~-30.5‰ (organic carbon), δ^{30} Si values -0.2‰ ~+0.7‰ (quartz) and +0.4‰ ~+1.3‰ (cherts). Hydrothermal F have $\delta^{18}O$ values -11.06‰ ~+15.34‰ (calculated from isotope fractionation equation of quartz-water and barite-water), and δD values -58‰ ~-122‰ (FI). Thus, the ore-forming solution was mainly derived from the ancient meteoric water, sulfur in the F from the reduced sulfur in the country rocks, carbon from organic carbon in the black layer, and silica from the silicalite formation. Lead isotopic composition shows that the ore lead has genetic relation with the leaching process in the silication [sic] formation. (From authors' abstract by E.R.)

LIU, Jianming, CHU, Xuelei, LIU, Wei, SUN, Shihua and CHANG, Xu, 1997, Ore-forming fluid systems in the crust: Progress in Geophys. (Diqiu Wulixue Jinzhan), v. 12, no. 1, p. 31-40.

A review.

LIU, Jianming, LIU, Jiajun and GU, Xuexiang, 1997, Basin fluids and their related ore deposits: Acta Petrologica et Mineralogica (Yanshikuangwuxue Zazhi), v. 16, no. 4, p. 341-352 (in Chinese; Engl. abst.). First author at Research Center of Mineral Resources Exploration, Chinese Acad. of Sci., Beijing 100101.

Basin F show typical features of low-T hydrothermal geochemistry, with T mainly ranging 80-150°C. Isotope composition and dissolved compositions of basin F are controlled by sediment types (decided by F-mineral interactions) and their spatial distribution. The contribution of organic matters plays a very important role in such aspects as the F-mineral interaction, the change in physical-chemical parameters of basin F themselves and their environments, the dissolutions, transport, deposition and ore-forming process of metals and the formation of S porosity of sedimentary rocks.

Two examples of deposits in China formed by basin F, one belonging to sedex type and the other to sediment-hosted micro-disseminated gold deposit, are briefly discussed in this paper.

(From authors' abstract by H.E.B.). FI data are presented for each example (H.E.B.)

LIU, Jiaqi, 1997, Thermobarogeochemistry, ore-forming age and genesis study for the Yishui copper-rich multimetal deposit in Meixian County, Guangdong Province, southern China: Geology and Mineral Resources of South China (Huanan Dizhi Yu Kuangchan), 1997, no. 1, p. 37-48 (in Chinese; Engl. abst.). Author at Yichang Inst. of Geol. and Mineral Resource, Yichang 443003.

The Yishui Cu-rich multimetal deposit in Meixian County, Guangdong Province, is a hydrothermal deposit, formed by filling and metasomatism of ore-forming hydrothermal F along the interbedded tectonic zone.

The FI is abound in sphalerite, quartz and calcite, and three main types of I can be recognized, as G-L phase, L phase and L_{CO_2} multi-phase. At the main ore-forming stage of Cu (Pb, Zn) mineralization, it was dominated by G-L I, with the forming T of 250~310°C, the sal of 8%~13% (eq. NaCl wt.%), the density of 0.82~0.98 g/cm^3, the P of 24~108 MPa. Both the I in the hematite-silicified rock of the incipient ore-forming stage, and in the quartz of the post-mineralization pyrite-quartz vein, are dominated by L phase, with the forming T of 150~210°C, sal of 4%~6%, density of 0.92~1.02 g/cm^3.

The major G components in the I from sulfide of main ore-forming stage are H_2O (>90%) and CO_2 (~9.7%) with the minimum amount of H_2, CH_4 and CO. The L phase is characterized by $Ca^{2+}>Na^+>K^+>Mg^{2+}$ and $SO_4^{2-}>Cl^->F^-$, with the pH of 5.5. The G components of the I from post ore-forming quartz is also dominated by H_2O (~77%) and CO_2 (~23%). It is characterized by $Ca^{2+}>Mg^{2+}>K^+>Na^{2+}$ and $SO_4^{2-}>HCO_3^->Cl^->F^-$, with pH of 7.1, for the L phase.

The δS^{34} values of pyrite, chalcopyrite, bornite, sphalerite and galena range from +2‰~-4‰, with a pagoda pattern on the histogram. The H, O isotope data δD_{H_2O}=-78‰, $\delta^{18}O_{H_2O}$=+10.4‰, of the L I in sphalerite, suggest its thermal L origin. The $\delta^{18}O$ value from the pyrite-quartz vein of the post ore-forming stage gives $\delta^{18}O$ of 7‰, and the $\delta^{18}O_{H_2O}$, δD_{H_2O} of the ore-forming F are -6‰ and -44‰ respectively, indicating its meteoric water characteristics.

In conclusion, it is considered that the ore-forming F having a typical hydrothermal genesis, based on the combined evidences of thermobarochemistry, stable isotopic characteristics of H, O, S and the structure and texture of the ore. (From authors' abstract by E.R.)

LIU, Jiaqi and ZENG, Yishan, 1997, Study on carboxylic acids of fluid inclusions in minerals from the Xihuashan–Dangping tungsten–beryllium deposit, south China: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 8 (in English). First author at Yichang Inst. of Geol. and Mineral Resources, MGMR, Yichang, 443003.

Systematic study is carried out on the thermobarogeochemical features of FI in quartz, wolframite, beryl and fluorite from the Xihuashan-Dangping tungsten-beryllium deposit, south China. It is the first time that the components of carboxylates of F leached from the I in the above minerals are studied with ion chromatography. The result shows that the low-molecular-weight carboxylates are common components in ore-forming hydrothermal F of pneumatolytic-hypothermal deposits and the carboxylates are composed mainly of formate, acetate, propionate and oxalate with formate>acetate » oxalate. (Authors' abstract)

LIU, Jinhui, 1997, Isotopic study and application of the ore-forming fossil hydrothermal system in Xiazhuang uranium field: Contributions to Geol. and Mineral Resources Research, v. 12, no. 2, p. 50-56. Author at East China Geological Inst., Lin Chuan Jiangxi 344000.

Isotopic analysis of C, O, H, and Pb for ore-forming geological setting in Xiazhuang field suggest that δD and $\delta^{18}O$ values of uranium ore-forming hydrothermal solution in mineralization epoch are characteristic of the isotope for meteoric water with obvious "oxygen drift." Before interacting with rock, the ancient underground water has low $\delta^{18}O$ value. The initial lead in pitchblende belongs to radioactive origin from crust. The $\delta^{13}C$ values in calcite (-6.071 ~-9.228‰ (PDB)) are just in the range of magmatic or deep metamorphic carbon. Therefore, the water source, uranium source and mineralizer source should derive from meteoric water, surrounding rock and deep magmatic or metamorphic carbon respectively. (From author's abstract by E.R.)

LIU, Jinhui, LI, Xueli, SHI, Weijun and SUN, Zhanxue, 1997, The water source for the ore-forming hydrothermal solution in Xiazhuang uranium field: J. of Changchun Univ. of Earth Sci. (Changchun Dizhi Xueyuan Xuebao), v. 27, no. 4, p. 415-419 (in Chinese; English abst.). Authors at East China Geological Inst., Linchuan 344000.

See previous abstract (E.R.)

LIU, Shuwen, 1997, Study on fluid-rock equilibrium systems of Fuping gneiss complex, Taihang Mountains: Science in China (Series D), v. 40, no. 3, p. 239-245 (in Engl.). Author at Dept. of Geol., Peking Univ., Beijing 100871, China.

The characters of F composition and F-rock equilibrium system of the Archean Fuping gneiss complex, Taihang Mountains, are first determined by F-rock equilibrium thermodynamics calculations and microthermometry of FI. These investigations suggest that the $X(H_2O)$ is generally less than 0.05 in F equilibrating with the granulite facies metamorphic mineral assemblage of Fuping gneiss complex, and F-rock interaction is chiefly controlled by CO_2-rich F infiltration. (Author's abstract)

LIU, Wenjun, ZHENG, Rongcai, LI, Yuanlin and CHANG, Sihe, 1997, Research of the daughter minerals in fluid inclusions of the Huayuan lead-zinc deposit: J. of Chengdu Univ. of Tech., v. 24, no. 4, p. 65-69. Authors at Chengdu Univ. of Tech., China.

The Huayuan lead-zinc deposit is a large MVT ore deposit in Hunan Province, southern China, which occurs in the algal reef limestone of Lower Cambrian. FI are very common in this ore mineral [sic], and seven dm have been found in it through the use of SEM and EDX: sphalerite, pyrite, gypsum, barite, calcite, halite and bitumen. The presence of sulphate minerals shows that the concentration of SO_4^{2-} is relatively high, and it may be migrated with metallic ion in mineralizing F. (Authors' abstract)

LIU, Yiqun, FENG, Qiao and LI, Wenhou, 1997, Palaeotemperatures and diagenetic phases of the Upper Triassic oil-bearing sandstones in the eastern part of the Ordos Basin: Acta Geologica Sinica (Dizhi Xuebao), v. 71, no. 3, p. 305-316 (in Engl.). Authors at Dept. of Geol., Northwest Univ., Xi'an, Shaanxi.

The maximum palaeotemperature of oil-bearing sandstones in the Upper Triassic in the eastern Ordos basin has been determined by using many methods including the virtinite reflectance, FI, apatite fission track, illite crystallinity, chlorite polytype and diagenetic change of authigenic minerals. (Authors' abstract from H.E.B.)

LIU, Yiqun, LI, Wenhou and **FENG, Qiao,** 1997, Palaeotemperatures and diagenetic stage of the Upper Triassic oil sandstones in the eastern Ordos basin: Acta Geologica Sinica (Dizhi Xuebao), v. 71, no. 1, p. 65-74 (in Chinese; English abst.). Authors at Dept. of Geol., Northwest Univ. Xi'an, Shaanxi.

Same as previous abstract (E.R.)

LIU, Zhihong, WANG, Anjian and **XU, Hong,** 1997, Genetic model of ductile-shear type gold deposits in Wutai Mountain area: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 4, p. 350-363 (in Chinese; Engl. abst.). First author at Dept. of Earth Sci., Nanjing Univ., Nanjing 210093.

H, O, C, S isotopic analyses of quartz, carbonate minerals and wall rocks show that in ore-forming F $\delta^{18}O_{H2O}$ = -2.1‰ ~4.9‰, and δD = -69‰ ~-112‰, in altered carbonates $\delta^{13}C_{PDB}$ = -2.0‰ ~-1.4‰, and $\delta^{18}O_{SMOW}$ = 10‰ ~20‰, and in gold-carrying pyrite $\delta^{34}S$ = -3.7‰ ~5.6‰. The premineral F possess medium-high sal, the F of the ore-forming stage are characterized by rich CO_2, seawater - implying $\delta^{18}O$ values and marine carbonate $\delta^{13}C$ values [sic]. The ore-forming F mainly reflect the mixture of metamorphic F and saturant thermal brine of mafic rocks formed during diagenesis in the sea basin. (From authors' abstract by E.R.)

LOCKWOOD, M.S., 1990, Controls on precious-metal mineralization, Easton-Pacific vein, Virginia City mining district, Madison County, Montana: unpublished MS thesis, New Mexico Inst. of Mining and Tech., 136 pp.

The deposits bridge the artifical boundary between epithermal and mesothermal deposits. FI (ore-forming stage) shows 275°C, 3-6% NaCl eq. to 175°C + 10-12% NaCl, presumably from mixing of F. (As quoted by Eimon, SEG Newsletter, v. 28, p. 1, 10-14, 1997).

LODEMANN, Manuela, FRITZ, Peter, WOLF, Manfred, IVANOVICH, Miro, HANSEN, B.T. and **NOLTE, Eckehart,** 1997, On the origin of saline fluids in the KTB (continental deep drilling project of Germany): Applied Geochem., v. 12, p. 831-849. First author at GSF-Nat'l. Center for Environment and Health, Inst. of Hydrology, D-85764 Neuherberg, Germany and Schelztorstr. 42, D-73728 Esslingen, Germany.

Highly saline F were encountered during the German Continental Deep Drilling Project (KTB) from depths ranging between 2 and 3 km to about 9 km. Geochemical and isotopic data support the long term pumping hydraulic tests which suggest the presence of an open and large F reservoir at depth. The pumped F from this main fracture system were released from a deep reservoir situated at more than 5500 m depth which is hydraulically connected with the 9101 m deep KTB main hole, drilled some 250 m to the northeast of the pilot hole.

While Ca and Sr contents of the extracted brines may be the result of water-rock interaction, Cl is most likely of external origin. The Cl is hypothesized to derive from geotectonic processes. Several isotopic studies have identified an admixture of descending paleowaters down to more than 4000 m depth. The high ^{36}Cl /Cl ratio of the F sampled during the long-term pumping test point to a host rock highly enriched in U-Th, unlike the sampled KTB country rocks. (From authors' abstract by E.R.)

LOIZENBAUER and **NEUMAYR,** 1996, [title unavailable–see Taylor, W.E.G., this volume for citation; page numbers refer to Egyptian Geol. Survey volume, as given by Taylor. Ed.]

These authors' summarize (p. 106-111) the controls on the mineralization in the Fawakhir Gold Mine at El Six which is situated in the central part of the Eastern Desert. From a consideration of structures, microscopic geochemistry and FI they were able to demonstrate that the mineralization occurred mainly along a brittle deformation zone which occurred within adjacent serpentinite and granite bodies. The rheological behaviour of the quartz grains indicate that they formed at a T of about 320°C and that this was interpreted as being associated with the gold mineralization. Three-phase CO_2-bearing I were very common. The combination of the estimated T of formation and the field evidence suggested T of 300 to 350°C and P from 1.8 to 2.2 kb (i.e. lower greenschist facies of metamorphism). (Authors' abstract)

LONDON, David, 1997, Estimating abundance of volatile and other mobile components in evolved silicic melts through mineral-melt equilibria: J. of Petrol., v. 38, no. 12, p. 1691-1706. Author at School of Geol. and Geophys., Univ. of Oklahoma, 100 E. Boyd St., 810 Sec, Norman, OK 73019.

In combination with trapped M I, the mineral equilibria described here provide useful measures of these petrologically and economically important components in high-silica melts [rare alkalies, F, B, and P]. (From author's abstract by E.R.)

LOPEZ, C.A., YUSTE, O.A. and **FERNANDEZ, N.C.,** 1997, Structural and mineralogical aspects of the Loscos polymetallic veins, northern Teruel, eastern Iberian Mountains: Boletin Sociedad Espanola de Mineralogia, v. 20, p. 89-114.

Indexed under FI (E.R.)

LOSH, Steven, 1997, Stable isotope studies of fluid-rock interaction associated with the Snake Range and Mormon Peak detachment faults, Nevada: Geological Society of America Bulletin, 1997, v. 109, no. 3, p. 300-323. Author at Dept. of Geological Sci., Cornell Univ., Snee Hall, Ithaca, NY 14853.

Stable isotope and FI data were obtained from rocks from traverses within and above the Snake Range and Mormon Peak detachments in Nevada in order to evaluate F sources and the nature of F flow associated with detachment faults during faulting, and to determine whether the initial depth of the detachment fault influenced the nature of syntectonic F flow. The model computations indicate that cumulative syntectonic F flux along the detachment faults was between 1700 and 11,000 kg/cm^2, depending on location. Time-averaged fault permeabilities are estimated by modeling between 2 and 20 mD. (From author's abstract by E.R.)

FI were scarce in the studied samples and were nearly all <5 µm in diameter. FI from syntectonic veins in detachment faults and in their respective hanging walls homogenized over a range of T from 70-130°C in samples from the Mormon Mountains, whereas Lexington Creek samples homogenized between 95 and 200°C, and Rock Canyon FI homogenized between 70 and 295°C. When corrected for up to 800 bars F P, corresponding to 8 km of hydrostatic head, and assuming F sal between 1 and 20 wt.% NaCl (Potter, 1977), the main population of FI yields calculated filling T as high as 280°C. The high Th in some Rock Canyon detachment fault breccia veins are noteworthy; the solitary I are in clear, undeformed calcite veins that crosscut cataclastic fabric, and are considered credible indicators of T. When corrected for a minimum of 2 km of hydrostatic head, I in this group yield P-corrected filling T of 273 to 315°C. (From author's abstract by E.R.)

LOTH, G., KLING, M., HÖLL, R. and **STIGLER, A.**, 1997, Mineralogical, fluid inclusion and stable isotope studies on the origin of the Göpfersgrün talc deposit (Northeast Bavaria, Germany): in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 737-739. First author at Institut für Allgemeine und Angewandte Geologie, München, Germany.

Our data favor the interpretation of a metasomatic origin of the Göpfersgrün talc deposit. The talc formation is linked to a F activity after the intrusion of an Upper Carboniferous granite into dolomitic marbles and shales. It has been calculated at about 400°C and about 2 kbar confining P. The mineralizing F was obviously characterized by a low CO_2 content and a high sal. It was most probably derived from formation waters. (Authors' abstract)

LOTT, D.A. and **COVENEY, R.M., Jr.**, 1997, Fluids associated with Ni-Mo sulfide beds from China (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-209. Authors at Geosci. Dept., Univ. of Missouri-Kansas City, 5100 Rockhill Rd., Kansas City, Mo. 64110-2499; email (dlott@cctr.umkc.edu).

Cambrian black shales in southern China contain unusual stratified ores in the form of a single, thin, discontinuous Ni-Mo sulfide bed, which also contains appreciable amounts of Zn, As, Au, Ag, and Pt group elements.

Our studies concentrated on quartz crystals derived from Proterozoic dolomites that underlie the deposits. Petrographic observations suggest that the quartz formed during ore deposition because hexagonal growth zones are decorated with P I of sulfide minerals including sphalerite and pyrite with detectable amounts of As and Ba which also occur in the ore (Fig. 1). I of hematite are also present. The minimum T of deposition as indicated by Th values for P FI range from 65 to 266°C and sal range from 0.4 to 21.8 wt.% eq. NaCl. The presence of microfossils in the ores and hematite are suggestive of episodes of oxidation, as well as FI evidence for phase separation and radically varying sal and Th values all suggest that hydrothermal venting and associated chemolithotrophic biota played a role in the formation of the metals on and beneath the Cambrian sea floor. (Authors' abstract) *See figure on page 240.*

LOWENSTERN, J.B., CLYNNE, M.A., DUFFIELD, W.A. and **SMITH, J.G.**, 1997, Degassing, undercooling and granophyre formation beneath the Alid volcanic center, Eritrea, northeast Africa (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-359. Authors at U.S. Geological Survey, 345 Middlefield Road, MS910, Menlo Park, CA 94025; email (jlwnstrn@usgs.gov).

Blocks of anorthoclase- and clinopyroxene-bearing micrographic granophyre were ejected with rhyolitic pumice during a late-Pleistocene eruption at the Alid volcanic center, Eritrea. The blocks are chemically, isotopically, and mineralogically similar to the host rhyolite. They appear to have crystallized at the top of a shallow magma body beneath Alid, a structural dome created as intruding granitic magma deformed and uplifted overlying lavas, marine sediments, and Precambrian basement rocks (see Duffield et al., this volume).

T of the granitic magma, by whole-rock Zr geothermometry, was 875±25°C. MI (n=21) in euhedral quartz phenocrysts from the pumice contain an average of 2.6 wt.% H_2O, 3800 ppm Cl, and 1300 to 5200 ppm F, (analyses by FTIR spectroscopy and EPMA). Six I analyzed for CO_2 contained between 30 and 60 ppm. Saturation P calculated for individual I require crystallization at depths (corresponding to lithostatic P) ranging from 1.4 to 3.4 km. Similar quartz grains in the granophyric blocks contain P, 2-phase, V-rich FI, consistent with V saturation during growth of these igneous phenocrysts. Granophyric intergrowths of quartz and feldspar in the groundmass contain abundant, P, V-rich FI, 1 to 10 µm in diameter. The presence of such I requires that growth of the granophyric texture from the silicate M was accompanied by degassing (2nd boiling).

Though crystallization apparently forced degassing, the converse also likely occurred. earlier eruptions from the rhyolite magma chamber would have caused P drops that would induce degassing of the already V-saturated M. If the magma resided at 2 km depth, eruptive decompression from lithostatic to hydrostatic conditions would cause a drop from 2.6 to 1.8 wt.% dissolved H_2O, causing compositional undercooling equivalent to 75°C. Micrographic and granophyric textures are consistent with such undercooling, and will be most common in shallow intrusive settings where P remains high enough to retain ~1-1.5 wt.% H_2O. In contrast, greater depressurization, degassing, and undercooling would create glasses, fine-grained felsites, and crude granophyres, without the well-crystallized micrographic intergrowths observed at Alid. (Authors' abstract)

LOWRY, D., BOYCE, A.J., FALLICK, A.E. and **STEPHENS, W.E.**, 1997, Sources of sulphur, metals and fluids in granitoid-related mineralization the Southern Uplands, Scotland: Trans. Instn. Min. Metall. (Sect. B: Appl. Earth Sci.), v. 106, May-August 1997, p. B157-B168.

Stable isotopic and FI data from three deposits have been used in conjunction with mineralogical data to assess the roles of the intrusives and host sediments in supplying the components of mineralization.

At least three F pulses were involved in mineralization in the subvolcanic porphyry systems at Black Stockarton Moor and Cairngarroch Bay. Intrusive-hosted mineralization was dominated by a boiling subcrustal magmatic F (>450°C) with $\delta^{34}S$ of 0±2‰, and sal of 5-20 wt.% eq. NaCl. Quartz veins in peripheral sediments (<450°C) contain sulphides with $\delta^{34}S$ of -2.5±1.5‰ and F with sal of 5-10 wt.% eq. NaCl and varying CO_2 and CH_4 contents. These characteristics probably resulted because intrusion of the porphyries caused dewatering of the host greywackes, releasing a F that mixed with magmatic F during formation of peripheral veins. A third F entered both porphyry- and greywacke-hosted veins systems at T between 120 and 300°C. This moderate- to high-sal F (6-35 wt.% eq. NaCl) probably represents modified meteoric water that percolated down from the earth's surface. (From authors' abstract by E.R.)

LOZANO, R.P., BACHILLER, N. and **CASQUET, C.,** 1997, Fluids associated with the formation of epidote + (chlorite-quartz) in pegmatites of the Cabrera pluton; Spanish Central System: Geogaceta, v. 21, p. 155-158.

Indexed under FI (E.R.)

LU, F.H., MEYERS, W.J. and **SCHOONEN, M.A.A.,** 1997, Minor and trace element analyses on gypsum; an experimental study: Chemical Geol., v. 142, no. 1-2, p. 1-10.

Gypsum and anhydrite may contain abundant F and solid I which can contribute considerable amounts of elements to bulk-analyses. This study developed procedures for grinding, heating, and rinsing with alcohol, HNO_3, and deionized water to fracture and remove F and solid I from gypsum and anhydrite. Na concentrations in treated gypsum samples are orders of magnitude lower than previously published analyses and the "marine" Na values calculated by using published $K^{Na}{}_{gypsum}$. The previously published $K^{Na}{}_{gypsum}$ may need to be revised. Moreover, the methods used in this study can be applied in other evaporative minerals (e.g., halite and dolomite) for minor and trace analyses. (From authors' abstract by E.R.)

LU, H.-Z and **WANG, Zhonggang,** 1997, Geology and fluid inclusions studies on Keketuohai No. 3 rare-element pegmatite, Xinjiang, northwest China: Proc. 30th Int'l. Geol. Congr., v. 16, p. 277-297, H. Yunhui and C. Yawen, eds. First author at Science de la terre, Univ. du Québec à Chicoutimi, Quebec, G7H 2B1, Canada.

See FIR 29, p. 125 (E.R.)

LU, Huanzhang, WANG, Zhonggang and **LI, Yuansheng,** 1997, Magma-fluid transition and the genesis of Pegmatite Dike No. 3, Altay, Xinjiang, northwest China: Chinese J. of Geochem., v. 16, no. 1, p. 43-52 (in English). Authors at Inst. of Geochem., Chinese Acad. of Sci., Guiyang, 550002.

The physico-chemical conditions under which the pegmatite dyke no. 3 was formed were discussed in the light of F-M I evidence. Our results lend support to the fractionation of hydrothermal solutions from magma. For the pegmatite dike no. 3, the magma-derived hydrothermal solutions are dominated by NaCl + CO_2 + H_2O. (Authors' abstract)

LU, J. and **LOTTERMOSER, B.G.,** 1997, Petrogenesis of rare-element pegmatites in the Olary Block, south Australia, part 2. Fluid inclusion study: Mineral. and Petrol., vol. 59, p. 21-41. First author at School of Earth Sci., Univ. of Melbourne, Melbourne, Australia.

FI were investigated in quartz, beryl, apatite and triplite from the border and intermediate zones and core of pegmatites within the Proterozoic Olary Block, south Australia. Three compositionally distinct types of I were recognized including pure CO_2 I, mixed H_2O-CO_2 I, and aq I with some of them containing a solid phase. Three F events occurred during pegmatite formation and subsolidus alteration. Initial F are characterised by a low to intermediate sal (4.1 to 23.4 wt.% NaCl eq.), and a composition of about 10 mol% CO_2, 4.2 mol% NaCl eq., and 85.6 mol% H_2O. F were trapped as homogeneous H_2O-CO_2 phases. The second pulse of F was of intermediate to high sal at 11 to 33 wt.% NaCl eq. These F were most likely trapped as separated CO_2 and H_2O phases. Finally, intermediate to high sal F of post-pegmatite origin with approximately 15 to 30 wt.% NaCl eq. were introduced. The P-T regime for the three F events has been estimated at 520 to >650°C and 2 to 5 kbars, 400 to 650°C and 1.8 to 3.3 kbars, and 380 to 480°C and 2.0 to 2.6 kbars, respectively. These conditions indicate a declining P path implying a tectonic uplift of the Olary Block during successive F emplacements. (Authors' abstract)

LU, Yuangfa, MA, Liyan, XU, Kunhua and **XIE, Yanguang,** 1997, Geological-geochemical characters and genesis of the Sushikeng lead-zinc deposit, Guangdong Province: Geology and Mineral Resources of South China (Huanan Dizhi Yu Kuangchan), 1997, no. 1, p. 18-26 (in Chinese; Engl. abst.). First author at Yichang Inst. of Geol. and Mineral Resources, Yichang 443003.

In this paper, the genesis of the Sushikeng lead-zinc deposit, Guangdong Province has been discussed based on the study of geological features of the deposit, regional geochemical background of ore-forming elements, lead, sulfur and carbon-oxygen isotope composition of the ore, and characteristics of FI in minerals, etc. It is suggested that the ore-forming material and F are mainly derived from magma (bodies); that the mineralization T is 100~230°C, dominantly 120~150°C; that the P is $354\text{~}481 \times 10^5$Pa; that the depth is 1.31~1.82 km; and that the sal of mineralized solution is 5~8 wt.% (NaCl). (Authors' abstract)

LÜDERS, Volker, PRACEJUS, Bernhard and **HALBACH, Peter,** 1997, Fluid inclusion studies in massive sulphide ores and barite from the Jade hydrothermal field (Central Okinawa Trough, Japan): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 188. First author at GeoForschungsZentrum Potsdam, P.B. 4.3 Lagerstättenbildung, D-14473 Potsdam, Germany; email (volue@gfz-potsdam.de).

Active and inactive sulphide-sulphate chimneys, up to 5 m high, and mounds are distributed irregularly in this hydrothermal zone. One "black smoker" chimney emits a solution of 320°C with suspended sulphide particles and a pH of 4.7. Other chimneys and mounds in the same area exhale clear solutions of up to 220°C. The latter indicate that the sulphide minerals of the F already precipitated to a large extent prior to discharge.

The main sulphide minerals are sphalerite, galena, pyrite, marcasite, chalcopyrite, and fahlore (Sb-/As-rich). Barite, amorphous silica, and anglesite constitute the bulk of the gangue minerals. The $\delta^{34}S$ values of massive sulphides range between 3.2 and 5.2‰ whereas barite from the rim of the chimney shows higher $\delta^{34}S$ values between 10.2 and 17.3‰, indicating mixing of the hydrothermal F with ocean water.

P two-phase FI in sphalerite from impregnation ores show Th between 285 and 346°C (mean 315°C) and yield sal between 5.0 and 6.5 eq. wt.% NaCl. Laser Ablation ICP-MS analysis of FI in sphalerite indicate Na/K ratios between 0.56 and 0.65 (mean 0.59) and traces of Mn, Cu, Sb, Ga, Ge and Ba besides Zn in aq phases. The Th of two-phase I in barite from smokers are considerably lower than those of I in sphalerite (mean Th 190°C) but show similar sal (4.4-6.1 eq. wt.% NaCl). FI in barite from outside the chimneys only contain monophase, low-sal aq I. (From authors' abstract by E.R.)

LUSK, John and **KROUSE, H.R.,** 1997, Comparative stable isotope and temperature investigation of minerals and associated fluids in two regionally metamorphosed (Kuroko-type) volcanogenic massive sulfide deposits: Chemical Geol., v. 143, p. 231-353. First author at School of Earth Sci., Macquarie Univ., N.S.W. 2109, Australia; email (jlusk@atlas.es.mq.edu.au)

The B.M.&S. No. 12 deposit in New Brunswick, Canada, and the Woodlawn deposit in N.S.W., Australia, are volcanogenic massive sulfide deposits that have been extensively deformed and metamorphosed at moderate and low grades of greenschist facies regional metamorphism. These deposits yield similar stable isotope signatures for carbonates and quartz deposited during metamorphism, and also for FI waters contained in these minerals. In both deposits the metamorphic quartz and carbonates have $\delta^{18}O$ values of ~8-13.6‰ and 11-12.6‰, respectively. The carbonates have $\delta^{13}C$ values of -0.2 to -12‰ and $^{87}Sr/^{86}Sr$ ratios between 0.7073 and 0.7115. Bulk FI waters extracted from the quartz and carbonates have δD values of -87 to -169‰ and $\delta^{18}O$ values of -14 to -32‰. The B.M.&S. and Woodlawn F are mainly water-NaCl L with sal averaging around 8 and 6.5 wt.%, respectively, but range up to ~38 wt.% in a small population of three phase I in one B.M.&S. sample. Regional metamorphism is suggested to have generated these sal through water losses occurring in response to periodic boiling of F of mainly marine derivation, combined with possible contributions from waters liberated through thermal cracking of organic matter contained in the associated black shales. Exchange between F and organic matter may account for the negative $\delta^{13}C$ and δD values shown by the metamorphic carbonates and waters, respectively. Strontium isotope ratios in the B.M.&S. carbonates span the full range of variation. This implies appreciable F mobility and exchange with other sources of strontium during moderate grade greenschist facies metamorphism. Selected sulfur isotope data for massive sulfides in the New Brunswick and Woodlawn deposits suggest attainment of isotopic equilibrium within the metamorphic T ranges ~370-270°C and ~320-200°C, respectively. FI microthermometry yields respective minimum Th of ~440-120°C and ~350-120°C for F contained in the metamorphic quartz and carbonates. The appreciable overlap between these geothermometers is attributed to deformation-induced rupture-and-seal events which involved the FI, and to accompanying recovery and recrystallization processes which locally affected both FI and the massive sulfides during retrograde cooling from peak regional metamorphic T-P conditions. (From authors' abstract by E.R.)

LUTZ, S.J., MOORE, J.N. and **BENOIT, Dick,** 1997, Cenozoic hydrothermal alteration in Dixie Valley and northern Stillwater Range, Nevada (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-50. First author at Energy and Geosci. Inst., Univ. of Utah, 423 Wakara Way, Salt Lake City, UT 84108; email (sjlutz@egi.utah.edu).

Cuttings from deep geothermal wells in Dixie Valley, Nevada, document a long and complex history of the Jurassic reservoir rocks now contained within the hanging wall of the Stillwater normal fault. Six stages of post-Oligocene alteration can be recognized on the basis of mineral paragenesis, rock associations, FI T and apparent sal. The paragenetic sequence from oldest to youngest consists of: Stage I) epidote-chlorite-calcite veins; Stage II) illite; Stage III) wairakite-quartz-calcite-potassium feldspar-epidote veins; Stage IV) mixed-layer illite-smectite and quartz-calcite veins; Stage V) chalcedonic quartz-dolomite-calcite-chlorite/smectite-barite-hematite veins; and Stage VI) quartz-calcite veins. FI data yield the following T and apparent sal in weight percent NaCl eq.; Stage I) 270 to 325°C and 1.4 to 1.6%; Stage III) 230 to 240°C and 1.9%; Stage IV) 180 to 200°C and 1.0 to 1.2%; Stage V) <160°C and 0.0%; and Stage VI) 200 to 230°C and 0.0 to 0.5%.

Stages I through V appear to be associated with hydrothermal systems that developed during Basin and Range extension, prior to the development of the modern geothermal system. Stage II sericite at the Dixie Comstock gold mine has been dated at 15-11 Ma and occurs along NNW-trending faults (Vikre, 1994). Stage III is associated with Miocene dikes. Descent of the hanging wall of the NE-striking Stillwater fault occurred after the deposition of flat-lying, Miocene basalt flows and dike intrusion. Stage IV and V FI suggest the presence of cool F at shallow depths along the Stillwater fault. Stage VI minerals were deposited by the modern geothermal system (Tmax=248°C, sal=0.1-0.2 wt.%) after the Jurassic rocks descended to their present depth of 2-3 km along this still-active fault. (Authors' abstract)

LYAKHOVSKY, V., CHEKHMIR, A. and **NAVON, O.,** 1997, Bubble growth in rhyolitic melts (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 159. Authors at Inst. of Earth Sci., The Hebrew Univ., Jerusalem 91904, Israel; e-mail vladi@cc.huji.ac.il)

Bubble growth controlled by mass transfer of water from hydrated rhyolitic M at high P and T was studied experimentally and simulated numerically. Bubbles were grown in water-rich rhyolites (C_0>5 wt.%) by instantaneously decompressing samples from 150 MPa to final P of 15-145 MPa at 780-850°C, or by heating hydrated samples under atmospheric P in a heating stage at ~500°C and video-recording their vesiculation.

Good agreement between experimental results, numerical simulations and analytical solutions enables accurate examination of bubble growth from a limited volume of supersaturated M.

For explosive silicic eruptions, our results indicate that equilibrium degassing is a good approximation in M with high water contents (C_0>3 wt.% water) during most of their ascent. Even if nucleation occurs at high supersaturation M and bubbles quickly approach equilibrium. Only close to, or after fragmentation when the magma accelerates, equilibrium is no longer maintained and new bubbles may nucleate and grow. In highly viscous lava-domes new bubbles may nucleate upon extrusion, but their growth is delayed and may lead to a late buildup of P and stress in the dome. (From authors' abstract by E.R.)

MAALØE, Sven and **McBIRNEY, A.R.,** 1997, Liquid fractionation. Part IV: Scale models for liquid fractionation of calc-alkaline magmas: J. of Volcanol. and Geothermal Research, v. 76, p. 111-125.

MACAULAY, C.I., BOYCE, A.J., FALLICK, A.E. and **HASZELDINE, R.S.,** 1997, Quartz veins record vertical flow at a graben edge; Fulmar oil field, central North Sea: AAPG Bull., v. 81, no. 12, p. 2024-2033.

Indexed under FI (E.R.)

MACLEOD, Gordon, LARTER, S.R. and **APLIN, A.C.**, 1997, Complex charge and filling histories of North Sea reservoirs reveal origin of gas-condensate: Annual Meeting Abstracts - American Assoc. of Petroleum Geologists and Soc. of Economic Paleontologists and Mineralogists, v. 6, p. 73-74.

Some FI in diagenetic cements contain samples of petroleum previously present in a reservoir or on a migration pathway. We have used Confocal Scanning Laser Microscopy to accurately and non-destructively determine the volumetric L:V ratio of petroleum within single FI in diagenetic minerals. By using these data within the PVT simulation software VTFLINC (Calsep a.s./NRG) we have determined the phase envelope, isochore and physical properties (e.g. GOR) of included petroleum to within a few percent of the true values. The data can be used in two general ways. With data from coexisting aq I, they give more accurate palaeopressure determinations than previously possible. The data also allow one to track the compositional evolution of petroleum in reservoirs and on migration pathways. For example, I data from two North Sea gas-condensate fields suggest that both condensates formed by engulfment of oil by gas at T close to present values (differs from 120°C) but P significantly below present values. Gas injection caused a phase change in the reservoired petroleum from oil to gas-condensate, increasing its volume and causing either/or both spillage to adjacent structures and increased F P. This model, which has important exploration consequences, is supported by the chemical composition of the petroleum, which contains a broad suite of $>C_{10}$ hydrocarbons. (Authors' abstract)

MAEDA, H., BODNAR, R.J. and **REED, M.H.**, 1997, Fluid inclusion study of pre-main stage vein quartz at the Butte, Montana, porphyry copper deposit: Eos Trans. AGU v. 78 (17), Spring Meet. Suppl., p. S335. First author at Kitami Inst. of Tech., Dept. of Civil Engineering, Kitami, 090 Japan; email (maeda@rock.civil.kitami-it.ac.jp)

The Butte, Montana, ore deposit represents one of the world's classic examples of porphyry-style mineralization. In an attempt to constrain the sources of F responsible for mineralization and alteration in the deposit, FI from the early, deep pre-Main Stage K-silicate and sericitic alteration and mineralization have been studied. The mineralization is hosted by the Butte quartz monzonite.

Several different types of FI were observed in pre-Main Stage vein quartz from the deep drilling at the Pittsmont dome in the east half of the Butte district. Early pre-Main Stage vein quartz contains L-rich, V-rich (±opaques) and multiphase, halite-bearing I. The multiphase I have between one and four dm, including chalcopyrite, hematite, gypsum, halite and sylvite. The halite-bering I have sal ranging from 36-52 wt.% eq. NaCl. Multiphase I containing chalcopyrite and/or hematite and halite are similar to I observed in early stage veins in other porphyry copper deposits. Late pre-Main Stage vein quartz is characterized by V-rich and L-rich low sal I having a chalcopyrite daughter. These I homogenize at 370±40°C and have sal ranging from 0.35-8.68 wt.% eq. NaCl.

All I observed have phase relations consistent with trapping of magmatic F in a deep porphyry environment. The presence of chalcopyrite and other opaque dm in these I suggests that the magmatic F transported metal into the ore-forming system. This interpretation is consistent with earlier synchrotron XRF analyses of individual FI from Butte which show that these F were transporting not only copper and iron, but also significant amounts of zinc, lead and manganese. (Authors' abstract)

MAINERI, Cinzia and **LATTANZI, Pierfranco**, 1997, Fluid circulation in post-deformation and extensional polymetallic sulphides veins at Promontorio del Franco, Isola del Giglio (Italy): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 189. First author at CNR-Minerogenesi e Geochimica Applicata, Via La Pira, 4-50121 Firenze; email (cmaineri@steno.geo.unifi.it).

Several Fe and Pb Zn-Cu sulphide ore bodies occur in several Mesozoic metamorphic and sedimentary tectonic slices, which underwent regional metamorphism and deformation during and after the Alpine/Apenninic orogeny.

Isoclinally folded veins are formed by I-free mylonitic quartz and by undeformed quartz grains with abundant L-rich, high-sal (up to 25 wt.% NaCl eq.) FI (type I). Raman analyses indicate traces of CO_2 in the gas phase and Th=260°C. Undeformed quartz grains are associated with an albite+chlorite+pyrite assemblage, indicative of relatively low T conditions.

Tabular quartz veins are found parallel to the axial planes of open brittle folds. Microthermometric characteristics of FI hosted in these veins are similar to those of type I. Differences in fold styles indicate decreasing T and P during deformation. The undeformed quartz grains formed after the main stages of compression. F circulation in the two systems was probably contemporaneous, as suggested by the similarity of F in P I. FI (type II) from quartz (fluorite-calcite) – Fe-(Pb-Zn-Cu) sulphide veins observed along normal faults show much lower sal (2-5 wt.% NaCl eq.) and higher Th (300°C). This may reflect an interaction between these F and the cooling intrusive body. (From authors' abstract by E.R.)

MALÍKOVA, Petra and **ZACHARIÁ, Jiøí**, 1997, Sapphires from Czech Republic and their origin: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 190-191. Authors at Charles Univ., Fac. of Sci., Albertov 6, 128 43 Prague 2, Czech Republic; email (zachar@mail.natur.cuni.cz).

In spite of being the most important European alluvial sapphire deposit, origin of the sapphires from Jizerská louka in North Bohemia was not known: it might either be granitoid pegmatitic or basaltic vent breccia.

Types of FI found in Jizerská louka sapphires include hexagon-shaped MI of low relief and typical size of 10-20 micrometers. They contain clear isotropic phase and a bubble (5-10 vol.%), and usually also a darker (or opaque) phase. During the microthermometry (-195 to 50°C), these I [showed no] phase change. Microprobe analyses revealed about 60% SiO_2, 24% Al_2O_3, 2% CaO, 1% FeO and 32% SiO_2, 56% Al_2O_3, 2% FeO respectively. I on this type may represent P silicate MI.

CO_2-bearing FI were found only in a limited area of one sample. Some I homogenised to V at about 24°C, others displayed critical (or near-to) behavior (at 29 to 30.5°C). One smaller (5x3 μm) I homogenised to L at 11.5°C. Tm-CO_2 range from -58.2 to -57.7°C. Assuming binary mixtures, this small I may contain CO_2 with 6% CH_4, or 12% N_2; calculated densities of 0.784 g/cc (CH_4) and 0.668 g/cc (N_2) correspond to 4.6 kbar and 3.3 kbar P at 1100°C, respectively. Unfortunately still smaller I could not be examined because of poor translucency.

The most common FI type are PS and/or S healing fissures: these are so called fingerprints set up of round to oval I and vermicular to channel-like patterns, and dark larger negative crystals associated with them. During the microthermometry (-195 to 50°C), no phase changes were observed. Some dark I of negative crystal shapes can contain critical or near-to critical CO_2.

In a red corundum from Ceské Stredohorí Mts., PS and/or S high density CO_2 I were found. According to low Tm-CO_2 (-68.3 to -58.4°C), they probably contain minor amount of an another phase (CH_4 or N_2). A population with the lowest Th observed (-27°C to L) may contain 8% CH_4, or 13% N_2. Calculated densities of 0.962 g/cc (CH_4) and 0.947 g.cc (N_2) correspond to 8.2 and 7.5 kbar P at 1100°C, respectively.

Another stone (light blue) hosted only silicate MI. We observed initial melting at about 500°C, but any other progressive changes did not occur until 600°C (the limit for a Linkam THMSG 600 stage). Analysis of samples from Ceské Stredohorí showed Fe-rich silicate M, and mineral I of what is probably calcite and rutile.

A blue corundum from Wilcza Poreba shows some CO_2-bearing I with Th V at 3 to 28°C. Tm-CO_2 is from -62.8 to -62.1°C. The lowest Th corresponds to the density of 0.452 g/cc (28% CH_4), or 0.490 g.cc (30% N_2).

In conclusion, these occurrences are probably associated with alkaline basaltic terraines. The origin of sapphires from other localities is still in doubt. (From authors' abstract by E.R.)

MALININ, S.D. and **KUROVSKAYA, N.A.**, 1997, Mineral solubilities in water-chloride homogenous and heterogenous fluid phases (abst.): IAGOD Newsletter 1997, p. 45. Authors at Vernadsky Inst. of Geochem., Kossygina str. 19 117334, Moscow, Russia.

Fluorite and scheelite solubilities at 600 and 800°C and variable P 0.5 to 2 kbar have been studied. The increase of mineral solubilities in homogenous region of the system NaCl-H_2O with increase of P was found. The dissolution reaction[s] are accompanied by high volume effects, attaining in cube sm/mol (-40) by 600°C and (-243)-(-345) by 800°C in dependence on NaCl-concentrations.

In heterogenous region of NaCl-H_2O F the sharp positive leap of solubilities up to one order of magnitude in correct coordination system has been found.

Such kinds of leaps is the result of the sharp dependence of mineral solubilities on NaCl-concentration in F. Thus, the F disintegration under influence, for example, of P decrease at isothermal conditions will stabilize the mineral forming solubilities, instead of promoting the deposition of mineral phases. Proceeding from the widespread phenomena of F disintegration on the example of NaCl-H_2O system (Bodnar 1985), authors at last period of time have focused on mineral behaviours in heterogenous region of NaCl-H_2O system.

It has been established that in heterogenous region at the system NaCl-H_2O, the mineral solubilities can be described in semi-quantitative and even quantitative approximation both by the NaCl concentrations. These results demonstrate that hydrolyses of NaCl in NaCl-H_2O system doesn't become apparent essentially at 800°C and at heterogenous F, in spite of heterogenised state of F promotes the hydrolytic processes in water-salt systems. Those data create the basis for the forecast of mineral behaviour in the widespread region of heterogenous and homogenous F disposing if minimal volume of experimental data and as well for the simulating of nature mineralization processes at high T-high P conditions. (Authors' abstract)

MALYSHEV, B.I., MIRONOVA, O.F., NAUMOV, V.B., SAVEL'EVA, N.I., SALAZKIN, A.N. and **VOLOSOV, A.G.**, 1997, Fluids of the Hemmerlein skarn-greisen tin deposit, Erzgebirge, Germany: Geokhimiya, 1997, no. 1, p. 179-188, (in Russian, trans. in Geochem. Internat'l., v. 35 no. 2, p. 146-154.) Authors at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, ul. Kosygina 19, Moscow, 117975 Russia.

New data on F composition derived from a study of FI in minerals coupled with an analysis of available data on geologic structure, mineralogy, and geochemistry of the large Hemmerlein skarn-greisen tin deposit suggest an evolution scheme of the ore-forming process. A large amount of carbon dioxide was released during the transformation of a carbonate horizon to pyroxene-garnet skarn. CO_2 under high P filled capillary pores and microcracks of ambient rocks and was entrapped in FI in minerals of the deposit and country rocks. A large aureole with highest CO_2 contents of 4.0-4.5 mol/kg H_2O was produced, which was of importance for subsequent fracturing. The CO_2 concentrations of 1.5 mol/kg H_2O that occur within the deposit decrease successively to early quartz veins (0.57 mol/kg H_2O) and then to ore-bearing veins and veinlets (0.08-0.14 mol/kg H_2O). The F compositions evolved from being rich in CO_2 to being moderately rich in chloride and later to being low-sal chloride-carbon dioxide (during the deposition of cassiterite). The solutions entrapped in cassiterite have high contents of major F components (CO_2, Cl, and F), which could be accounted for by the enrichment in these components and tin due to water incorporation in minerals during the extensive amphibole chloritization in the skarns and mica crystallization in the schists. The SnO_2 deposition [was] associated with a pH increase in solutions. Each subsequent replenishment of solutions decreased pH to neutral or slightly acidic level and caused quartz crystallization. These alternate regimes caused rhythmic precipitation of SnO_2 and SiO_2, which is typical of the Hemmerlein deposit. (Authors' abstract)

MANAC, H.G., LECUYER, C. and **JUTEAU, T.**, 1997, Evolution of hydrothermal circulation in a transform fault context; the Blanco Trough, Juan de Fuca Ridge: Comptes Rendus de l'Academie des Sciences, Serie II. Sciences de la Terre et des Planetes, v. 324, no. 12, p. 993-1000 (in French).

The Blanco Trough (Juan de Fuca ridge) exposes a continuous section of the upper part of the oceanic crust (basalts and sheeted dykes) hydrothermally altered in a transform fault context. Coupled microthermometric measurements on FI and stable oxygen isotope compositions of S phases from the diabase unit were performed to investigate the evolution of hydrothermal F. The existence of a dense fracture network directly linked to the geotectonic transform fault environment has maintained a still hot hydrothermal circulation (about 200°C) rooted down to the top of the diabase unit. (Authors' abstract)

MANGAS, J., PÉREZ-TORRADO, F.J., CLOCCHIATTI, R. and **MASSARE, D.**, 1997, Characteristics of peridotite xenoliths, olivine-pyroxene megacrystals and cumulates from the Bandama volcanic complex (Gran Canaria, Spain) (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 72. First author at Dept. Geol., ULPGC, 35017 Las Palmas, Spain; e-mail (jose.mangas@fisica.ulpgc.es)

MI in olivine phenocrystals from fall deposits and lava flows have SiO_2 content: 39.1-44.2%, sum of alkalis: 5.4-7% and high values of S and Cl (<5,500 and <980 ppm, respectively). These values are similar to the lava whole rock and to the fall mesostasis. The total Th of MI range between 1,100 and 1,290°C. The FI in most of the samples consist of pure, or almost pure, CO_2. These FI show a wide range of Th of CO_2 (-39 to 31°C) in L, indicating minimum depths of mineral formations (at Th: 1200°C) between 12-18 km for olivine megacrystals, 5-27 km for olivine-pyroxene cumulates, 11-25 km for peridotite xenoliths, and 33-8 km for olivine of lava flows. (From authors' abstract by E.R.)

MAPANI, B.S.E., 1995, The use of fluid inclusions in shear zones to determine processes of fluid flow: An example of the Magdala gold mine, Stawell: Zambian J. of Applied Earth Sci., v. 8, no. 1, p. 1-30. Author at School of Earth Sci., Univ. of Melbourne, Parkville 3052, Australia.

The morphology, association and population of FI have been used to deduce information related to the processes that have affected the rocks since trapping occurred. FI from the deformed Magdala quartz vein systems that host gold mineralization are divided into several categories. These categories have each been analysed by Laser Raman Spectrometry (LRS) to obtain F compositions which were contemporaneous with gold deposition.

Sal determinations from the two major shear zones have yielded different values. The younger Scotchmans Fault Zone (SFZ) has low to 0 wt.% eq. NaCl, whereas the older Central Lode System (CLS) has an average of 10 wt.% eq. NaCl. I from the Magdala can be divided on the basis of composition into H_2O-only I, H_2O-CO_2 I and gas-only I with varying sal. This difference implies that there were significant differences in the F histories that led to gold deposition and associated sulphides.

The distribution and chronology of FI has shown that F activity was not a single event but was protracted over a period of time coinciding with precipitation of quartz, sulphide deposition and deformation. (Author's abstract)

MARCOS-PASCUAL, C. and **MOREIRAS, D.B.**, 1997, Characterization of alexandrite, emerald and phenakite from Franqueira (NW Spain): J. of Gemmology, v. 25, no. 5, p. 340-357. Authors at Dept. of Geol. and Inst. of Organometallic Chem., "Enrique Moles," Univ. of Oviedo, Spain.

Illustrates with color photomicrographs previously studied FI (complex two-phase $CH_4 + H_2O$, complex two-phase $CO_2 + H_2O$ and mixed salt two phase). (H.E.B.)

MARESCOTTI, Pietro and **FREZZOTTI, M.L.**, 1997, Manganese-bearing fluids in composite vein systems in the braunite deposit from Molinello mine (Val Graveglia, Northern Apennine, Italy): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 192-193. First author at Dpto. Scienze della Terra, Univ. di Genova, C.so Europa 26, 1-16132 Genova, Italy; email (marescot@dister.unige.it).

The manganese ores of the Northern Apennine ophiolites outcrop within chert sequences mainly as stratiform layers (1-10 m thick) or massive lenses (5-20 m thick). Ores originated in the oceanic basin by concentration of manganese during turbiditic re-sedimentation of hydrothermally Mn-enriched submarine muds.

The P sedimentary oxide assemblages (i.e. low crystallinity Mn oxides and hydroxides were then completely recrystallized to braunite+quartz assemblages under prehnite-pumpellyite facies conditions (T=275±25°C; P=2.5±0.5 kbars). This tectonic event induced mobilization of Mn and Si, and thickening of the mineralized layers.

The interaction between the massive Mn-mineralization and the circulating [H_2O-CO_2?] F formed a reaction rim (1-5 cm) on the wall rock, where the braunite+quartz assemblage is replaced by Mn-silicates (bementite, johannsenite, parsettensite and rhodonite) and carbonates (Mn-calcite and rhodochrosite). F-rock interaction caused water consumption and an increase of the CO_2 content in the residual F.

We have analyzed the FI present in the quartz crystals of the veins. They contain aq solutions; they are biphase (L+V) at room T and have high degrees of filling (0.8-0.9). Growth zones in quartz provide a temporal framework to which the spatial distribution of FI may be referred.

Microthermometric investigations revealed two main F types:

Fluid A in P, Ps and S inclusions: low sal NaCl-KCl-bearing F (≤1.5% in NaCl eq. wt.%; Tm ice is between -0.9 and -0.1°C): Th L is between 150 and 200°C.

Fluid B, in isolated P I: show a distinct microthermometric behaviour. On cooling all I freeze around -50°C and form brownish aggregates. On subsequent heating, the first melting (Te) is observed around -39°C while final melting (Tm ice) takes place between -8.5 and -10.5°C.

SEM analyses in open I indicate that Mn is present. The low Tm ice indirectly suggests a relatively high sal F. However, Cl was never detected during SEM analyses. Raman microspectroscopy reveals that very low density CH_4 is present in the gas bubble, while no CO_2 has been detected.

Isochores of fluid A and B are consistent with the estimated conditions for the metamorphic events at 250-300°C and 2-3 kbars. The distribution of the isochores relative to P, PS and S I, however, indicate an overall decompressional retrograde P-T path. (From authors' abstract by E.R.)

MARFIL, R., LOZANO, R.P., ROSSI, C. and **PERMANYER, A.**, 1997, Constraints on temperatures of quartz cementation in the Middle Jurassic Khatatba Reservoir (Salam Field, northern Egypt): Evidence from fluid inclusions: GAEA 3, 18th IAS, Regional European Meeting of Sedimentology, Heidelberg, Sept. 2-4, 1997, Abstracts, p. 226-227. First author at Dept. of Petrol. and Geochem., U.C.M., 28040 Madrid, Spain.

This paper illustrates the diagenetic evolution of the sandstones establishing the sequence of events in relation to the loss of porosity permeability. Since quartz is the most common diagenetic mineral we have tried to determine the timing and T of cementation measuring the Th for FI trapped within quartz overgrowths. The sources of quartz cement and the effects of hydrocarbon emplacements on quartz and other cements are also considered.

Core samples from between 3,374 m and 3,536 m were analyzed. The diagenetic sequence is as follow: (1) dissolution of feldspar with precipitation of kaolinite and silica remobilization, (2) development of quartz overgrowths, (3) carbonate cements in restricted levels, (4) dissolution and generation of secondary porosity, (5) hydrocarbon emplacement begins, (6) quartz overgrowths, as consequence of pressure-solution, (7) dickite replaces kaolinite, and (8) last pyrite and pyrrhotite cements.

Most FI in quartz occur at the boundary between the detrital grain and the diagenetic overgrowth. They are biphased (L+G). The Th range from 120 to 145°C (av = 133°C). The measured ice melting T are -1.4 and -3.6 and the freezing T indicate sal around 2.31 and 5.78 wt.% eq. NaCl. The Te is <-35°C, which could correspond to the system H_2O-NaCl-$FeCl_2$, due to the presence of Fe minerals trapped in some I. Hydrocarbon-bearing I are not visible.

The main source of quartz cement could be the P-solution reactions in the most pressured sandstones, where no overgrowths are visible, followed by subsequent transport of silica along permeable beds or vertical fractures precipitating into the less pressured levels of sandstones.

The small difference in T between the Th range and the T obtained from vitrinite reflectance (R_0) in the intercalated shales (0.71 to 0.77 and 111.7 to 120°C, respectively) need to be explained. Furthermore, the effects of the time-T, depth and the organic matter reactions on the evolution of the quartz cement in these sandstones, also need to be investigated in depth. (From authors' abstract by E.R.)

MARIANELLI, P., CIONI, R. and SANTACROCE, R., 1997, The history of Vesuvius magma chambers as inferred by melt inclusions in pyroxene (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 55. Authors at Dip.to Scienze della Terra, v. S.Maria 53 56126 Pisa, Italia; e-mail (marianelli@dst.unipi.it)

MI-bearing pyroxenes from selected Vesuvius eruptions were investigated to provide information about the history of the Vesuvius magma chamber. A complex texture (concentric, sector or oscillatory zoning) characterizes the pyroxene from 1906 eruption (open conduit activity). MI along the growth surfaces of crystals show Th from 1060° to 1220°C increasing with MgO content of MI and decreasing with the Fe-content of the host zone. In pumice from explosive eruptions preceded by long quiescence periods, single pyroxenes have nearly constant composition (diopside or salite), generally unzoned, or directly, moderately zoned with gradual core-mantle transition, independently of the composition of the host rock. Th of MI ranges among 800° and 1180°C, well correlating with the composition of the included M and of the host pyroxene. Assuming MI as representative of the magma from which the host mineral crystallized, clinopyroxene with their MI testify the different evolution of Vesuvius plumbing system during periods of open or obstructed conduit conditions. When conduit is open the MI summarize the evolution of resident magma, as resulted of the processes acting throughout the life time of the chamber, characterized by an easy thermal perturbability of the resident magma due to its moderate volume. The oscillatory zoning of pyroxene and the variability of Th within single crystals record thermal and compositional fluctuations, with "hot" diopsidic zones marking the recurrent hot magma inputs. When the conduit is obstructed, larger magma chambers form following the periodical arrival of deep magma batches. Diopside results from rapid crystallization of these batches before reaching thermal equilibrium and mixing with resident magma. In diopside, MI record the compositional range of deep batches while glass I in salite summarize the M evolution within the chamber. (Authors' abstract)

MARIGNAC, Christian, CATHELINEAU, Michel, BANKS, David, BOIRON, M.-C., AYT OUGOUGDAL, Mohammed, ARGOUARC'H, Yann and POTY, Bernard, 1997, Alpine fault sealing at the contact between a crystalline basement and its sedimentary cover: La Gardette (French Alps): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 194-195. First author at EMN and CRPG-CNRS, BP 20, F-54501 Vandœuvre-lès-Nancy Cedex.

The La Gardette vein Au deposit was first mined for gold but is mostly known for its famous elongated and clear colourless quartz crystals. The now usually called Japan law twin has been discovered in 1829 in this deposit.

A great part of the studied FI are S and trapped at the bases of the quartz crystals, probably during the tectonic reactivation of the vein. They are two phases (L/V), but contain frequently a solid phase displaying a spiny shape. The solid has been identified by Raman spectroscopy as a silicate, probably a K-mica. Most also display a low density volatile phase, which is identified mostly by the melting of a clathrate around 3 to 7°C. Tm ice=-4 to -8°C range. Tm ice varies among groups of I in a sample and depends also on the sample location within the vein. Final Th occurs within a rather wide range of T from 165 to 215°C.

Rather significant differences characterize the different populations of I found within one crystal, or within a given part of the vein. At least three end-members are distinguished: 1) a $CO_2(N_2)$-rich end member characterized by rather high Th around 205 to 210°C, and low Tm ice around -7 to -8°C. This F can be related to the F described by Poty (1969), and is considered associated to the growth of quartz crystals; 2) a CH_4-N_2 rich end member characterized by slightly less saline features (Tm ice around -4 to -5°C) and low Th around 165 to 170°C; and 3) a dilute F in the sedimentary cover, characterized by low sal (Tm ice=-0.5°C/-2°C) (Poty, 1969).

A nearly continuous trend is observed between the two first types. The overall consideration of the data give a trend in the Tm ice-Th diagram from the low Th-low sal F found in the sedimentary cover, and the high Th-high sal F. This trend could attest of significant F mixing within the fault.

The samples have been studied by crush-leach techniques. The F are characterized by rather low K/Na ratios, as the F described in the Mont Blanc granite in relation with the CO_2-rich F responsible for the quartz-ankerite-muscovite assemblage. The K/Na ratios indicate the lack of equilibrium of the F with two feldspars, this being in good agreement with the crystallization of K-micas within the vein and in the wall-rocks.

The La Gardette F display rather high Br/Cl ratios, which could attest of a Br enrichment in sediments.

Two processes yield the host quartz: dewatering and illitisation of liassic schists producing a silica-rich F, or rhythmic P changes, which is attested by: i) the repeated microfissuring of the quartz crystals, and banded texture of sheared zones, ii) the rather wide range of P (150-320 MPa) calculated at an estimated T of 300-350°C, which is assumed to be rather constant during quartz precipitation. This behaviour of the fault suggests analogies to Sibson's model of seismic valve, although the geometry of the La Gardette fault is somewhat different than the Canadian reverse faults. (From authors' abstract by E.R.)

MARKL, Gregor, 1997, Cassiterite-bearing greisen assemblages and beryl-bearing pegmatites in the leucogranite of the Triberg granite-complex, Schwarzwald: Jh. geol. Landesamt Baden-Württemberg, v. 36, p. 7-51 (in German, Engl. abst.). Author at Institut für Mineralogie, Petrologie und Geoschemie, Albert-Ludwigs-Universität, Albertstraße 23 b, D-79104 Freiburg.

Within the Tribert granite-complex pegmatites (partly beryl-bearing) and cassiterite-bearing greisen assemblages occur only in a leucogranitic unit. The latter ones form by the reaction of late-magmatic F accumulated in the roof-pendant of the pluton with the cooled rim of the granite body, preferentially along fractures. The granite is thereby altered to typical quartz-mica-rocks with cassiterite±topaz±fluorite±apatite. Where the F were able to react with beryl-bearing pegmatites the beryl was corroded and the beryllium was subsequently either transported away or precipitated as new Be-mineral (second beryl-generation or phenakite). The T and chemical properties of the F were investigated using FI in beryl and cassiterite as well as thermodynamic calculations concerning mineral stabilities and mineral-F equilibria. In the course of this study it could be shown that T and fluorine-content of the F decrease with increasing distance from the center of greisen activity near Niederwasser from about -550°C, ~0.06 mol HF/l at 1500 bars to about ~250°C, ~0.0016 mol HF/l at 1500 bars. The maximum distance between cassiterite-bearing greisens and the center at Niederwasser is about 4 km. (Author's abstract)

MARKL, Gregor, MUSASHI, Masaaki and **BUCHER, Kurt,** 1997, Chlorine stable isotope composition of granulites from Lofoten, Norway: Implications for the Cl isotopic composition and for the source of Cl enrichment in the lower crust: Earth and Planetary Sci. Letters, v. 150, p. 95-102. First author at Inst. für Mineralogie, Petrologie und Geochemie, Albert-Ludwigs-Univ., Albertstrasse 23 b, D-79104 Freiburg, Germany.

The Cl isotopic composition of lower crustal granulites from the Lofoten Islands, Northern Norway indicates that there was only minor involvement of mantle-derived Cl in fluid-involving processes in the middle and lower crust. Assuming a $\delta^{37}Cl$ of 4.7‰ for the undegassed mantle, Cl isotopic values of the granulites do not support the influx of significant amounts of mantle derived Cl. The maximum possible mantle contribution to the sample with the highest $\delta^{37}Cl$ is about 33%. Thus, the common occurrence of Cl-enriched minerals in granulite facies terrains is regarded as a product of remobilized crustal Cl, either during magmatism or during later F activity. The results support the hypothesis that the crust can be regarded as a reservoir with Cl isotopic values very similar to Standard Mean Ocean Chloride. (From authors' abstract by E.R.)

MARKL, Gregor and **SCHUMACHER, J.C.,** 1997, Beryl stability in local hydrothermal and chemical environments in a mineralized granite: Amer. Mineral., v. 82, p. 194-202. Authors at Institut für Mineralogie, Petrologie und Geoschemie, Albert-Ludwigs-Universität, Albertstraße 23 b, D-79104 Freiburg.

The T and chemistry of hydrothermal F control the breakdown and formation of beryl in rocks of appropriate bulk composition. In rocks of the Triberg granitic complex in the Schwarzwald, Germany, late-magmatic to hydrothermal greisen F interacted with beryl-bearing pegmatites and the leucogranitic host rocks over a range of T, but the greisen overprint was not pervasive. As a result, it is possible to examine the effects of the greisen F on beryl stability and the host granitic rock over a range of T. Replacement of P (pegmatitic) beryl resulted in the formation of S beryllium minerals. At high T (~550°C), gem-quality aquamarine was precipitated in vugs with alteration halos of albite, muscovite, cassiterite, and fluorite. At lower T (~250°C), blue anhedral beryl replaced potassium feldspar in granite adjacent to fractures. At slightly lower T (~220-230°C), pegmatitic beryl was replaced by kaolinite±bertrandite±phenakite.

Calculated activity and phase diagrams suggest that precipitation of S beryl depends chiefly on variations in the ratio Na/K in the F. These same F were responsible for the albite and white mica formation in the surrounding granite. Further, the effective F-to-rock ratio determines the progress of the alteration reactions, which in turn determines the ability of the F to precipitate beryl. On the basis of FI measurements and the activity-diagram calculations, a pH of about 5 (at ~550°C and 4% NaCl eq.) was estimated for the F that caused the mineralization. (Authors' abstract)

MARSHALL, D., KIRSCHNER, D. and **BUSSY, F.,** 1997, A Variscan pressure-temperature-time path for the NE Mont Blanc massif: Contrib. Mineral. Petrol., v. 126, no. 4, p. 416-428.

Indexed under FI (E.R.)

MARSHALL, D., MEISSER, N. and **TAYLOR, R.P.,** 1997, Fluid inclusion, stable isotope and Ar-Ar evidence for the age and origin of gold-bearing quartz veins at Mont Chemin, Switzerland: Mineral. and Petrol., 1998, v. 62, p. 147-165. First author at Inst. of Mineral. and Petrog., Univ. of Lausanne, Switzerland.

A new Swiss gold occurrence at Mont Chemin, comprising gold-bearing quartz veins, displays many characteristics that are typical of mesothermal gold deposits within the Alps and globally. The most notable of these features are: i) the presence of $NaCl-H_2O-CO_2$-bearing F with an XCO_2 of approximately 0.016 and NaCl equivalents in the range 4.6 to 10.6 wt.%, ii) greenschist formational T and P in the range 265-285°C and 700-1400 bars; and iii) the proximity of the occurrence to the Rhone-Simplon Line, a deep crustal structure in the Swiss Alps.

Corrected Ar-Ar data for hydrothermal adularia, considered to be contemporaneous with mineral deposition from the gold-bearing F, yields an age of 9.9±1.0 Ma. Geothermal gradients and uplift rates derived from the Ar-Ar age data and the geothermometry are in agreement with existing data for this region, and indicate that the hydrothermal activity at the Mont Chemin gold occurrence records one of the last Alpine metamorphic events in the northeastern Mont Blanc massif.

T estimates from F-muscovite-quartz-feldspar equilibrium and oxygen isotope thermometry of coexisting adularia and quartz are combined with the FI isochores to derive depositional P. These data yield geothermal gradients on the order of 50°C/km and uplift rates of 0.44 mm/a for the NE portion of the Mont Blanc massif. (Authors' abstract)

MARSHALL, Dan, PFEIFER, H.-R. and **HUNZIKER, J.C.,** 1997, Alpine pressure-temperature-time path for the NE Mont Blanc massif: Fluid inclusion, isotopic and thermobarometric evidence: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 196-197. Authors at Inst. of Mineral. and Petrog., Univ. of Lausanne, Switzerland.

FI, F-mineral equilibria, stable and radiogenic isotope studies have been used to derive P, T, age (PTt) and F composition constraints for a number of Alpine events.

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.)

MARTIN-C,T., LOPEZ, J.A., BANKS, D. and **VINDEL, E.,** 1997a, Composition and origin of fluids associated with barren quartz veins, Spanish Central System: Boletin Sociedad Espanola de Mineralogia, v. 20-A, p. 53-54.

Indexed under FI (E.R.)

MARTIN-CRESPO, T., LÓPEZ, J.A., BANKS, D. and **VINDEL, E.,** 1997b, Fluids associated with late orogenic quartz veins (Spanish Central System): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 198-199. First author at Dept. Cristalografia y Mineralogía, Univ. Complutense, 28040 Madrid, Spain; email (jangel@eucmax.sim.ucm.es).

The Spanish Central System has been subjected to repeated F incursions which were responsible for different mineralisation including W-Sn, Cu-Zn-Pb sulphides and F-Ba. One of the last F events is recorded by barren quartz veins. The aim of this study is to compare these late F with the earlier F associated with W and fluorite mineralisation of the Spanish Central System.

The FI are trapped as P and S aq I in well-formed quartz crystals in the central part of the barren quartz veins. Three types of FI have been recognized; all are aq with no C-H-O-(N-S) species:

1) Lwl I are H_2O-$CaCl_2$-(NaCl) L+V, and are P. They are P I in the center of the quartz crystals. Low Te=-50 to -40°C; Tm ice=-0.4 and 0°C indicating a sal of 0. to 0.7 wt.% eq. NaCl; Th=170-295°C.

2) Lw2 I are P, contain H_2O-NaCl-$CaCl_2$. Tm hydrohalite=between -12 and -4.5°C, and Tm ice between -24 and -25.5°C. The sal is ~25 wt.% eq. NaCl, and Th=90 to 160°C.

3) Lw-s I are generally 3-phase with one or more dxl, halite and/or sylvite, as well as trapped carbonates, plagioclases and phyllosilicates, (identified by SEM+EDS). They are S I, post-dating the former types and represent the latest event in the hydrothermal activity. They have a sal from 29-35 wt.% eq. NaCl.

FI associated with W(Sn) veins contain H_2O-NaCl-CO_2-(CH_4) L and show two or three F phases at room T. Sal=0.2 to 2 wt.% eq. NaCl, Th=between 210 and 410°C. Late aq H_2O-NaCl F have low to moderate sal (1 to 9 wt.% eq. NaCl) and Th ranging between 140-380°C. Aq FI in fluorite show Th in the range 150-270°C, and Tm ice between -7 and 0°C (0-10.5 wt.% eq. NaCl) with a maximum between -4 and -1°C.

Cl/Br (molar) ratios were determined using the technique in Yardley et al. (1993). The oldest W-Sn veins have Cl/Br ratios averaging 1010 which are similar to those recorded for similar mineralisation in western Europe. Intermediate age fluorite F have Cl/Br 3850 which when combined with the low sal is suggestive of dissolution of evaporites by low sal water. The youngest F in the barren veins have Cl/Br averaging 710 representative of the higher sal F. This is close to the ratio for evaporating seawater (655) prior to halite precipitation.

In conclusion, the data suggest that the different types of veins of different age came from different sources. It will be necessary to revise the prevailing model of the hydrological evolution of the Spanish Central System that extends from 200 M.y. and to analyse the relation between the oldest and youngest hydrothermal events. (From authors' abstract by E.R.)

MARTY, Bernard, 1997, Neon signs mark Australian plume: Nature, v. 388, 10 July, p. 127-129.

A discussion of paper by Matsumoto et al (this volume) and the apatite-inclusion explanation. (E.R.)

MARTY, Bernard and **HUMBERT, Franck,** 1997, Nitrogen and argon isotopes in oceanic basalts: Earth and Planetary Sci. Letters, v. 152, no. 1-4, p. 101-112.

In order to document the isotopic composition of nitrogen in the convective mantle, we have analysed nitrogen isotopes together with argon isotopes in oceanic basalt glasses. Gases were extracted from FI by crushing and, after removal of interfering compounds, were analysed by static mass spectrometry. The results show that, of the 25 samples analysed, 12 have $\delta^{15}N$ values between -1.4 and -6.5 per mil relative to the atmospheric composition, 8 have $\delta^{15}N$ close to 0 per mil, and 5 present enrichments in $\delta^{15}N$ (from +2.1 to +5.4 per mil). A comparison between nitrogen and argon isotopic ratios suggests mixing between a surface-derived component enriched in $\delta^{15}N$ and a mantle end-member characterised by extremely high $^{40}Ar/^{36}Ar$ ratio and depletion in $\delta^{15}N$ of about -3 to ca. -5 per mil relative to atmospheric N. Such isotopic compositions and the very high $N/^{36}Ar$ ratios compared to the atmospheric value of these mantle-derived samples are difficult to reconcile with derivation of atmospheric N_2 from the convective mantle through time, and are more consistent with early volatile fractionation in the Earth-Atmosphere system. (Authors' abstract)

MATHIEU, R., CUNEY, M., CATHELINEAU, M., DUBESSY, J., PIRONON, J., BOIRON, M.-C. and **GAUTHIER-LAFAYE, F.,** 1997, Fluid movements in Franceville basin and around the Oklo nuclear reaction zones (Gabon): Synthesis of the fluid inclusions data and new geochemical characteristics: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 200-201. First author at CREGU and EP578, BP23, 54501 Vandœuvre lès Nancy Cedex, France; email (mathieu@cregu.cnrs-nancy.fr).

The purpose of this contribution is to provide new geochemical characterization of F (gas at low concentrations, ionic ratios, hydrocarbon compound characterization) using micro-Raman, Laser ablation optical emission and micro-FTIR spectroscopies on FI from samples previously characterized by microthermometry from Openshaw et al. (1978) and an overview of the P-T-X-t evolution of the F in the basin and around Oklo nuclear reactors from already published data (mostly microthermometric). Five groups of FI are distinguished, and related to five different F circulation events:

(I) Siliceous diagenesis registered in quartz overgrowths and quartz-bitumen veins (2030 Ma). Th and Tm ice range respectively between 100 to 300°C, with a mode around 140-180°C and -1 to -6°C, corrresponding to 3-10 wt.% eq. NaCl. They contain low density CH_4 component in the V phase. Na/Ca ratios are around 0.7 to 1.4 similar to those from oil field basins, but rather low Na/K ratios (2.2-2.8) reflecting the lack of equilibrium between the F and feldspars. The burial P has been the subject of different estimations.

(II) Reactor functioning registered in quartz overgrowths and quartz veins (1970 Ma). Th and Tm ice range respectively between 250 and 500°C and -1 to -6°C, corresponding to 3-10 wt.% eq. NaCl. New Raman microspectroscopy shows a low density volatile V phase, H_2O and CO_2, which could be attributed to oxidation processes of the C compounds in the vicinity of the reactor zone. These F display similar Na/K, Na/Li and Na/K ratios as F from group I. Some I display hydrocarbon compounds identified by fluorescence microscopy. Micro FTIR spectroscopy shows that the CH_2/CH_3 ratios range from 2.3 to 2.8. Thus, these F contain an equivalent of decane without gas.

(III) Reactor cooling registered in apatites, quartz veins, quartz overgrowths and calcite veins (<1970 Ma, during 2 Ma). Th and Tm ice are between 150 and 380°C and -20 and -6°C, respectively.

(IV) Carbonate diagenesis registered in calcite-UO_2-bitumen-veinlets, quartz-calcite veins and dolomite in surrounding rocks (1900 Ma). Th and Tm ice of these range respectively between 100 and 140°C and -40 and -15°C, representing very high sal and suggesting the presence of divalent cations.

(V) Intrusion of dolerite dyke registered in FIP of some calcite veins and quartz included in galena (780 Ma). Th and Tm ice range respectively between 110 and 260°C, with two modes around 140 and 250°C and -19 to -13°C, corresponding to 18-20 wt.% eq. NaCl. This event is responsible of lead migration. No volatile or hydrocarbon component was detected in F from this group. (From authors' abstract by E.R.)

MATSUMOTO, T., HONDA, M., McDOUGALL, I. and O'REILLY, S.Y., 1997, Noble gases in anhydrous lherzolites from the Newer Volcanics, southeastern Australia: a MORB-like reservoir in the subcontinental mantle: (abst.) The Australian National Univ. Research School of Earth Sci., Annual Report 1997, p.156-157.

The elemental and isotopic composition of noble G trapped in mantle-derived samples, such as in basalts erupted at mid-oceanic ridges (MORBs) and from intraplate settings associated with plumes (e.g., Hawaii, Réunion, Samoa, Kerguelen), have provided unique and important constraints on the evolution of the solid Earth and its atmosphere. However, in contrast to the relatively abundant data obtained from samples derived from the suboceanic mantle, data from samples from the subcontinental environment are scarce.

Abundances of all five noble G were determined from nine anhydrous spinel-lherzolites from five eruption centres in the youthful Newer Volcanics, southeastern Australia. These anhydrous lherzolites are considered to be compositions representative of the upper lithospheric mantle. A MORB-like component was found in the samples. The MORB-like noble G component is most clearly found in G released in crushing experiments. Thus, it is likely that this component is trapped in CO_2-rich FI in these samples, and is probably of metasomatic origin, having been introduced into the lithospheric mantle by M derived from the asthenospheric mantle source. Noble G dissolved in the metasomatising M would be effectively decoupled from LILE (large ion lithophile elements) during segregation of CO_2-rich F in the ascending M, because the noble G would be partitioned into the CO_2-rich F whereas the LILE would remain in the M phase. Metasomatic addition of the LILE-enriched M to mantle wall-rock is probably responsible for the previously reported highly variable REE abundance patterns and Nd and Sr isotopic ratios in the xenoliths. In contrast, once trapped within the mantle wall-rocks, noble G in CO_2-rich FI would preseve their source signatures without being affected significantly by the ingrowth of radiogenic and nucleogenic products, as U, Th and K would not be partitioned into the CO_2-rich F phase. The predominant occurrence of MORB-like noble G signatures in FI of the xenoliths is interpreted as indicating that the majority of volatiles, and possibly metasomatising LILE-enriched components, in the lithospheric mantle, were derived from the underlying asthenospheric mantle in southeastern Australia. (From authors' abstract by E.R.)

MATSUMOTO, Takuya, HONDA, Masahiko, McDOUGALL, Ian, YATSEVICH, Igor and O'REILLY, S.Y., 1997, Plume-like neon in a metasomatic apatite from the Australian lithospheric mantle: Nature, v. 388, no. 6638, p. 162-164. First author at Research School of Earth Sci., The Australian Nat'l. Univ., Canberra, ACT 0200, Australia.

The nature of metasomatizing F and M in the mantle are of interest for understanding the chemical evolution of the Earth's interior. The study of noble-gas isotopes in appropriate mantle-derived samples has the potential to provide valuable insight into this question, by constraining the origin of the F and the timing of metasomatic events. Here we report the application of neon-isotope systematics to investigate the metasomatic history of apatite grains in spinel-lherzolite xenoliths from the Australian lithospheric mantle. We find that the apatite has a neon-isotope signature similar to that associated with plume-related volcanism, as is found in Hawaii, whereas coexisting mineral phases (olivine and amphibole) and non-apatite-bearing lherzolites have isotope signatures more typical of mid-ocean-ridge basalts. The occurrence of plume-like neon in the apatite implicates deep plume-like material beneath southeastern Australia as the source of the metasomatizing agent. (Authors' abstract)

The most plausible candidate for the site of the plume-like neon would be FI would occur at T below that of apatite melting (~1,600°C). If this is the case, then the high confining P in the mantle would prevent decrepitation of the I, and F$^-$ crystal partitioning would prevent diffusive loss of neon from the I. From authors' text (E.R.)

See also discussion by Marty, this volume (E.R.)

MATVEEV, S., BALLHAUS, C., FRICKE, K., TRUCKENBRODT, J. and ZIEGENBEIN, D., 1997, Volatiles in the Earth's mantle: I. Synthesis of CHO fluids at 1273 K and 2.4 GPa: Geochim. Cosmo. Acta, v. 61, no. 15, p. 3081-3088. First author at Max-Planck Inst. für Chemie, Abteilung Kosmochemie, 55122 Mainz, Germany.

We have synthesized graphite-saturated CHO F at 1273K and 2.4 GPa over 7.5 orders of magnitude in fO_2. Bulk H/O of the F ranges from 1.78 (oxidized F in the H_2O-CO_2 stability field) to 1330 (highly reduced F at the Si-SiC buffer). The maximum H_2O content at 1273K and 2.4 GPa at the water maximum (H/O) = 2) is 95±1 mol%. Molar H_2 is <0.05% in the CO_2 stability field (H/O<2), 1.5±0.5% at the H_2O maximum, and 6.5±1% in pure C-H F. Molar C_2H_6 ranges from <0.05% at the H_2O maximum to 2% in a pure C-H F. Molar H_2/C_2H_6 and H_2/CH_4 are independent of the bulk H/O of the F over a wide range in H/O, indicating that internal reaction rates amongst F species are faster than H_2 loss. Experiments quenched with variable cooling rates show that CHO F preserve their high P-T species distribution during quenching, provided maximum quench rates are employed. (Authors' abstract)

MATVIYENKO, Alexander, SAKHNO, Bogdan and IVANOV, Boris, 1997, Physical-chemical conditions of spodumene-petalite pegmatite formations in the central part of the Ukrainian shield: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 202. First author at Naukova Str., 3a, 290053 Lviv, Ukraine.

Two types of pegmatites were distinguished by mineralogical features: quartz-albite-spodumen-petalite (productive) and quartz-microcline (non-productive). The gases, by MS, were mainly carbon dioxide (about 81%) and nitrogen (about 44%) [sic]; methane does not exceed 5.3%. CO_2 increases toward quartz-petalite-microcline. Four stages can be recognized:

Early quartz-microcline pegmatite 660-580°C;

Quartz veins in amphibole xenolites 600-440°C;

Middle T stage of pegmatite formation 400-220°C, and influx of Li; and

Late stage pegmatite formation 180-100°C and petalite replacement by spodumene.

(From authors' abstract by E.R.)

MAYANOVIC, R.A. and ANDERSON, A.J., 1997a, Bond contraction in iron (II) and zinc chloride complexes occurring under hydrothermal conditions in fluid inclusions: Abstracts of Papers, Part 1, 214th ACS Nat'l. Meeting, American Chemical Society, Sept. 7-11, 1997, Las Vegas, NV (abst. #031, Div. of Geochemistry). Authors at Dept. of Physics and Astronomy, Southwest Missouri State Univ., Springfield, MO 65804.

The structure and bonding properties of metal ion complexes in near-critical and supercritical F are still largely unknown. We have measured both Fe and Zn K-edge microbeam XAFS spectra from a single FI (in quartz) at a time, in the T range 25-500°C. Analysis shows that the $ZnCl_4^{2-}$ complex is predominant at all measured T while the $FeCl_4^{2-}$ complex becomes predominant at 400°C and remains so up to 500°C. Both the Zn-Cl and Fe-Cl bond lengths were found to decrease uniformly with T, by roughly 0.5%/100°C. A mechanism which may account for the contraction of the bond lengths could be due to a progressive reduction of the dielectric constant of the F, leading to enhanced Zn or Fe 3d (t_{2g}) and Cl 3p orbital interaction with T and resulting in a greater repulsion between t_{2g} and 3_g bonding versus antibonding ligand orbitals. (Authors' abstract)

MAYANOVIC, R.A. and ANDERSON, A.J., 1997b, Micro-beam XAFS studies on fluid inclusions under hydrothermal conditions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 203-204. First author at Dept. of Physics and Astronomy, Southwest Missouri State Univ., Springfield, MO 65804.

Synchrotron micro-beam X-ray absorption fine structure (XAFS) spectroscopy is ideally suited for structure studies on constituents of FI for many reasons, and in particular it can be very useful for the determination of structure of complexed and/or hydrated metal ions in FI at T ranging from 25 to 500°C.

We have successfully measured T-dependent XAFS spectra from individual FI in quartz found in the pegmatites from the Saxon Granulite Massif, Germany. The synchrotron X-ray beam is made monochromatic using a single Si(111) channel-cut crystal and focused with a 8:1 ellipsoidal Al (Pt coated) mirror, giving a flux of ~1×10^5 photons at 230 mA of stored electron current. We have been able to collect XAFS spectra, at either the Zn, Fe, or Cu K edge, from I having a mean diameter ranging from 40 to 80 µm and having a minimum target metal (Zn, Fe, or Cu) concentration of roughly 100 ppm.

Data are analyzed using the Univ. of Washington software package, according to the principles outlined by Sayers and Bunker (1988). From such studies, we showed that there are roughly four chlorine ligands coordinated to each Fe ion in the iron complex at a distance of 2.26 Å at 400°C. (From authors' abstract by E.R.)

McCONNELL, V.S., VALLEY, J.W. and EICHELBERGER, J.C., 1997, Oxygen isotope compositions of intracaldera rocks: Hydrothermal history of the Long Valley Caldera, California: J. of Volcanology and Geothermal Research, v. 76, p. 83-109. First author at Geophys. Inst., Univ. of Alaska Fairbanks, P.O. Box 757320, 903 N. Koyukuk Dr., Fairbanks, AK 99775-7320.

The Bishop Tuff and associated rocks filling Long Valley Caldera, California, represent a case where thick and relatively uniform geologic units of known initial compositions have been subjected to a strong geothermal F flux within an enclosed basin. Samples from the Long Valley Exploratory Well (LVEW) centered on the resurgent dome show a present-day T maximum of ~100°C, and the geothermal gradient is 50°C/km. Fossil hydrothermal water, trapped in FI in hydrothermal vein quartz hosted by intracaldera rocks, has a calculated oxygen isotope composition of -10.2‰ based on chemistry and Tt. This is 4‰ heavier than the average value for the present-day hydrothermal water and consistent with higher T and water/rock ratios. (From authors' abstract by E.R.)

Three average values of Th are given (p. 98) for vein quartz: 204, 230 and 245°C. (E.R.)

McCUAIG, T.C. and **KISSIN, S.A.**, 1997, The Port Coldwell veins, northern Ontario; Pb-Zn-Ag deposits in a rift setting: Geological Society of America, Special Paper v. 312, p. 187-194.

Indexed under FI (E.R.)

MEINERT, L.D., 1997, High salinity brines, phase separation, and ore deposits: Evidence from the Big Gossan Cu-Au deposit, Ertsberg district, Irian Jaya (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-359.

See next item (E.R.).

MEIER, Stefanie and **KLEMD, Reiner**, 1997, Cooling and uplift history of selected syenite pipes of the Phalaborwa Igneous Complex, South Africa; evidence from microthermometry and petrography: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 205-206. Authors at Fachbereich Geowissenschaften, Univ. Bremen, Postfach 330440, 28334 Bremen, Germany; email (stmeier@geopol.uni-bremen.de).

Phalaborwa is the second largest open-cast copper mine in the world and the largest in Africa. Its economic importance is mainly based on low grade copper mineralisation and furthermore it is mined for apatite, vermiculite and magnetite. The Phalaborwa carbonatite complex intruded into the Archean basement in early Proterozoic times and represents the oldest known carbonatite complex of the southern African continent.

The petrography of the brecciated syenites shows that all samples have undergone a moderate fenitization. The fenitizing F emanate from alkali-silicate and carbonatite magmas and overprint the surrounding rocks metasomatically.

Microthermometric investigations were carried out on FI for types (generations) of quartz veins within syenite breccias. Type A inclusions contain L water, a V bubble and a halite dm (28-41 wt.% eq. NaCl). They homogenize by halite disappearance at 127-341°C. Type B inclusions are S and abundant in all samples. They contain L H_2O and a V bubble (13-17 wt.% eq. NaCl). Th varies from 125 to 250°C. Type C inclusions consist of an aq phase (13-20 wt.% eq. NaCl), CO_2 and occasionally a CO_2-bearing V phase, and are assumed to be P or PS origin. Th is ~400°C. Type D inclusions are probably P and contain L H_2O, an euhedral halite dm (30-35 wt.% eq. NaCl)., L CO_2 and sometimes have a CO_2-rich V phase. They decrepitate below Th.

In chronological order, FI of type D became trapped first. The estimated PT-range is 700°C and 5 kbar. The CO_2-bearing, hypersaline FI became trapped during the precipitation of quartz in a late magmatic stage of silication. After silication took place, the Complex has undergone an almost isochoric cooling and exhumation to T of about 400°C and P of 2±0.5 kbar when FI of type C became trapped. Erosion proceeded and the Complex was further uplifted.

During this slow isochoric uplift, the hypersaline brines (40-41 wt.% eq. NaCl) of type A became trapped at ~350°C and 5 kbar. This type A fluid underwent a rapid isochoric exhumation to 150°C and 0.75 kbar correlated with a depletion in NaCl, yielding I of type A with lower sal (28--35 wt.% eq. NaCl) and low Th (127-341°C). The trapping of type B I abundant in all samples represents the final stage. They circulated at 125-250°C and 0.5-1 kbar after all syenite pipes were exposed to the same level. (From authors' abstract by E.R.)

MEINERT, L.D., **HEFTON, K.K.**, **MAYES, David** and **TASIRAN, Ian**, 1997, Geology, zonation, and fluid evolution of the Big Gossan Cu-Au skarn deposit, Ertsberg district, Irian Jaya: Econ. Geol., v. 92, no. 5, p. 509-534. First author at Dept. of Geol., Washington State Univ., Pullman, Washington 99164-2812; email (meinert@wsu.edu)

The Big Gossan Cu-Au skarn deposit is the highest grade copper deposit in the world-class Ertsberg district, Irian Jaya. Most mineralization and alteration occurs in the purer carbonate rocks although biotite and calc-silicate hornfels alteration also occurs in the footwall rocks adjacent to mineralization.

Prograde skarn alteration consists dominantly of pyroxene and garnet. The skarn is zoned in three dimensions relative to the main F conduit along the Ekami-Waripi contact, and chalcopyrite and anhydrite are present in all skarn zones. Skarn zonation in terms of mineral ratios, colors, and compositions can be used for exploration on both a local and district scale.

In addition to mineralogy, Big Gossan is zoned with respect to metals. All except Mo increase toward the top of the system. F associated with prograde skarn are high-T, low CO_2 (<0.05 mol%), NaCl-KCl brines. P-corrected T for FI in prograde skarn range from 360 to 535°C and average 460°C. Most pyroxene FI contain multiple dm including halite, sylvite, chalcopyrite, hematite, and anhydrite. Total sal ranges from 38 to 65 wt.% NaCl+KCl and mean sal are 22 wt.% KCl, 35 wt.% NaCl, and 57 wt.% NaCl+KCl. FI in quartz and anhydrite associated with retrograde alteration homogenize from 250 to 410°C and average 369°C. These FI do not contain dm, average 7.1 wt.% NaCl eq., and are V rich with evidence for boiling at T of 370 to 380°C. This corresponds to a P of 20 MPa and a depth of 2 km under hydrostatic conditions. P-depth reconstructions from FI data indicate that 1.4 km of erosion has occurred in the Ertsberg district in the past 4 million years.

Both the high- and low-T F can be modeled as originating from 6-9 wt.% solutions, most likely exsolved from an underlying pluton, which followed different cooling paths on ascent such that the early F reached its solvus at high T and the later F did not. This resulted in the early F separating into a hypersaline brine, whereas the later F maintained its original sal. (From authors' abstract by E.R.)

MELCHER, Frank, **GRUM, Walter**, **SIMON, Grigore**, **THALHAMMER, Tatiana** and **STUMPFL, E.F.**, 1997, Petrogenesis of the ophiolitic giant chromite deposits of Kempirsai, Kazakhstan: A study of solid and fluid inclusions in chromite: J. of Petrol., v. 38, no. 10, p. 1419-1458. First author at Inst. of Geological Sci., Univ. of Leoben, 8700 Leoben, Austria.

Chromites forming giant orebodies in the Kempirsai massif contain a large number of I, of silicates, sulphides, alloys, arsenides, and F. Three textural types of I in chromite are distinguished: (1) In Main Ore Field chromites, P silicate I generally have high mg-number (>95), Cr and Ni, and are dominated by pargasitic amphibole, forsterite, diopside, enstatite and Na-phlogopite.

Chromite formed over a T range from ~1200 to <1000°C at oxygen fugacities 1-2 log units above the fayalite-magnetite-quartz (FMQ) buffer. A diversity of P and S platinum-group minerals (PGM) is described, including alloys, sulphides, sulpharsenides and arsenides. (2) In addition to P PGM and hydrous silicates, FI of up to 50 µm size are frequently included in chromite within chromite-amphibole veins discordant to massive chromitite in the Main Ore Field. The F are low to moderately saline, sodium-dominated aq solutions with complex gas contents. Variable amounts of water, hydrogen, hydrocarbons, CO_2 and N have been determined in I-rich samples. (3) In the northern and western part of the Kempirsai massif, complex silicate-oxide I assemblages formed in small orebodies of orbicular Al-rich chrome spinel. The formation of chromitite in the Kempirsai massif is explained in terms of a multistage process involving mantle F. The large orebodies and the amphibole-chromite veins in the southern part formed later from interaction of hydrous, second-stage high-Mg M and F with depleted mantle in a convergent tectonic setting. Metasomatic alteration of the mantle wedge above subducted crust by F played an important role in generating second-stage M and in releasing metals. (From authors' abstract by E.R.)

File analyses are given of the composition and F phases in purified chromite (Table 8, p. 1428). H_2O and H_2 are majors, plus minor amounts of CH_4 (one sample 5.7 mol%), C_2H_6, C_3H_8, N_2, CO and CO_2, and <0.01 mol% of H_2S and SO_2. (E.R.)

MELCHER, F., GRUM, W., THALHAMMER, O.A.R. and STUMPFL, E.F., 1997, Giant chromite deposits and their host rocks, Kempirsai, Urals: An integrated study of precious metals, rare earth elements, stable and radiogenic isotopes, and the composition of fluid inclusions in chromite: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 479-482. Authors at Inst. of Geological Sci., Univ. of Leoben, Austria.

Sm-Nd, Rb-Sr, Re-Os, Ar-Ar, stable (O, D, C) isotope investigations, and FI studies led to a new, two-stage model of the formation of giant ophiolitic-podiform chromite orebodies of the Kempirsai massif, Southern Urals. In a first stage (420 to 395 Ma), fertile mantle was melted in an extensional setting, producing basaltic magma from which small bodies of low-Cr, high-Al chromite precipitated in conduits within the uppermost mantle. In a second stage, oceanic crust of the northwestern part of the massif, covered by sediments, was subducted underneath the southeastern part. Sediments of continental affinity dehydrated under eclogite-facies conditions, inducing a second melting event in the overlying, already depleted mantle wedge. Mg-rich M and volatiles percolating large parts of this mantle wedge mobilized Cr, Mg, and platinum-group elements. Large bodies of high-Cr chromitite formed after M and F transformed harzburgite to dunite which now mantles chromite orebodies. This process post-dated the first melting event by 15-35 Ma. (Authors' abstract)

MELCHOR, F.A., 1997, Fluid inclusion study of the Bismark skarn deposit, Mexico (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 2, p. 40. Author at Subdirección de Exploración, Industrias Peñoles S.A. de C.V., Av. de las Industrias 4335, Chihuahua, Chihuahua, Mexico.

This large Zn-Pb-Cu-Ag ore is hosted in steep skarn bodies at the contact of a quartz monzonite igneous stock and limestone. Sulphide mineralization is related to both prograde garnet-clinopyroxene-wollastonite and retrograde epidote-zoisite-quartz-calcite-fluorite alteration, the later predominating.

Samples from the orebodies display several mineralizing events recording a span of Th and melting points in FI. T determinations were run on P and S I in quartz, calcite, and fluorite intergrown with sulphides. Th spanned from 445 down to 202°C with later post-mineral pulses of Th 167 to 107°C.

Several constraints can be depicted from FIAS [sic] petrography and microthermometric measurements. In some instances S biphase FI coexist with monophase gas rich ones, evidencing boiling in the system, which is usually interpreted as a sulphide deposition control. Brines were also determined to be of high sal type because of the presence of halite and sylvite, thus, with sal of at least 26.3% NaCl eq. Freezing behavior reveals other systems along with $NaCl-H_2O$; these are $CaCl_2-H_2O$, $NaCl-MgCl_2-H_2O$, according to melting point depression measurements. Also, there is a CO_2-H_2O system recognized by clathrates, since final melting of solid phases occurred at T>15°C.

These microscopic observations help in the understanding of the solution chemistry of the system that undoubtedly developed from a magmatic source. (From author's abstract by E.R.)

MÉL'NIKOVA, F.P., AKBÁROV, Kh.A., POLYKOVSKY, V.S. and DZHILI, Khi, 1997, Problems and objectives of thermobarogeochemistry in the light of A.G. Betekhtin's studies on ore deposits and N.P. Ermakóv's ideas about the mineral-forming environment: in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 53-54, ISBN 5-88918-002-9 (in Russian; English translation courtesy Dr. D. B. Brown). First author at Moskvá State Univ., Geological Fac., Moskvá, Russia 119899.

In developing his studies on ore deposits, A.G. Betékhtin defined the following directions for investigations and means of separation of resolving problems of endogenic mineralization: the time and mode of separation of the ore solutions from the parent magma under deep-seated conditions, the physical state of the solutions during their passage from the magma towards the surface, the chemical properties of the solutions, the means of transferring the metalliferous compounds by the solutions, and the causes of deposition of the mineral substances from the solutions. In analysing and generalizing the results of TBG [i.e., thermobarogeochemistry] by N.P. Ermakóv and other scientists in 1941-1953, they introduced for the first time methods of study of mineral-forming solutions based on G-L I, with the aid of which it became possible to: 1) determine the T conditions of formation of minerals and rocks, 2) establish the phase composition and aggregate state of ore- and mineral-forming F, 3) carry out barometric studies, 4) define the salt and G composition of the F, 5) achieve photo-documentation of the processes of change in the state of the F during mineral-formation, and 6) use the results of TBG determinations to investigate concealed mineralization and forecasting methods.

The information from TBG-Symposia, conducted in Barcelona (ACROFi-XIII, Spain, 1995), Madison (PACROFi, USA, 1996), at the 13th Int. Geol. Congr.

(APiFiS-I, Beijing, 1996) and also the planning programs for the Symposia (ACROFi-XIY, Nancy, France, 1997) and APiFiS-II (Tashként, Uzbekistán, 1998) will enable us to determine the following objectives in TBG investigations, primarily directed toward the treatment of the main problems in the study of ore deposits in the 21st century: – theoretical investigations into questions of activity of ore-generating F during various stages and phases in the process of formation of the Earth's crust on the basis of a comprehensive study of FI in minerals and rocks; – studies of the T regime, the regime of P, the salt and G composition, the pH of mineral- and ore-forming F based on I in minerals and rocks; – TBG investigations of MI; – TBG investigations of F, involved in the metamorphic processes, the formation of the mantle, and other geological processes; – TBG investigations of geothermal systems; –a TBG study during regional and prospecting investigations; – a TBG study during prospecting for precious, rare, disseminated, non-ferrous and ferrous metals, rock crystal, fluorite, barite, Iceland spar, diamonds, and other mineral resources; – the use of TBG data in studying the geology and prospects of oil and sedimentary formations; – the mathematical treatment of TBG results using up-to-date computer techniques and programs for comparing them with the results of traditional geological, geochemical, mineragraphic, lithopetrographic, textural-structural, geophysical, and other methods of study; – the manufacture of new equipment for TBG investigations; – the equipping of TBG laboratories with instruments, ensuring the conduct of studies on a level of international achievements; – the development of instructions for practical geologists on the basis of TBG methods, during geological surveys, prospecting and geological-exploration work, and operational research on endogenic, exogenic, and placer resources; – the development of tables for determining working norms and time-motion norms, the values of individual kinds of TBG analyses, and other normative information, essential for setting-up projects and estimates in commercial and scientific-investigation organizations; – the development of programs for a specialized course on 'Practical Thermobarogeochemistry' for the benefit of students in geological specialities in universities, institutes, and colleges; and the publication of textbooks on TBG methods of research and prospecting in concealed mineralization; – the restoration of work on post-graduate specialized courses for increasing the qualifications of consulting (commercial) geologists based on an additional and advanced teaching program, 'TBG methods for studying conditions of the formation and prospecting of post-magmatic mineralization' in the countries of the Commonwealth of Independent States (former USSR) and APiFiS, and also 'Schools for Using Fluid Inclusions', working under the direction of D. Norman in America; – to create the First TBG Institute in Tashként (Uzbekistán) in accordance with the recommendation-PiFiS of the 30th Int. Geol. Congr. In Beijing, 1996; – to prepare and publish an atlas depicting the morphology and composition of I in quartz, fluorite, calcite, sphalerite (cleiophane), barite, cinnabar, and other minerals distributed in deposits of gold, silver, platinum, tungsten, molybdenum, copper, rock crystal, diamonds, etc.; – to maintain constant work on the classification of data on TBG investigations, and their publication in periodical technical journals from symposia, conferences, conventions, and congresses; and – the publication of monographs on the results of TBG investigations into current problems, research, and prospecting of concealed orebodies in individual regions, areas, and provinces of Europe, Asia, America, Australia, and Antarctica.

The intensification of TBG investigations in the scientific-research, laboratory-experimental, and practical divisions of geological work will promote further resolution of A.G. Betékhtin's problems on ore deposits and fortification of the mineral-resources databases of all countries of the world. (Authors' abstract)

MÉNEZ, B., PHILIPPOT, P., CHEVALLIER, P., GIBERT, F., LEGRAND, F. and POPULUS, P., 1997, Synchrotron X-ray microfluorescence analysis of individual fluid inclusions: $(K\alpha/K\beta)_i$ used as an absorption correction term for concentration estimates: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 207-208. First author at CNRS-URA 736, Laboratoire de Pétrologie, T26-E3, Univ. Paris 7, 4 Place Jussieu, 75005 Paris, France, email (menez@ccr.jussieu.fr).

In order to evaluate the relations between $(K\alpha/K\beta)_i$, host material thickness and FI geometry and composition, experiments have been performed on line D15 of the LURE (Orsay) synchrotron radiation facilities. The experimental protocol comprised three stages:

1) Interception of the X-ray beam emerging from pure metal targets (Cr, Mn, Fe, Ni, Cu, Zn) by quartz and aluminum plates of different thicknesses (i.e. absorption by the host).

2) Analysis of aq solutions of known metal concentrations and different sal (pure H_2O, Mn, Ni, Zn, and 15 wt.% eq. NaCl solution), with Mn, Ni, and Zn placed in silica glass capillaries of various wall thickness and inner diameter (i.e. absorption by the host and the F).

3) Analysis of synthetically-produced FI of known metal contents (Ni, Zn) trapped in NaCl crystals (i.e. absorption by the host and effect of I geometry).

Results of experiment I indicate that the $(K\alpha/K\beta)_i$ ratio is a function of host material thickness is in perfect agreement with theoretical prediction, independently of the local analytical environment (reproducibility of the measurements). [In spite of problems], results are better than 20% (experiment 2) and 32% (experiment 3) relative to the known concentrations implying that quantitative estimates of elemental concentration in individual FI can be obtained using $(K\alpha/K\beta)_i$ ratios as an absorption correction term. $(K\alpha/K\beta)_i$ ratio is extracted directly from X-ray spectrum thus avoiding considerations to be made on I depth and geometry. (From authors' abstract by E.R.)

MÉNEZ, B., PHILIPPOT, P., CHEVALIER, P., LEGRAND, F. and POPULUS, P., 1997, Quantitative elemental analysis of individual fluid inclusions using synchrotron X-ray microfluorescence (SXRF): Terra Nova, Abstract v. 9, p. 446.

MENUGE, J.F., FEELY, M. and O'REILLY, C., 1997, Origin and granite alteration effects of hydrothermal fluid: Isotopic evidence from fluorite veins, Co. Galway, Ireland: Mineralium Deposita, v. 32, p. 34-43. First author at Geol. Dept., Univ. of College Dublin, Belfield, Dublin 4, Ireland.

The Costelloe Murvey Granite is host to hydrothermal fluorite-quartz-calcite veins. The hydrothermal F extensively altered its granite wallrocks, leading to lower Sm and Nd and higher Rb concentrations in altered granite, disturbing both its Rb-Sr and Sm-Nd isotopic systems. The $^{87}Sr/^{86}Sr$ ratio of the hydrothermal F from which fluorite and calcite precipitated could not come from the granite. It is proposed that fluorite and calcite precipitated where hot, dilute F rising through the granite mixed with cooler, more saline F of basinal origin migrating through Lower Carboniferous limestone which then overlay the granite. (From authors' abstract by E.R.)

MERNAGH, T.P., HUSTON, D.L., LAWRIE, K.C., WYBORN, L.A.I., CASSIDY, K.F., SKIRROW, R.G. and **EWERS, G.R.**, 1997, A mineral systems approach for assessing ore deposit prospectivity. Abstracts - Geological Society of Australia, v. 44, p. 52.

A review, with a mention of use on FI (E.R.).

MESQUITA, M.J., FYFE, W.S. and **HARTMANN, L.A.**, 1997, Gold mineralization of the Porto Nacional Province/to, Brazil (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A102. First author at Dept. of Earth Sci., Univ. of Western Ontario, London, Ontario, N6A 5B7.

Widespread mesothermal gold mineralization in the Porto Nacional Province of north-central Brazil is controlled by percolation of high-sal F during major shearing events. Three phases are related to the F metamorphic-hydrothermal evoution of this system. The higher T (355-370°C) early phase precedes the gold mineralization and is composed by CH_4, CO_2 and low sal H_2O according to FI data, with a F isotope composition ($\delta^{18}O_{(f)}$) between 3 and 10‰ compatible with metamorphic F. The main gold formation phase is the second one, averaging 310 to 273°C. It is composed by a large range of sal (1 to 15 wt.% NaCl) H_2O and CO_2 with a $\delta^{18}O_{(f)}$ between 2.7 and 4.4‰. Occurring after the gold mineralization, the third phase is characterized by an aq high sal (15 wt.% NaCl) F with lower T (254 to 219°C) and $\delta^{18}O_{(f)}$ 0.2 to to 1.7‰. In the main gold formation phase the lighter oxygen isotope signature and large range of sal of the F could evoke a mixed metamorphic and superficial F. (From authors' abstract by E.R.)

MESSELLES, Hadj, 1997, Diagenesis related to thrust-sheet emplacement; Tellian Atlas, northern Algeria (abst.): Annual Meeting Abstracts - American Assoc. of Petroleum Geologists and Soc. of Economic Paleontologists and Mineralogists, v. 6, p. 82.

The Tellian Atlas in northern Algeria consist of a complex east-west oriented thrust-sheet. The area went through an uplift and erosion episode between two major burial phases. The result is complex cementation by quartz and carbonate in the Albian and Tertiary sequences. These cements have been investigated systematically employing a number of techniques: standard petrography (including CL), SEM, X-ray diffraction, FI analysis and geochemical techniques. The relative importance of compaction/cementation process using the modal analysis data shows that the original porosity has been destroyed by a combined effect of compaction and cementation (locally cementation dominated process). The average Th measured in the Albian sequence in the fore land basin are slightly lower than the one measured in the nappe zone. Quartz cementation occurred at T between 93 and 184°C and from a wide range of sal (3.39-11.7 wt.% NaCl eq.). Dolomitisation was emplaced at T between 85 and 99°C (lowest) in the fore land, whereas in the nappe zone Th are between 153 and 162°C. The petrography and FI studies suggested that these dolomites are of burial origin and precipitate from a brine with a wide range of sal. The carbon and oxygen stable isotope study constrain this figure. However, samples from Kef Gourine area exhibit more depleted values for the carbon ($\delta^{13}C$ = -2.618 and -3.672%), probably due to a contamination by meteoric water during the uplift erosion phase where the Albian has been exposed in that area. (Author's abstract)

MEYER, H.O.A., MILLEDGE, H.J., SUTHERLAND, F.L. and **KENNEWELL, P.**, 1997, Unusual diamonds and unique inclusions from New South Wales, Australia: Russian Geol. and Geophysics, v. 38, no. 2, p. 305.

MICHALLIDIS, K.M., NIMFOPOULOS, M.K., CHATZIKIRKOU, A. and **FOSTOUKOS, D.**, 1997, Fluid inclusion and stable isotope data of the base metal fluorite and barite veins in the Metallikon area, Macedonia, northern Greece (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 55-56 (in English), ISBN 5-88918-002-9. First author at Dept. of Mineral., Petrol. and Economic Geol., Aristotle Univ., 540 06 Thessaloniki, Macedonia, Greece.

Base metal, fluorite and barite vein mineralisation in the Akrita-Metallikon-Doumbia meta-volcanosedimentary sequence has been studied using FI and stable isotope techniques. Obtained FI data indicate a deposition of the mineralisation from low-moderate T (122-166°C) hydrothermal F with low sal (4.7-6.4 wt.% eq. NaCl) in a tensional fault system at shallow crustal level (P-1 kbar). Lead isotope data suggest a crustal origin of metals from the Paleozoic basement. Sulphur isotope data suggest a crustal origin for sulphur and that the mineralizing solutions were derived from a mixture of ascending geothermal F with seawater.

The Metallikon area mineralization is hosted within the Akrita-Metallikon-Doumbia meta-volcanosedimentary sequence of Permo-Triassic age. In this study, FI and stable isotope data are used to constrain the source of metals, the composition of the mineralizing solutions and the deposition processes for the Metallikon mineralisation. The mineralisation is characterized by the following simplified mineral succession: celsian, pyrite, sphalerite, silver-bearing tetrahedrite, fluorite-barite-calcite I, quartz, galena, sericite-calcite II. FI data obtained from main-stage fluorite mineralisation reveal a mean Th value of 145°C (range 122-166°C) indicating relatively low T. The average sal of 5.7 wt.% eq. NaCl (range 4.7-6.4 wt.%) indicates low to average salt content for the ore-F and average density values are 0.96 gr/cm^3. No dm were detected and methane was not found in the I. Tfm values range from -15°C to -20°C, whereas most I retain the same V proportion (15%). No L CO_2-bearing I were detected although CO_2-V is not absent from the F.

The barite and galena $\delta^{34}S$ values fall within a narrow range from 26.5 to 29.5 permil and 13.6 to 13.8 permil respectively. Barite values resemble those of seawater sulphates formed during Late Permian-Early Triassic. The $\delta^{34}S$ values of galena are significantly high excluding a single magmatic source for the F. The lead isotopic ratio values of galena suggest derivation from evolved, predominantly crustal material. Furthermore, by invoking the lead isotope evolution models plotting the ratios $^{206}Pb/^{204}Pb$ vs $^{208}Pb/^{204}Pb$ (38.39 to 38.45), it is suggested that lead from the Paleozoic basement is most likely involved in the Metallikon mineralisation.

The FI data strongly indicate that the Metallikon vein mineralisation was not formed either from basinal brines, metamorphic, skarn or, strictly speaking, epithermal F. The measured Th values, however, are similar to those of fluorite from hydrothermal systems and sal data support a close association to geothermal F. The most likely F source supported by the FI data could be a mixture of an ascending geothermal F with seawater. This is also supported by the elevated $\delta^{34}S$ isotopic values in galena. The barite $\delta^{34}S$ values correspond to the fact that in most cases the seawater sulphate mean $\delta^{34}S$ is about 15 permil higher than the associated sulphide deposit. Tfm data indicate that the main stage ore F had a composition of H_2O-NaCl-CO_2±$CaCl_2$ and the constant V proportions support lack of boiling. Calculating the P-T isochores for given densities, a maximum formation P of ~1 kbar could be determined. This corresponds to a hydrostatic maximum depth of ~1 km from the paleosurface.

The coexistence of sulphide and sulphate minerals at Metallikon indicates that oxidation of the ore F took place during the mineralizing episode. This has probably resulted by the suggested mixing of an ascending geothermal F with oxygen-bearing seawater and the associated increase in the SO_4^{2-}/H_2S ratio causing also the strong S isotope fractionation between sulphate and sulphide. Deposition of the ore minerals took place by decreasing the T of the F and by lowering the activity of the metal complexes due to dilution with seawater. (From authors' abstract by E.R.)

MILLER, M.F. and **PILLINGER, C.T.**, 1997, An appraisal of stepped heating release of fluid inclusion CO_2 for isotopic analysis: A preliminary to $\delta^{13}C$ characterisation of carbonaceous vesicles at the nanomole level: Geochim. Cosmo. Acta, v. 61, no. 1, p. 193-205. First author at British Geological Survey, Kingsley Dunham Centre, Keyworth NG 5GG, UK.

An appraisal of stepped heating methods for the extraction and isolation of FI CO_2 for carbon stable isotope ratio analysis indicates that the magnitude of the system blank, and thus its influence on the resulting data, has been considerably underestimated in previous studies. The problem derives largely from the unmodified application of stepped combusion techniques originally developed for the removal of terrestrial organic matter from extraterrestrial samples. In particular, the presence of heated Pt in the sample extraction chamber, as reported in the literature, is shown to have a serious deleterious effect on the analysis of small (sub-micromole) samples. If the extracted gases are not exposed to this combustion catalyst, the magnitude of the system blank is substantially reduced. Furthermore, excellent agreement is then generally obtained between FI $\delta^{13}C$ values determined after either stepped heating or crushing of the host mineral as the F extraction procedure. The release of a low T carbon component during stepped heating, and characterised invariably by a $\delta^{13}C$ value of ca. -25‰, is in accord with earlier studies and is attributed to surficial contamination by ubiquitous, airborne particulates of biological origin. Effective discrimination between this source of CO_2 and that derived from palaeofluid I is fundamental to accurate isotopic characterisation of the latter.

Application of the revised stepped heating procedure to the extraction of hydrothermal FI CO_2 from single quartz grains (~10-20 mg), for carbon stable isotope analysis by static vacuum mass spectrometry, is reported. Under optimum conditions, and where the isotopic composition of the sample gas is enriched in ^{13}C by <~20‰ relative to the associated procedural blank, 2-3 nmol of sample gas may be analysed with an attendant extraneous (blank) contribution to the $\delta^{13}C$ value that is less than the optimal analytical precision of the measurement (~±1‰, at the 1σ level).

Further progress in the application of ultra-high sensitivity mass spectrometric techniques to accurate $\delta^{13}C$ analysis of carbonaceous FI components, particularly coexisting CO_2 and methane, is dependent on proper assessment of the associated blanks and rigorous control thereof. (Authors' abstract)

MITCHELL, R.H., 1997, Carbonate-carbonate immiscibility, neighborite and potassium iron sulphide in Oldoinyo Lengai natrocarbonatite: Mineralogical Magazine, v. 61, p. 779-789. Author at Dept. of Geol., Lakehead Univ., Thunder Bay, Ontario, Canada P7B 5E1.

Porphyritic natrocarbonatite lavas erupted from the Oldoinyo Lengai volcano (Tanzania) on 17 October 1995 and 15-19 December 1995 differ from previously studied lavas in that they preserve textures indicative of groundmass carbonate-carbonate immiscibility. The immiscible fractions are considered to involve: a Na-K-Ca-CO_2-Cl-rich, F-bearing F crystallizing gregoryite, sodian sylvite, potassium neighborite as well as a complex Ba-rich carbonate; and a Na-rich, Cl-poor carbonate L approximating to a nyerereite-gregoryite cotectic composition. Textural and paragenetic data are interpreted to suggest that these recent lavas are more evolved than previously investigated Oldoinyo Lengai lavas and that natrocarbonatite is a highly evolved rather than a primitive magma. (From author's abstract by E.R.)

MIZOTA, C., NAKAYAMA, K., FAURE, K. and **ZENG, N.**, 1997, Overgrown quartz crystal fragments from Seto Porcelain Clay Formation, central Japan: (abst.): Geol. Soc. Japan Annual Meeting, Fukuoka, Oct. 10-12, Program, p. 403 (in Japanese).

MO, Cehui, WANG, Xiuzhang, CHENG, Jingping and **LIANG, Huaying**, 1997, Rb-Sr isochron determination for fluid inclusions within quartz vein from Dongping gold deposit, NW Hebei Province and its implications for metallogeny: Geochimica, v. 26, no. 3, p. 21-27. Authors at Guangzhou Inst. of Geochem., Chinese Acad. of Sci., Guangzhou 510640.

In order to understand the genesis of ore deposits, it is fundamental to know the timing of gold deposition. Dongping gold deposit occur[ring] in alkaline intrusions and with super-large scale potential, is dated by Rb-Sr isochron for FI within quartz vein at (103±8) Ma. This age is significantly younger than that of emplacement of its host intrusions (Middle Proterozoic), precluding the direct genetic link between gold mineralization and alkaline magmatism. Initial $^{87}Sr/^{86}Sr$ ratios suggest that ore-forming materials of Dongping gold deposit were derived predominantly from the host rocks. It is, therefore, concluded that Dongping gold deposit is not traditionally magmatic hydrothermal genesis, but the product of reworked mineralization related to meteoric water long after the formation of alkaline intrusion. (Authors' abstract)

MOELLER, P and **twenty-five others**, 1997, Paleofluids and recent fluids in the upper continental crust; results from the German Continental deep drilling program (KTB): J. of Geophys. Research, B, Solid Earth and Planets, v. 102, no. 8, p. 18,233-18,254.

Indexed under FI (E.R.)

MOINE, Bernard, RAMAMBAZAFY, Andrianasolo, RAKOTONDRAZAFY, Michel, CUNEY, Michel and **de PARSEVAL, Philippe,** 1997, The role of fluor-rich F in the transport of Th, Zr, Ti and REE: An example from the granulites of south Madagascar: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 209-210. First author at Lab Minéralogie, 39 allès J. Guesde, 31000 Toulouse, France; email (fmartin@cict.fr).

The possibilities of transport of Th, Zr, Ti and REE in two environments (a granulite and a skarn) are evaluated in view of the composition of the F available, on the basis of FI studies (E.R.).

MOISEYENKO, V.G., 1997, Mineral parageneses as indicators of ores' origin at gold deposits (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 158-159 (In Russian; Engl. translation from: English Version of the Abstracts of the Oral Presentations of the Papers of the Russian Participants, p. 26-27). ISBN 5-88918-002-9. Author at AmurKNII FEB RAS, Blagoveschensk.

For to continue development A.G. Betekhtin's ideas in ore formation and mineragraphy the mineral associations as indicators of genesis of ores in gold deposts are considered. Thermobarogeochemical studies of native gold and minerals associated with it shows that ores of essentially quartz type have been formed from hydrothermal solutions, usually in the T interval 350-90°C with sedimentation of the most amount of native gold into the main productive stage under the T 250-180°C. In this case composition of I in native gold of the main productive stage at the most deposits of this type differs sharply from composition of I in quartz of the same deposit and are highly concentrated solutions, in which natrium dominates in cation group. The available data allow to assert that when essentially quartz deposits have been formed gold was mainly transported as complex natrium salts and it was precipitated from highly concentrated solutions.

The above supposition has been proved by experiments, simulating gold behavior in natrium M under the T 600-400°C and in natrium solutions (250-130°C). The conditions under which the spontaneous amalgamation of fine gold particles in M and solutions with formation during 1.5 hour of coarse aggregates (up to 5 cm) of growing together crystals of this metal have been established.

Essentially quartz ores are of crustal origin and they have been formed under conditions of high oxygen potential with prevailing natrium over potassium. Poor quartz ores have been formed under significant participation of mantle processes with weighty potential of sulphur and obvious predomination of potassium over natrium. (From author's abstract by E.R.)

MOISSETTE, Alain, DUBESSY, Jean, BOIRON, M.-C., FABRE, Cécile, MAUCHIEN, Patrick and **LACOUR, J.-L.,** 1997, Laser ablation – optical emission spectroscopy (LA-OES) and its application to individual fluid inclusion analysis: State of the art: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 211-212. First author at CREGU and EP 578, BP 23, 54501 Vandœuvre-lès-Nancy cedex, France.

This study describes the calibration of a Laser-Ablation Optical Emission Spectroscopy (LA-OES) microprobe for the cation analysis in individual FI. Lateral resolution is 6 μm and the depth of the crater hole obtained for one laser shot is 1 μm for quartz and 6 μm for copper. For a constant ablated mass of an element, the excitation T of the plasma controls the intensity of emission lines. Consequently, emission line ratio is also a function of T for two distinct elements.

Sweeping the sample with an argon flow enhances the plasma T and then the line intensities. Our results show that synthetic glasses can be used for the establishment of calibration curves of atomic ratios. At least 10 laser shots are required to empty an I of 20 μm x 20 μm. With bigger I, 30 to 50 shots can readily be done. This effect is due to the short laser pulse duration (5 ns) and to the supersonic ejection of plasma (10 μm/10 ns) which prevents heat transfer to non-ablated L and so its vaporization after one laser shot. Noise of the electronic detection system limits the reproducibility to 5%.

Using synthetic FI of known composition in quartz and in salt (halite, sylvite), calibration curves have been established for Na/Li, K/Li, Ca/Sr, Ca/Mg elemental ratios. Detection limits have been calculated: 10-20 ppm for Ca, Sr, Mg, Li, Na and 200 ppm for K. Finally this new technique has been applied to natural FI. Elemental ratios are in good agreement with those obtained by bulk analyses and display clearly different populations of I within one sample. (From authors' abstract by E.R.)

MOLES, Norman, PARNELL, John, O'REILLY, Cian and **RODGERS, Andrew,** 1997, Mesothermal vein mineralization in the Lower Palaeozoic of Northern Ireland: Evidence for multiple fluid pulses (abst.): Mineral Deposits Study Group Annual General Meeting, Glasgow Univ., 1997, Programme and Abstracts Volume, p. xxx.

First author at School of Geosci., Queen's Univ., Belfast, UK.

Lead-zinc-(copper) sulphide vein mineralization occurs at several localities within the Lower Palaeozoic greywacke-shale belt which forms the Southern Uplands of Scotland and the Longford Down outcrop in the north of Ireland. These veins trend similar to that of Caledonian strike-slip faults and barren quartz veins in the Lower Palaeozoic. The age of this mineralization and its relationship to the Carboniferous limestone-hosted Pb-Zn ore deposits in Ireland and Britain, has been a subject of speculation and debate. In this contribution we present paragenetic and FI data for the Newtownards deposit and other vein mineralization in the Lower Palaeozoic of the eastern Northern Ireland. While the base metal mineralization appears to be of Carboniferous age, it was preceded by late Caledonian hydrothermal events and, at Newtownards, succeeded by limited hydrothermal activity associated with intrusion of a dolerite dyke in the Tertiary.

The Newtownards and Castleward lead (Cu-Ag) mines occur in silicified, sericitized breccia. The metallic minerals are principally galena and chalcopyrite with lesser ferroan sphalerite. Baryte is a common gangue mineral. Calcite occurs as a late cavity or vein fill in both silica- and dolomite-matrix breccias and in joints in the dolerite, together with the barium zeolite harmotome, suggesting at least four stages of mineral deposition: (1) milky quartz veins similar to barren 'Caledonide' veins which are widespread in the Lower Palaeozoic strata; (2)

an epithermal phase characterised by brecciation and silicification of the host rocks and deposition of chalcedony; (3) further brecciation and deposition of Pb-Zn-Cu sulphides with baryte and dolomite (mesothermal or MVT-related?); and (4) encrustation of cavities with a low-T pyrite-calcite-zeolite assemblage associated with Tertiary dyke emplacement. An episode of fracturing between stages 3 and 4 is indicated by evidence of deformation.

We have undertaken preliminary studies of FI trapped in quartz, dolomite and baryte in Newtownards mineralization. A vein of barren quartz contains abundant, low sal 2-phase I which homogenise at T of 220-270°C. This F is similar to that which deposited other 'Caledonide' (Devonian) veins in Ireland. A silica-cemented breccia shows two populations of I, with Th similar to the quartz veins and also a range of lower T peaking at ~155°C. Dolomite-hosted I are more saline (10-15 wt.% eq. NaCl and $CaCl_2$) and homogenise at intermediate T of 180-230°C. S I of F similar to that hosted by dolomite were also found within the barren quartz vein. Baryte hosts monophase aq I which are similar in sal to those in dolomite, but extreme necking precluded their use for T estimation. No FI were found in late-stage calcite vein fills.

FI Th were also determined in mineralized quartz from Castleward. Most I homogenised at T in the range 150-160°C, however, about one-third of I homogenised at higher T, up to 260°C. In six samples of barren 'Caledonide' quartz veins from various localities in the Strangford area, FI T are predominantly in the range 120-140°C.

In the Southern Uplands, the base metal vein mineralization is considered to be of Carboniferous age (e.g. Samson & Banks 1988), and it is probable that mineralizing F were also available along strike in Ireland at that time. Early barren quartz veins at Leadhills were deposited from mesothermal F of low sal. These are comparable to F trapped in Newtownards early barren quartz, which we suggest was deposited by upwardly-penetrating metamorphic F during late Caledonian brittle deformation. Lower Tt characteristic of minor quartz veins found regionally in the Lower Palaeozoic strata suggest they formed by lateral secretion from cooler ambient F. Main stage (metalliferous) veins at Leadhills and other mineralized veins in the Southern Uplands were deposited from highly saline, low T (<150°C) F, which Samson & Banks (1988) suggest were Carboniferous meteoric waters made saline by dissolution of halite beds within overlying Carboniferous lacustrine beds. FI in ore-stage minerals within Irish Carboniferous stratabound ore deposits show a range of modal Th from 137 to 190°C and sal peaking at 8-15 an 17-24 wt.% eq. NaCl (Andrew 1993). Mixing of high-T, moderate sal, deep-seated hydrothermal F with hypersaline connate brines resulted in ore deposition. Similar deep hydrothermal F appear to have deposited the dolomite, baryte and associated 'main phase' sulphides at Newtownards, although it is recognised that moderate sal mesothermal F have been available regionally in the crust from Carboniferous to Mesozoic times. We [believe] that structural reactivation and multiple F pulses were responsible for the larger base metal vein deposits hosted by Lower Palaeozoic rocks in Northern Ireland and Scotland. The most significant F event appears to have been of Carboniferous age, coeval with the formation of the carbonate-hosted vein and stratabound Pb-Zn deposits elsewhere in Britain and Ireland. (From authors' abstract by E.R.)

MOLNÁR, Ferenc, WATKINSON, D.H., JONES, P.C. and GATTER, István, 1997, Fluid inclusion evidence for hydrothermal enrichment of magmatic ore at the contact zone of the Ni-Cu-Platinum-group element 4b deposit, Lindsley Mine, Sudbury, Canada: Econ. Geol., v. 92, p. 674-685. First author at Dept. of Mineral., Eötvös Loránd Univ., Budapest, Múzeum krt 4/A, 1088 Hungary.

The PGE-bearing assemblages in fracture-controlled veins and disseminations are compatible with hydrothermal processes being responsible for the enriched grade near the contact. FI petrography and microthermometry reveal that hydrothermal activity took place in five stages. Early $NaCl-CaCl_2-H_2O$-type F were trapped in K feldspar of the metasomatically altered Murray Granite at T of about 370 to 410°C and 270°C. Later quartz intergrown with sulfides contains FI with $NaCl-KCl-CaCl_2-H_2O$-type solutions trapped between 200 to 380°C and 130 to 230°C. SEM-EDS analyses of chlorides in I reveal that these F were also enriched in Ba, Pb, Fe, and Mn. Later F trapped in S I (200-240°C) were $CaCl_2-(NaCl)-H_2O$ type. T calculations assume 2 kbars lithostatic P. All aq I are characterized by high sal (23-43 wt.%). Low-T S contain CO_2-CH_4 F. Carbonic F are related to metamorphism accompanying deformation during the Penokean orogeny. The higher T F were heated by the Sudbury Igneous Complex. The observations support the hypothesis that very saline hot F interacted with igneous minerals and P magmatic ores and remobilized base and precious metals, and precipitated them along permeable, fractured, and brecciated zones to produce Cu-PGE-Au concentration, disseminated sulfides, and veins. (From authors' abstract by E.R.)

MONGELLI, Francesco and PAGLIARULO, Pietro, 1997, Influence of water recharge on heat transfer in a semi-infinite aquifer: Geothermics, v. 26, no. 3, p. 365-378.

Indexed under FI (E.R.)

MONTOMOLI, Chiara, RUGGIERI, Giovanni, BOIRON, M.-C. and CATHELINEAU, Michel, 1997, Pressure-temperature condition during late extensional tectonic in the northern Apennines: A fluid inclusion study in syntectonic veins of the Tuscan nappe: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 213-214. First author at Dpto. di Scienze della Terra, Via S. Maria 53, 56126 Pisa, Italy; email (montomoli@cln.it).

In this study we propose a P-T reconstruction for F circulating after the main collisional stage of the Northern Apennines orogenesis, from FI data. A P-T reconstruction during the formation of extensional syntectonic veins is proposed on the basis of the microthermometric and Raman data of Lw-m I. In particular, the P (140-250 MPa) and T (190-300°C) conditions are constrained by limiting isochores, L-V isoplethes and estimation of the maximum P and T limits, based on geological consideration and illite crystallinity and vitrinite reflectivity studies.

The methane contained in the FI can be produced by maturation of the organic matter and the cracking of heavier hydrocarbons during heating process. The presence of methane I suggests that methane-water immiscbility conditions sometimes occurred in the system. The P features of methane I indicate that they are approximately coeval with water-methane I, suggesting unmixing. (From authors' abstract by E.R.)

MOORE, J.N., POWELL, T.S., BRUTON, C.J., NORMAN, D.I. and HEIZLER, M.T., 1997, Thermal and chemical evolution of the Tiwi geothermal system, Philippines (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-360. First author at Energy and Geosci. Inst., Univ. of Utah, Salt Lake City, UT 84108; email (jmoore@egi.utah.edu).

Tiwi is a large geothermal field [measured T ~270°C] related to young volcanic activity on the island of Luzon, in the Philippines. Eight stages of alteration and vein mineralization have been documented in core. Maximum FI T of stages 3, 4, and 5 are close to the boiling point and typically exceed 300°C. A similar T is implied by the presence of actinolite. Minimum FI T are as much as 35°C below the present T. FI sal and gas contents indicate that the mineralizing F were mixtures of fresh and seawater modified by gases derived from crustal and possibly magmatic sources. Together, the data indicate that the hydrothermal alteration reflects: 1) initial heating of the system (stage 1); 2) episodic boiling (stages 2, 4, and 6) followed by the formation of P sinks; 3) heating of cooler F that moved into the P lows (stages 3, 5, and 7); and 4) cooling followed by renewed heating and boiling (stage 8). ${}^{40}Ar/{}^{39}Ar$ spectrum dating of adularia constrains the age of stage 4 mineralization to 0.30 Ma, stage 7 to >0.20 Ma, and the present thermal regime to <0.05 Ma. (From authors' abstract by E.R.)

MORALES-RUANO, S., FENOLL HACH-ALÍ, P., TOURAY, J.C. and BARBANSON, L., 1997, Complex H_2S-bearing fluid inclusions in stratabound fluorite ore-deposits from Turon (Southern Spain) as indications of a thermal culmination in the Alpujarrides: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 551-554. First author at IACT (CSIC-Universidad Granada), Facultad de Ciencias, Spain.

A succession of 4 F types is presented, from a microcryoscopic (± Raman) characterisation of FI in fluorite. Attention is focused on "hot" H_2S-rich I [Th 284-343°C], representative of a post-orogenic thermal culmination in the Alpujarrides. (Authors' abstract)

The sulfur-rich F are suggested to be the result of reduction of sulfate by carbonaceous material. (From authors' text by E.R.)

MORALES-RUANO, Salvador, TOURAY, J.-C., FENOLL HACH-ALI, Purificación and BARBANSON, Luc, 1997, A "cocktail" of exotic fluids in the C-O-H-S system evidencing the polyphase history of the Turon fluorite deposit (Betic Cordillera, south Spain): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 215-216. First author at IACT (CSIC-Univ. de Granada), Facultad de Ciencias, Avenida Fuentenueva, s/n, 18002 Granada, Spain; email (smorales@goliat.ugr.es).

The stratabound Turon F-Pb-(Zn) ore deposit is hosted by carbonate rocks. Banded [BF] and massive [MF] fluorite contain common H_2O-bearing and rare water-free organic ones. Measurements on the many types that were found suggest that, during a late event, hot hydrothermal pulses involving a "cocktail of volatiles" have overheated pre-existing FI in BF above their Th while FI in MF remained intact. This process occurred under a confining P too small to prevent overheating, probably at relatively shallow depth.

Eventually, referring to the chronology and characterization of the main FI types, accounting for the "overheating effect" in banded fluorite and neglecting P corrections, the following F sequence may be reconstructed at Turon: (I) basinal brines ($NaCl-CaCl_2-H_2O$) at about 150°C; (II) stronger brines associated with immiscible $CO_2 \pm CH_4$ at 200°C or higher T; (III) complex F in the system $NaCl-CaCl_2-H_2O-H_2S-CO_2-CH_4$, at T sometimes above 300°C and forming immiscible L+V systems; (IV) low sal and low T aq solutions, resulting in a late remobilization of fluorite. (From authors' abstract by E.R.)

MORAN, Kathleen and PALMER, James, 1997, Fluid inclusion analyses from an As-polluted area; Zimapan, State of Hidalgo, Mexico (abst.): Geological Society of America Abstracts with Programs, v. 29, no. 3, p. 60.

MORAN, R.A., FEELY, Martin and KENNAN, P.S., 1997, Fluid inclusion studies of the Late Caledonian Leinster granite and its quartz veins in SE Ireland: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 217. First author at Dept. of Geol., Univ. College Galway.

A variety of sulphide mineral deposits is associated with the eastern flank of the Leinster granite. In a study of quartz from mineralised and unmineralised veins from granite and country rock localities, three FI types have been recorded; all are S, L+V: Type 1, low sal, high Th, $H_2O-NaCl-CO_2$; Type 2, low sal, moderate Th, $H_2O-NaCl$; and Type 3, moderate to high sal, moderate to low Th, $H_2O-NaCl-CaCl_2$. A plot of Th vs. sal of these data is shown on Fig. 1. (From authors' abstract by E.R.) *See figure on page 236.*

MOREIRA, M., KUNZ, J. and ALLÉGRE, C.J., 1997, Rare-gas systematics in the upper mantle: A complete study of a popping rock: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 144, Lunar and Planetary Inst., Houston. Univ. Denis Diderot, Laboratoire de Géochimie et Cosmochimie, T14, 3eme étage, 4 Place Jussieu, 75252 Paris Cedex 05, France; email (moreira@ipgp.jussieu.fr)

We have studied rare-gas systematics by the stepwise crushing method to release the gas from the vesicules.

The ${}^{40}Ar/{}^{36}Ar$ and ${}^{129}Xe/{}^{130}Xe$ ratios are perfectly correlated to the ${}^{20}Ne/{}^{22}Ne$ ratios and reflect a mixing between the MORB component with high ${}^{20}Ne/{}^{22}Ne$, ${}^{21}Ne/{}^{22}Ne$, ${}^{40}Ar/{}^{36}Ar$, and ${}^{129}Xe/{}^{130}Xe$ ratios and an air component.

We conclude that the ${}^{3}He/{}^{22}Ne$ is between 4.9 and 7.3, $0.42<{}^{3}He/{}^{36}Ar<0.74$, and $760<{}^{3}He/{}^{130}Xe<1110$ in the upper mantle.

There are important constraints for the so-called "steady-state model" that proposes that all the noble gas stable isotopes come from the lower mantle. (From authors' abstract by E.R.)

MORITZ, Robert and GHAZBAN, Fereydoun, 1997, Fluid evolution and gold mineralization during uplift and extensional tectonics of a metamorphic rock complex in the Sanandaj-Sirjan tectonic zone, western Iran: abst., XIV ECROFI, Proc. of the XIVth European

Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 218-219. First author at Dép. Minéralogie, Univ. de Genève, rue des Maraîchers 13, 1211 Genève 4, Switzerland; email (Robert.Moritz@terre.unige.ch).

The Muteh gold mine, a major gold deposit of Iran, is in metamorphic rock complex where abundant granitic intrusions are present. The gold orebodies are within faults cross-cutting the metamorphic host rocks. Alteration and irregular veining related to the gold orebodies overprint the metamorphic minerals and consist of quartz-muscovite-pyrite-dolomite-albite-rutile-chlorite.

FI were studied in regional quartz veins subparallel to the schistosity, in the regional metamorphic rocks, and in quartz veins and silicified host rocks from the gold deposit. The FI are typically more abundant in vein quartz than in the host rock, in particular in the amphibolite facies rocks of the western part of the study area.

Regional quartz veins contain one phase CO_2-rich I at room T with Th CO_2 to the L between -23.8 and +18.3°C, and Tm CO_2 between -57.0 and -59.1°C, and L-rich H_2O-CO_2-NaCl I with total Th to the L between 186 and 295°C.

In addition, some quartz shows rare V-rich H_2O-CO_2-NaCl I (V phase about 75 vol.% at room T). They decrepitate around 230°C but show homogenization toward the V phase. Th CO_2 is between -57.2 and -58.4°C and sal based on the dissociation of clathrate ranges between 1 and 16 wt.% eq. NaCl. XCO_2 is between 0.5 and 0.6. The isochores of the V-rich H_2O-CO_2-NaCl I pass through the maximum metamorphic conditions of 550-700°C and 4-6 kbars. The retrograde cooling and uplift path of the metamorphic complex is based on the isochores of this early F.

By contrast, the isochores of the L-rich H_2O-CO_2-NaCl and the CO_2-rich F are not conformable with the maximum metamorphic P and T conditions determined in this study. Retrograde cooling and uplift of the metamorphic complex resulted in the adjustment of the densities of these FI by partial decrepitation.

Following the circulation of the dilute, low-CO_2 aq F associated with the gold mineralization event, the entire metamorphic complex was invaded by a low T Ca-Na-bearing basinal brine. (From authors' abstract by E.R.)

MOUNTJOY, Eric, GREEN, Darryl, DUGGAN, James and SMITH, Sean, 1997a, in Ross, G.M., (compiler), 1997 Alberta Basement Transects Workshop, Lithoprobe Report #59, Lithoprobe Secretariat, Univ. of British Columbia, p. 183. Authors at Dept. of Earth & Planetary Sci., 3450 University St., Montreal H3A 2A7.

C, O and Sr isotopes together with FI data from saddle dolomites and late calcite cements indicate considerable variation in both T and sources of F in the deep basin (>3000 m) at or near maximum burial. On the basis of light hydrocarbons and CO_2 in FI, saddle dolomites at Kaybob were precipitated during early oil generation, whereas most calcites appear to be related to thermochemical sulphate reduction (TSR) during deepest burial.

Most saddle dolomites have similar minimum Th between 100 and 170°C (modes about 150°C) with T increasing outwards in individual crystals in most parts of the deep basin. They are also moderately radiogenic with $^{87}Sr/^{86}Sr$ values around 0.7100 with some up to 0.7130, except at Simonette where they are radiogenic (0.7100 to 0.7350).

Later coarse calcite cements have light C isotopes associated with TSR, except at Simonette. In west central Alberta, minimum Th range from 105 to 170°C with modes around 130°C suggesting that these calcites precipitated at cooler T given their formation at 1 to 2 km deeper depths than saddle dolomites. However, these calcites are strongly radiogenic with $^{87}Sr/^{86}Sr$ values between 0.7200 and 0.7369. The sal of FI increase from saddle dolomite to anhydrite, but in the late calcites decrease to values similar to those in saddle dolomite. Also the Simonette reservoir is unusual in that it contains oil (43 API) at depths of 3900 m and thus reflects a low geothermal gradient since the Late Cretaceous.

Thus the west central deep basin was subjected to different F and heat flow regimes during deepest burial involving strongly radiogenic brines, with F flow apparently controlled by faults. (From authors' abstract by E.R.)

MOUNTJOY, Eric, GREEN, Darryl, DUGGAN, James and SMITH, Sean, 1997b, Burial fluids and heat flow regimes in the deep Alberta Basin; C, O and Sr isotope and fluid inclusion evidence from late cements: GAEA 3, 18th IAS, Regional European Meeting of Sedimentology, Heidelberg, Sept. 2-4, 1997, Abstracts, p. 241-242. Authors at Dept. of Earth & Planetary Sci., McGill Univ., 3450 University St., Montreal H3A 2A7, Canada; email (Eric_M@geosci.Ian.mcgill.ca)

C, O and Sr isotopes together with FI data from saddle dolomites and late calcite cements indicate considerable variation in both T and sources of F in the deep basin (>3000 m) at or near maximum burial. On the basis of light hydrocarbons and CO_2 in FI, saddle dolomites were precipitated during early oil generation, whereas most calcites appear to be related to thermochemical sulphate reduction (TSR) during deepest burial.

Most saddle dolomites have similar minimum Th between 100 and 170°C (modes about 150°C) with T increasing outwards in individual crystals in most parts of the deep basin. They are also moderately radiogenic with $^{87}Sr/^{86}Sr$ values between 0.7200 and 0.7369, contrasting with low radiogenic values from the deeper part (0.7082 to 0.7095). The sal of FI increase from saddle dolomite to anhydrite, but in the late calcites decrease to values similar to those in saddle dolomites. (From authors' abstract by E.R.)

MOURA, António, NORONHA, Fernando, CATHELINEAU, Michel and BOIRON, M.-C., 1997, Fluids from the Neves-Corvo volcanic massive sulphide deposit, Portugal: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 220-221. First author at Centro de Geologia da Univ. do Porto, Fac. Ciências, 4050 Porto, Portugal; email (ajmoura@fc.up.pt).

The Iberian pyrite belt hosts one of the most outstanding metallogenic provinces in the world with more than 1000 Mt of volcanosedimentary massive sulphide Cu-Zn-Pb ores. The ore is hosted by phyllites, shales and greywackes metamorphosed to the prehnite-pumpellyite facies. However, the grade increases to the greenschist facies north-east to the deposit.

FI in ore-bearing quartz samples range as follows: Th 226-268°C; P(bar) 1500-3600; H_2O 88.9-92.4, CO_2 6.7-9.6, NaCl 0.8-0.9, CH_4 0.0-1.4. These data are compatible with the metamorphism of the area. This data suggests that these F could be contemporaneous with regional metamorphism and representative of the peak P-T metamorphic conditions. (From authors' abstract by E.R.)

MUCHEZ, Philippe and **SINTUBIN, Manuel,** 1997, Contrasting origin of palaeofluids in a strike-slip fault system: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 222-223. First author at Fysico-chemische geologie, Celestijnenlaan 200C, B-3001, Heverlee, Belgium; email (philippe.muchez@geo.kuleuven.ac.be).

The aim of this paper is to discuss the origin of palaeofluids associated with strike-slip fault activity at shallow burial depth and to demonstrate how different flow regimes have been intersected by the fault system. A tentative model is proposed which couples the hydrogeological with the tectonic system.

A non-ferroan (stage A) and ferroan (stage B) calcite generation formed along the fault. P FI in the non-ferroan calcites indicate precipitation from a high sal H_2O-NaCl-$CaCl_2$ F (18.1 to 25.3 wt.% eq. $CaCl_2$) at a T around 50°C. This low T implies a shallow setting, which is in agreement with the regional geology. The ferroan calcite generation, post-dating the stage A calcites, contain P one-phase aq FI of sal 19-24% $CaCl_2$.

A tentative hydrotectonic model focused F discharges from a depth of over 4 kilometres (precipitating stage A calcites). This implies a F source in the lower Palaeozoic siliciclastic basement. Still later, F migrated from the Upper Palaeozoic shales and carbonates along the fault, causing the precipitation of the stage B ferroan calcites. (From authors' abstract by E.R.)

MUCHEZ, P., SLOBODNIK, M., SINTUBIN, M., VIAENE, W. and **KEPPENS, E.,** 1997, Origin and migration of palaeofluids in the Lower Carboniferous of southern and eastern Belgium: Zbl. Geol. Paläont. Teil I, 1995, no. 11/12, p. 1107-1112 [published 1997].

Carbonate veins in the Lower Carboniferous of southern and eastern Belgium have been investigated to deduce the palaeofluid flow systems which were active at the Variscan thrust front. An attempt has been made to relate the structural or stress field characteristics, the period of tectonism and the F types (T, sal, origin). (Authors' abstract)

Th and sal were measured in six types of calcite veins, of various ages up to Recent, and Th from ≤20°C and 0% (Recent) to ≤205°C and 28% (E.R.).

MUKHERJEE, Abhijeet and **BALLURKAR, Ashok,** 1997, Fluid inclusion study of vein and bedded-type barite of Cuddapah Basin, Andhra Pradesh: J. Geological Soc. of India, v. 50, p. 587-592. First author at Nat'l. Mineral Development Corp., Khanij Bhavan, Masab tank, Hyderabad-500028.

FI study is carried out on the vein and bedded-type barite of the Proterozoic Cuddapah basin of Andhra Pradesh. In the case of vein barite, P I are mostly monophase and L-rich biphase (L+V), with their freezing T indicating their compositon as H_2O + NaCl±KCl and density of the ore forming F as 0.901 to 0.944 g/cm^3. The P L-rich biphase (L+V) I of the hydrothermal vein barite shows Th in the range of 230-260°C. The P I of the bedded (volcanogenic) barite deposits of Mangampeta are monophase carbonic with densities corresponding to 0.76 to 0.88 g/cm^3. A conceptual mobilization-deposition model for the vein-type barite mineralization is given. (Authors' abstract)

MULLIS, Josef, 1997, The application of fluid inclusions to fluid geochemistry and geothermobarometry in diagenetic and low-grade metamorphic rocks in the external parts of the Central Alps: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 224-225. Author at Mineralogisch-Petrographisches Institut, Bernoullistrasse 30, 4056 Basel, Switzerland; email (mullis@ubaclu.unibas.ch).

Careful fabric, host mineral and FI analyses of several hundred localities of the external parts of the Central Alps [permit] a critical discussion about their application to F evolution and F thermobarometry. Results indicate that F trapped at an early stage along the prograde path have generally left the host mineral due to F overpressure, decrepitation and recrystallization [and hence] do not reflect composition and density of the F trapped during mineral growth. Very small early prograde FI may be preserved. Hydrocarbon-saturated water-rich and water-saturated hydrocarbon-rich FI formed around the PT-maximum and during retrograde conditions. Care has to be taken for originally high dense FI, that were evacuated by local and temporary P drops and refilled again by a new F. (From author's abstract by E.R.)

MULLIS, Josef and **DE CAPITANI, Christian,** 1997, Fluid immiscibility in the Central Alps: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 226-227. First author at Mineralogisch-Petrographisches Institut, Bernoullistrasse 30, 4056 Basel, Switzerland; email (mullis@ubaclu.unibas.ch).

Observations of natural F systems show six different geological processes that lead to F unmixing:

1. isobaric decrease in T
2. isothermal decrease in P
3. input of salt-enriched F (salting out)
4. volatile production during cracking of kerogen and higher hydrocarbon and by decarbonation and oxidation or reduction of carbonaceous matter
5. upward and downward movement of the gas-water contact, mimicking unmixing phenomena
6. channeled influx of unmixed allochtonous volatiles.

Depending on the tectonometamorphic and lithologic environment, F immiscibility in the Central Alps is controlled by one or several unmixing processes:

– In HHC-bearing diagenetic rocks, unmixing processes 2,4,5 and 6 are dominant.

– In CH_4-bearing diagenetic and low-grade anchimetamorphic rocks, unmixing processes 1,2,4,5 and 6 are dominant.

– In CO_2-bearing rocks that suffered high-grade anchizonal and greenschist-facies conditions, unmixing processes 2 and 6 are dominant.

– In N_2-bearing rocks exposed to anchizonal and greenschist facies conditions, process 2 is dominant.

– In rocks containing little or no volatiles, process 6 is connected to fractures and faults. (From authors' abstract by E.R.)

MULLIS, Josef and **DE CAPITANI, Christian,**

1997, Modeling of water-rock interaction for an alpine fissure in the Central Alps: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 228-229. First author at Mineralogisch-Petrographisches Institut, Bernoullistrasse 30, 4056 Basel, Switzerland; email (mullis@ubaclu.unibas.ch).

FI in fissure quartz from Zinggenstock in the Aar Massif were studied by microthermometry, Raman spectroscopy and sodium-potassium thermometry yielding composition, density, T and P of F trapping and crystal growth. The aim of the present study is to investigate whether the available thermodynamic data is sufficient to model the observed dissolution and precipitation. The results are shown as paths on T-T and T-P plots. (From authors' abstract by E.R.)

MULSHAW, S.C., 1995, Magmato-hydrothermal precious metal mineralisation at San Bartolomé, Carar-Azxuay Ag-belt, Ecuador (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). Author at Dept. of Geol., Imperial College of Sci., Tech. and Med., Prince Consort Road, London, UN. SW7 2BP.

See FIR, v. 28, p. 108 (E.R.).

MULSHAW, S.C., PUIG, Carlos, SPIRO, Baruch and **BUCHANAN, D.L.**, 1997, Genesis of epizonal Ag vein mineralization at San Bartolomé in Central Ecuador: Textural evidence, fluid inclusions and stable isotope geochemistry: Econ. Geol., v. 92, p. 210-227. First author at Dept. Geol., Imperial College of Sci., Tech. and Medicine, Prince Consort Rd., London, UK SW7 2BP.

Epizonal Ag-Pb-Zn vein mineralization at San Bartolomé occurred in five stages: comb quartz selvages on vein margins; coarse, crystalline sphalerite associated with freibergite and galena, with minor stannite; pyrrhotite with interstitial galena, freibergite, arsenopyrite, sphalerite, and minor stannite; coarse galena and Ag-bearing sulfosalts; and finally, a gangue assemblage of quartz, rhodochrosite, and dolomitic carbonates.

Sulfur isotopes indicate ore-forming T of 219 to 354°C and imply a magmatic origin for a dominantly reducing, sulfide F. The $\delta^{13}C$ and $\delta^{18}O$ values in rhodochrosite are consistent with carbonate-depositing F also having a primarily magmatic source with a minor meteoric component.

Microthermometry of FI in quartz, carbonate, and sphalerite shows that three F have contributed to mineralization: a hypersaline F (30 wt.% NaCl eq.) and an intermediate-sal F (6-15 wt.% NaCl eq.), both associated with I Th in the range of 200 to 400°C; and a low-sal F (<6 wt.% NaCl eq.) associated with lower Th in the range of 100 to 300°C.

On the basis of these observations, it is most likely that the San Bartolomé veins formed from magmato-hydrothermal F possibly linked to the intrusion of an S-type pluton, close to the palaeocontinental margin. Mineralizing F invaded a dilatant fracture system as a series of discrete pulses, where they were subsequently diluted by the later introduction of cooler, meteoric ground waters. (From authors' abstract by E.R.)

MUNZ, I.A., ANDRESEN, Bjørg and **KIHLE, Jan**, 1997, PVT calculation of hydrocarbon inclusion fluids: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 230-231. Authors at Institut for Energiteknikk, P.O. Box 40, N-2007 Kjeller, Norway; email (ingridm@ife.no).

In spite of the obvious important applications of quantitative data, only few attempts have been done to use hydrocarbon I for PVT modelling. Isochores have been calculated by combining microthermometry data with compositional data of the present, mobile hydrocarbon F. The scarcity of studies using hydrocarbon I for PVT modelling have probably two reasons: (1) problems with obtaining a complete chemical analysis of hydrocarbon IF, and (2) software adapted for PVT modelling of hydrocarbon FI is scarce.

The weak point of cubic equations of state is unfortunately the calculation of saturated L densities. The PVT calculations for complex hydrocarbon IF would therefore largely depend on gas chromatography analysis. We have obtained a complete composition of the IF by crushing the sample in vacuum. The GC analysis of the gas and L fraction was done on the same aliquot of sample, which allows for recombination. (From authors' abstract by E.R.)

MURAMATSU, Y. and **KOMATSU, R.**, 1997a, Activity of hyper to low saline fluids in the Mori geothermal reservoir, Hokkaido-microthermometric study of fluid inclusions (abst.): Program, 1997, Annual meeting Mineralogical Society of Japan/Japanese Association of Mineralogists, Petrologists and Economic Geologists, p. 221 (in Japanese, translated courtesy T. Sawaki).

Evolutionary processes of geothermal F in the Mori geothermal system are established, based on microthermometric studies of FI in 18 samples from the system where the Mori geothermal power station is running. Six types of FI occur in samples from deeper levels (2000-2265 m): polyphase, V, Ca-rich L, CO_2-bearing L, and medium-saline L I and low-saline L I. Polyphase I mainly contain halite as a dm, whose melting points (Tm hal) are 132-160°C. Tm ice of polyphase and L I are -40.1 to -43.6°C and -28.5 to -33.0°C, respectively, and are lower than the eutectic point of H_2O-NaCl solution (-21.2°C). The Tm ice data suggest that the I contain $CaCl_2$. In the Mori area, the geothermal reservoir consists of limestone, and calcium probably originated from the limestone. Sal of FI which were calculated from Tm ice and Tm hal, based on Vanko et al. (1992), were estimated at 33-35 wt.% NaCl + $CaCl_2$ eq. ($CaCl_2$/NaCl = 2.2-2.9). FI from shallower levels are L, with Tm ice -0.4 to -2.0°C. Their sal are estimated 0.0-1.9 wt.% NaCl eq. after correction for the effects of CO_2 on Tm ice. The sal are in range of those of present day discharged F (0.6-0.8 wt.%), and Th of the I are consistent with present day borehole T. These indicate that the L I were formed by trapping the present day geothermal F.

This study suggests that sea water was at deeper levels of the Mori geothermal system at the early geothermal stage. The water was heated and boiled, and was separated into high-saline L and V phases. Polyphase and CO_2-bearing I were formed by trapping the L and V, respectively. Then, meteoric water infiltrated the deeper part of the geothermal system, and sal of geothermal F decreased. After the Mori geothermal power station started to run, geothermal F of low sal have been predominant in all the geothermal reservoirs. (From authors' abstract by E.R.)

MURAMATSU, Yoichi, KOMATSU, Ryo,

SAWAKI, Takayuki, and SASAKI, Munetake, 1997, Gas composition of fluid inclusions from the Mori geothermal reservoir, southwestern Hokkaido, Japan: Resource Geol., v. 47, no. 5, p. 283-291. First author at Dept. of Liberal Arts, Faculty of Sci. and Tech., Science Univ. of Tokyo, Noda, Chiba 278, Japan.

FI in hydrothermal quartz and anhydrite are divided into the following four types: L-rich two-phase, V-rich two phase, CO_2-bearing, and polyphase I which contain large halite as a dm. The L-rich I coexist with V-rich I in many samples, indicating that the I F were trapped in these samples under boiling condition. The minimum values of Th of L-rich I are in general agreement with the measured static borehole T, and it suggests that the I which has minimum Th value were formed at the recent stage of geothermal activity.

Bulk gas contents of L-rich I in quartz and anhydrite analyzed by the QMS method are as follows: 91.5 to 99.3 mol% H_2O, 0.56 to 2.4 mol% CO_2, 0.029 to 5.8 mol% N_2, 0.00043 to 0.063 mol% CH_4 and <0.001 mol% Ar. The CO_2/N_2 ratios generally increase with increasing the CO_2/CH_4 ratios. This tendency and the variation of CO_2 contents with the minimum Th values reveals that CO_2, N_2 and CH_4 contents in the I F are controlled by degassing from initial F due to boiling and dilution with groundwater. On the other hand, these gas contents of the I F are nearly equal to or higher than those of geothermal F at the initial stage of exploitation (Yoshida, 1991). From the results and the boiling evidence of the F I as mentioned above, it is inferred that CO_2, N_2 and CH_4 degassing of geothermal F have proceeded from the early stage of geothermal activity to the initial stage of exploitation in the Mori geothermal reservoir. (From authors' abstract by E.R.)

See previous item. Dr. Sawaki adds that the CO_2 contents of FI from the Mori geothermal system were measured on his gas analytical system (QMS), and CO_2 effects on Tm could be estimated. (E.R.)

MURPHY, P.J. and **ROBERTS, S.,** 1997a, Evolution of a metamorphic F and its role in lode gold mineralisation in the Central Iberian Zone: Mineralium Deposita, v. 32, p. 459-474. First author at Dept. of Geol., Univ. of Southampton, Southampton Oceanography Centre, Empress Dock, European Way, Southampton SO14 3ZH, UK.

The Central Iberian Zone of Spain and Portugal contains numerous gold deposits in greenshchist facies metasedimentary units intruded by Hercynian granitoids. Hercynian deformation occurred in three main stages, with several stages of veining. F chemistry studies of samples of known chronology indicate three main sources of F. The dominant F throughout the region is a dilute aqueo-carbonic F of varying composition. The combination of FI analyses and geochemical studies of wallrock alteration indicates that the F was the result of devolatilisation and dehydration during prograde metamorphism at varying depths. The resulting aqueo-carbonic F flowed upwards, mixing with each other and with meteoric waters. Contact metamorphism released further aqueo-carbonic F, which in some cases unmixed to form separate carbonic and aq I. Circulation of meteoric waters was important during later stages. Prolonged low T F-rock interaction produced highly saline aq F which post-date all major quartz veining. No single set of characeristics exists for gold mineralisation in the Central Iberian Zone. The gold mineralisation in the Central Iberian Zone supports the continuum model for lode gold deposits. Gold was leached from metasediments during prograde metamoprhism, transported to shallower crustal levels, and deposited wherever suitable traps occurred. Channelling of F from deeper levels resulted in the localisation of deposits close to major shear zones. (From authors' abstract by E.R.)

MURPHY, P.J. and **ROBERTS, S.,** 1997b, Melting and nucleation behavior of clathrates in multivolatile fluid inclusions: Evidences of thermodynamic inequilibrium: Chem. Geol., v. 135, p. 1-20. Authors at Dept. of Geol., Univ. of Southampton, Southampton Oceanography Centre, Empress Dock, European Way, Southampton SO14 3ZH, UK.

The occurrence of clathrates (solid gas hydrates) in FI severely complicates the use of microthermometry to estimate the composition and density of aqueo-carbonic F. Although models are available to predict clathrate phase equilibria, the models are based on chemical engineering data from ideal systems.

Microthermometric and laser Raman microspectrometric studies of both natural and synthetic aqueo-carbonic I provide evidence that in the presence of clathrates such I are not at equilibrium. Contrary to predictive models, two or more separate clathrates of distinct composition can occur within an I, in local equilibrium with either the aq solution or the carbonic phase rather than the bulk F composition. These results suggest a problem with the use of predictive thermodynamic models based on final clathrate melting T and the assumption of equilibrium within aqueo-carbonic FI.

Data are presented which demonstrate that, as a result of the formation of clathrate, differences in the degree of aq fill can result in very different microthermometric behaviour for I of similar carbonic composition and density.

Although the solubility of CO_2 in water is low, it increases rapidly with decreasing T. This increase can affect both the CO_2 content and the density of the carbonic phase, and may invalidate the use of Th CO_2 at low T, in the metastable absence of clathrate, to calculate carbonic density. (Authors' abstract)

MUTEMERI, Nellia, FRIMMEL, H.E. and **TOURET, J.L.R.,** 1997, Fluids associated with a granite-greenstone contact: The Chinyika shear zone in the Late Archaean Harare greenstone belt, Zimbabwe: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 232-233. First author at Inst. of Mining Research, Univ. of Zimbabwe, P.O. Box Mineral. and Petrol., v. 59, p.167, Harare, Zimbabwe; email (mutemeri@imr.uz.zw).

This study concerns FI from the Chinyika Shear Zone (CSZ), that were associated with the syntectonic emplacement of the Chinyika Tonalite into the Harare Greenstone Belt (HGB) and compares these with F from mineralised shear zones in the same greenstone belt.

It is concluded from this data that the CSZ had a cooling history that was initially isobaric, progressing into decompression. The earliest F, most probably of magmatic origin, are CO_2-CH_4-bearing aq F and were trapped at 550-590°C which correspond to the peak metamorphic T of the HGB. During the cooling of the Chinyika Tonalite, the F became progressively more saline. A late F generation of very high sal is probably associated with the emplacement of late pegmatites.

In contrast, the gold mineralising F in the Arcturus Mine (low sal, CO_2-CH_4-bearing aq) probably came from metamorphic devolatilisation of the greenstone volcanic pile. The PT conditions for the formation of the quartz, as derived from intersecting isochores are at 1.3-2.4 kbars and 340-360°C and, 0.4-1.0 kbars and 200-250°C for the early and later quartz. (From authors' abstract by E.R.)

NABELEK, P.I. and **TERNES, Kim,** 1997, Fluid inclusions in the Harney Peak Granite, Black Hills, South Dakota, USA: Implications for solubility and evolution of magmatic volatiles and crystallization of leucogranite magmas: Geochim. Cosmo. Acta, v. 61, no. 7, p. 1447-1465. Authors at Dept. of Geological Sci., Univ. of Missouri, Columbia, Missouri 65211.

F found in the I [here] are of magmatic origin and present an opportunity to directly sample magmatic F trapped during crystallization of a granitic magma and during subsolidus conditions.

The Harney Peak Granite was emplaced as multiple sills, dikes, and small intrusions, many of which differentiated into coupled aplite-pegmatite layers. Three types of FI are found in the granite. Type I consist of variable saline H_2O-CO_2 mixtures with minor CH_4 or other gases. I of this type are found in tourmaline and quartz in aplite layers, are generally isolated, and have negative crystal shapes. They are interpreted to be P. There is a general increase in sal and decrease in isochore T with decreasing CO_2/H_2O ratio of the I. The trend is ascribed to progressive change in F composition with crystallization due to the differential solubility of CO_2 and H_2O in the high-silica magma. Isochores, coupled with independently determined crystallization T, suggest entrapment P ~3.5 kbar, consistent with geobarometry in the wall-rocks.

Type 2 I are carbonic F dominated by CO_2, whereas type 3 I are saline aq F without a detected carbonic component. Both types are mostly found along healed fractures in quartz. They are interpreted to be S I that formed as a result of unmixing of type 1 I at subsolidus conditions during uplift and cooling of the Harney Peak Granite dome. Freezing-point depressions, birefringent dx, phase-equilibria considerations, and α-track mapping of B and Li distribution in thin sections, all indicate that both type 1 and type 3 I contain solutes such as K, Li, and B in addition to NaCl.

Using published solubility models for H_2O and CO_2 in granitic M and the composition of the most CO_2-rich type 1 I ($XCO_2 = 0.55$), the initial H_2O and CO_2 concentrations in the Harney Peak Granite magma are deduced to have been ~3.5 wt.% and 1500 ppm, respectively. (From authors' abstract by E.R.)

NAKAJIMA, Y., HIRAI, H., KOISHIKAWA, A. and **OHTANI, T.,** 1997a, Three-dimensional non-destructive imaging of fluid inclusions by high-resolution X-ray CT: (abst.): Geol. Soc. Japan Annual Meeting, Fukuoka, Oct. 10-12, Program, p. 162 (in Japanese).

See next item (E.R.).

NAKASHIMA, Yoshito, HIRAI, Hidekazu, KOISHIKAWA, Atsushi and **OHTANI, Tomoyuhi,** 1997b, Three-dimensional imaging of arrays of fluid inclusions in fluorite by high-resolution X-ray CT: N. Jb. Miner. Mh., 1997, no. 12, p. 559-568.

X-ray Computerized Tomography (CT) was successfully applied for the first time to the three-dimensional non-destructive imaging of arrays of FI in a mineral. A newly developed high-resolution X-ray CT system enabled us to take CT images with a resolution of 6.1 μm. We applied the CT system to the imaging of L-rich S FI (20-100 μm in diameter) in a transparent fluorite crystal (≈ 2 mm in length). The obtained images clearly show two I-planes which are cross-checked by conventional optical microscopy. The present study demonstrates that X-ray CT microscopy is useful in paleostress analysis. (Authors' abstract)

NANBU, A., 1996, Genesis of pegmatite deposit of the Kanamaru mine, Niigatu Pref: B.Sc. Thesis, Hokkaido Univ. (in Japanese with Engl. abst.), 51 pp.

Low Th values (170-320°C), even in "primary"-looking I. Quoted by Tanaka and Ishihara, 1997, this volume. See also next item. (E.R.)

NANBU, Asami, HAMANO, Koji, TANAKA, Ryoji and **ISHIHARA, Shunso,** 1997, Chemical and mineralogical characteristics of the Kanamaru pegmatite deposit, Niigata Prefecture, Japan: Resource Geol., v. 47, no. 1, p. 1-10. Authors at Dept. of Earth and Planetary Sci., Hokkaido Univ., Sapporo, 060 Japan.

The pegmatite deposit, which has a rugby-ball shape with an E-W axis, is hosted in the fine-grained biotite granite and the two-mica granite. It is leucocratic, containing a large amount of K-feldspar, some quartz and only a little mafic silicates, reflecting the K_2O-rich and Fe-poor characters of the original granitic magma. No mineralogical and textural zonings are observed in the pegmatite. FI study on quartz indicates low Th and presence of CO_2-bearing F. K-feldspars of the two-mica granite and pegmatite have high degrees of triclinicity. These rocks may have been solidified under volatile-rich environment, which made Al-Si ordering of the K-feldspars during the sub-solidus stage. (From authors' abstract by E.R.)

NARASIMHAN, D., KRISHNA, R.N., PANCHAPAKESAN, V. and **SAHU, K.C.,** 1997, Tungsten mineralisation at Khobna, Maharashtra; fluid inclusion studies: J. Geological Soc. of India, v. 50, no. 3, p. 343-346.

NAUMOV, Vladimir, KARPHUKHINA, Valentina and **BARANOV, Eduard,** 1997, Melt inclusions in quartz phenocrysts from felsic volcanities of the Verkhneuralsky area, southern Urals: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 234-235. First author at Vernadsky Inst. of Geochem. and Analytical Chem., Kosygin 19, Moscow 117975, Russia.

Massif sulfide deposits of the Urals are located within volcanogenic formations with felsic volcanites. Data composition of P M of felsic volcanites are lacking to this day since most such volcanites were subjected to greenstone alterations [but MI remain unaltered].

MI in quartz phenocrysts were studied in 150 samples of dacite, rhyodacite and rhyolite of three cycles of felsic volcanism. MI glasses and homogenized devitrified I were analyzed by electron microprobe for major elements and F, Cl (53 I) and with an ion microprobe for H_2O and trace elements (2 inclusions). [Seven analyses are presented.]

The content of water in the M by ion microprobe is 4.6-4.7 wt.%. The content of trace elements was defined by ion microprobe also (in ppm): Li-0.30, Be-0.35, B-115, Sr-100, Y-34.2, Zr-105, Nb-1.11, Ba-355, La-5.04, Ce-13.0, Nd-8.46, Sm-2.61, Eu-0.90, Dy-3.98, Er-2.80, Yb-3.12, Th-0.94. (From authors' abstract by E.R.)

NAUMOV, V.B. and **KOVALENKO, V.I.,** 1997, Sulfur concentration in magmatic melts: Evidence from inclusions in minerals: Geokhimiya, 1997, no. 1, p. 97-103, (in Russian, trans. in Geochem. Internat'l., v. 35 no. 1, p. 88-94). First author at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, ul. Kosygina 19, Moscow, 117975 Russia.

Table I contains data compiled from 560 analyses in 53 papers on sulfur and some major-element contents in magmatic silicate M, obtained by analysis of glasses from homogenous MI in minerals (319) and chilled glasses from volcanic rocks of the oceanic floor (241). MI were analyzed in 16 minerals, mostly in olivine (175 analyses), pyroxene (37), plagioclase (35), and quartz (33). (From authors' text by E.R.)

NAUMOV, V.B., KOVALENKO, V.I. and **DOROFEEVA, V.A.,** 1997a, Magmatic volatile components and their role in the formation of ore-forming F: Geologiia Rudnykh Mestorozhdenii (Geology of Ore Deposits), v. 39, no. 6, p. 451-xxx.

NAUMOV, Vladimir, KOVALENKO, Vyacheslav and **DOROFEEVA, Vera,** 1997b, Concentration of volatile components (H_2O, CO_2, S, Cl, F) in the magmas: Evidence from melt inclusions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 236-237. First author at Vernadsky Inst. of Geochem. and Analytical Chem., Kosygin 19, Moscow 117975, Russia.

Presents a table of the mean abundances (wt.%) of volatile and non-volatile components in six types of natural magmatic M from the studies of MI in minerals and quenched glasses from the ocean floor, based on ≤1365 analyses from the literature. (From authors' abstract by E.R.)

NAVON, O., CHEKHMIR, A. and **FINK, J.,** 1997, Crystal wetting by bubbles in rhyolitic melts (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 159. First author at Inst. of Earth Sci., The Hebrew Univ., Jerusalem, Israel; e-mail (oded@vms.huji.ac.il)

Nucleation of bubbles in silicic M is the initial stage of Plinian eruptions. Hurwitz and Navon (1994) demonstrated that high levels of supersaturation are needed for homogeneous bubble nucleation and emphasized the role of heterogeneous nucleation on crystals. The efficiency of a crystal as a nucleation site depends on the energy of the bubble-crystal surface relative to the bubble-M surface. It may be measured by examining the wetting of crystals by bubbles.

Grains of a single crystalline phase and rhyolitic glass were suspended in water and loaded in Pt capsules. Following melting and hydration at 850°C, 150 MPa for 3 hours, bubbles were allowed to grow at 70 MPa and approach textural equilibrium for 600 s. The recovered samples revealed extensive wetting of diopside, phlogopite, ilmenite, and magnetite by many bubbles. The case of quartz, labradorite and oligoclase is less clear, either they are not wetted at all, or are very poorly wetted.

Microscopic examination of vesiculated rhyolites from the RDO-2B drill core in the Inyo Obsidian Dome (vertical depth 4.0 and 11.5 m) supports the above conclusions. Iron oxides are found mainly inside vesicles (almost completely wetted by the bubbles), plagioclases are never wetted by the bubbles, biotite is wetted in some cases, but is clearly less well-wetted than the iron oxides.

Our observations suggest that it is possible to crystallize feldspars and quartz and reach high degrees of supersaturation without initiating nucleation of bubbles. Introduction of efficient nucleation sites in the form of iron-bearing phases will lead to nucleation and P buildup, and may trigger eruptions from shallow magma chambers or from rhyolitic lavas. (Authors' abstract)

NESBITT, B.E. and **MUEHLENBACHS, Karlis,** 1997, Paleo-hydrogeology of Late Proterozoic units of southeastern Canadian cordillera: American J. of Sci., v. 297, p. 359-392. Authors at Dept. of Earth and Atmos. Sci., Univ.of Alberta, Edmonton, Alberta T6G 2E3

A comprehensive geological and geochemical investigation of veining and other manifestations of F flow in late Proterozoic units of the Windermere Supergroup in the southeastern Canadian Cordillera was undertaken to characterize the nature of hydrogeological systems during and following deformation of a fold and thrust belt. The results of FI studies document vein formation from moderate to low T, low sal, aq F. Results of $\delta^{18}O$ studies of vein quartz and carbonate indicate that the veins formed from F with high $\delta^{18}O$ values, which in most cases were derived from extensive isotopic exchange between the F and Proterozoic units. In widespread, small, early, bedding-parallel veins and in larger subvertical veins in units of biotite greenschist or higher metamorphic grades, δD values of I F are generally >-90 per mil indicating vein formation from F originating from metamorphic devolatilization. In rocks of metamorphic grade less than biotite greenschist facies, larger, late tectonic, subvertical veins have δD values (-120 to -150 per mil) for I F indicative of vein formation from deeply circulated meteoric water. (From authors' abstract by E.R.)

NEUMANN, E.-R. and **WULFF-PEDERSEN, E.,** 1997, The origin of highly silicic glass in mantle xenoliths from the Canary Islands: J. of Petrol., v. 38, no. 11, p. 1513-1539. Authors at Mineralogisk-Geologisk Museum, Univ. of Oslo, Sarsgt. 1, N-0562 Oslo, Norway.

Spinel harzburgite, lherzolite, dunite and wehrlite mantle xenoliths from the Canary Islands (La Palma, Hierro, Tenerife and Lanzarote) contain a spectrum of silicate glasses as I in minerals, along grain boundaries, and in interstitial glass pockets. These glasses show a range in composition from basaltic (~44 wt.% SiO_2, to highly silicic, 71 wt.% SiO_2). Dm coexisting with highly silicic glass in polyphase I are similar in composition to the main phases in the host xenoliths (Fo>90, Cr-diopside, chromite), whereas those in less silicic glasses are richer in Al_2O_3, TiO_2 and FeO, and poorer in MgO. The systematic relations found to exist between glass composition, mineralogy of the host xenolith and locality (island) suggest a cogenetic relationship between the M and their mantle host xenoliths. The silicic glasses are interpreted as the products of reactions at 8-12 kbar between infiltrating alkali basaltic magmas and peridotitic wall-rocks. The silicic M appear to have been mobile over distances exceeding the diameter of a xenolith, that is, at least 20-30 cm. (From authors' abstract by E.R.)

NEWELL, K.D., 1997, Influence of an early Paleozoic cratonic arch on dolomitization in Upper Ordovician Viola Formation, south central Kansas, USA (abst.): Annual Meeting Abstracts - American Assoc. of Petroleum Geologists and Soc. of Economic Paleontologists and Mineralogists, v. 6, p. 87-88.

The Upper Ordovician Viola Fm., a shelf carbonate, is eroded over the broad Chautauqua arch, and is dolomitized on its flanks. FI indicate that dolomitization occurred at T less than about 50°C. Strontium isotopes of the concentric dolomite are consistent with dolomitization during the Late Ordovician, whereas those of the collage and mimetic dolomites are consistent with a Silurian event. P(?) FI in the collage dolomite are hypersaline, and may indicate seepage-reflux of brines entering the Viola where it is truncated on top of the arch. Isotopically negative oxygen in the mimetic and collage dolomites are not consistent with hypersalinity, but recrystallization may have altered the original isotopic signature. P(?) FI and oxygen isotopes in the concentric dolomite indicate generally lower but variable sal during precipitation, compatible with a mixing-zone environment. (From author's abstract by E.R.)

NEWMAN, B.D., CAMPBELL, A.R., NORMAN, D.I. and **RINGELBERG, D.B.**, 1997, A model for microbially induced precipitation of vadose-zone calcites in fractures at Los Alamos, New Mexico, USA: Geochim. Cosmo. Acta, v. 61, no. 9, p. 1783-1792. First author at Environmental Sci. Group, Los Alamos Nat'l. Laboratory, Los Alamos, NM 87545, USA.

Calcite fracture fillings are present in the near surface in the Bandelier Tuff Fm. at Los Alamos, New Mexico, and provide a record of the geochemical and hydrologic processes that have occurred in fractures. Scanning electron microscopy show morphologies which suggest that plants, fungi, and bacteria were important in the precipitation process. Quadrupole mass spectrometric analyses of FI gases show predominantly methane (17-99%) and little to no oxygen (0-8%), suggesting the development of anaerobic conditions in the fractures. (From authors' abstract by E.R.)

NIE, F.-J., 1997, Type and distribution of gold deposits along the northern margin of the north China craton, People's Republic of China: Internat'l. Geol. Review, v. 39, p. 151-180. Author at Inst. of Mineral Deposits, Chinese Acad. of Geological Sci., Baiwanzhuang Road 26, Beijing 100037, People's Republic of China.

About one-third of China's endogenic gold deposits and 45% of its gold reserve come from this belt, particularly in the Early Precambrian metamorphic terrains. All these gold deposits can be classified into five principal types according to their host rocks: (1) gold-bearing quartz or albite-quartz veins hosted by Archean amphibolite, gneiss, and migmatite; (2) gold-quartz veins hosted by Proterozoic schist, slate, sandstone, and marble; (3) gold deposits hosted by or related to intrusive complexes, including (3a) calc-alkaline granitoids, (3b) alkaline syenite and monzonite, and (3c) ultramafic intrusions; (4) gold deposits occurring in Phanerozoic volcanics; and (5) a group containing placer gold. Gold and base metals in types 3 and 4 were deposited from aq F with relatively low CO_2 content (<20 mol%) and low to moderate sal (5 to 16 wt.% NaCl eq.) that were related to a mixed F of magmatic and meteoric water. (From author's abstract by E.R.)

NIELSEN, T.F.D., SOLOVOVA, I.P. and **VEKSLER, I.V.**, 1997, Parental melts of melilitolite and origin of alkaline carbonatite: Evidence from crystallised melt inclusions, Gardiner complex: Contrib. Mineral. Petrol., 1997, no. 126, p. 331-344. First author at Danish Lithosphere Centre, Øster Voldgade 10, DK-1350 København K., Denmark.

Perovskite and melilite crystals from melilitolites of the ultramafic alkaline Gardiner complex (east Greenland) contain crystallised M I derived from [i.e., of the following compositions]: (1) melilitite; (2) low-alkali carbonatite; (3) natrocarbonatite. The melilitite I (1) Th of 1060°C is similar to liquidus T of experimentally investigated natural melilitites. The compositions are peralkaline, low in MgO (ca. 5 wt.%), Ni and Cr, and they are low-P fractionate of more magnesian larnite-normative ultramafic lamprophyre-type M of P mantle origin. Low-alkali carbonatite compositions (2) homogenise at 1060-1030°C and are compositionally similar to immiscible calcite carbonatite dykes derived from the melilitolite magma. Natrocarbonatite I (3) homogenise between 1030 and 900°C and are compositionally similar to natrocarbonatite lava from Oldoinyo Lengai. The Gardiner complex and similar melilitolite and carbonatite-bearing ultramafic alkaline complexes are believed to represent subvolcanic complexes formed beneath volcanoes comparable to Oldoinyo Lengai and that the suggested origin of natrocarbonatite may be applied to natrocarbonatites of Oldoinyo Lengai. (From authors' abstract by E.R.)

NIELSEN, T.F.D. and **VEKSLER, I.V.**, 1997, Ultramafic alkaline complexes: Lines of liquid descent and origin of natrocarbonatite in the Gardiner complex, east Greenland (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A109. First author at Danish Lithosphere Centre, Øster Voldgade 10, DK-1350 Copenhagen K., Denmark.

Ultramafic alkaline complexes are composed of alkaline ultramafic to mafic cumulates, evolved peralkaline undersaturated rocks and carbonatites. Extensive metasomatism often masks lines of L descent (LLDs). Dykes swarms and M I in the Gardiner complex show three LLDs from a common parent. The three trends develop in response to stability of liquidus phlogopite.

Melilite and perovskite in melilitolites contain four types of I within the same zone of melilite crystals: (1) melilitite M, Th of 1060°C; (2) alkali carbonatite in equilibrium with the melilitite, Th of 1060°C; (3) natrocarbonatite compositions, Th of 1030°C in close association or combined with pure CO_2 FI.

The LLDs, the experimental data and the M I studies support the association of alkali carbonatite M to larnite-normative LLDs, which both result from closed system CO_2-rich conditions. The melilitite and carbonatite M I show formation of immiscible alkali carbonatite in melilititic M with 6-8% total alkalies. The coexisting natrocarbonatite I and associated FI cannot be a second type of immiscible carbonate M and are interpreted as developed from a coexisting supercritical F phase at 1060°C, which evolves to natrocarbonatite and CO_2 F. This and new distribution coefficients indicate that natrocarbonatite may not be formed as immiscible M. The results are believed to apply to Oldoinyo Lengai. (From authors' abstract by E.R.)

NIKOGOSIAN, Igor, NAUMOV, Vladimir,

MAGAKYAN, Ruben and **SOBOLEV, Alexander,** 1997, High concentration of CO_2 in basanitic melt: Fluid and melt inclusions study in olivine from post-collision neovolcanics, Kapan (southeast Armenia): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 238. First author at Vernadsky Inst. of Geochem., Kosygin 19, Moscow 117975, Russia; email (inikogosian@glas.apc.org).

An extensive study of M and FI in olivine ($Fo_{90.5-8.8}$) from 8 basanite samples have been carried out. We distinguished two types of MI: glass+high-density CO_2 F bubble and some Cpx dxl, or just glass+cpx. Isolated CO_2 FI in olivine phenocrysts were not found. We found a few S carbonate MI, one of which shows direct evidence of immiscibility.

The absence of the CO_2 FI in olivine (~500 phenocrysts are investigated) and the constant ratio of F bubble to M volumes in I yields the conclusion that CO_2 phase in MI have separated as F after trapping from homogeneous M. From these measurements we estimate average CO_2 concentrations of 1.9-2.5 wt.% (five I) and 3.2 wt.% (one I). (From authors' abstract by E.R.)

NIKOGOSIAN, I.K. and **SOBOLEV, A.V.,** 1997, Ion-microprobe analysis of melt inclusions in olivine: Experience in estimating the olivine-melt partition coefficients of trace elements: Geokhimiya, 1997, no. 1, p. 149-157 (in Russian, trans. in Geochem. Internat'l., v. 35 no. 2, p. 119-126). Authors at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, ul. Kosygina 19, Moscow, 117975 Russia.

P M I in olivine from the picrite of Mauna Loa volcano, Hawaii Island, were studied by the methods of high-T optical thermometry, S ion mass spectrometry, and X-ray electron microprobe analysis to quantify the partitioning coefficients (K_d) of Ti, Dy, Li, Y, Yb and Cr between magnesian olivine and tholeiitic M at T of 1330-1280°C, a P of ~1 kbar, fO_2 at approximately the QFM buffer, and element contents approximating those in natural rocks. A significant linear correlation between ln K_d and 1/T was established for Ti, Li, and Cr. The correspondence between the K_d values determined for Ti, Dy, Y, Yb and Cr with the published ranges of these values indicates that studies of M I in minerals offer great promise as a method for determining K_d of elements between minerals and M. (Authors' abstract)

NISHIO, Y., SASAKI, S., GAMO, T., HIYAGON, H. and **SANO, Y.,** 1997, Carbon and helium isotope systematics of north Fiji basin basalt glasses: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 151, Lunar and Planetary Inst., Houston. First author at Geological Inst., School of Sci., Univ. of Tokyo, Tokyo 113, Japan; email (nishio@geol.s.u-tokyo.ac.jp)

We have measured $\delta^{13}C$ values and $CO_2/^3He$ ratios of vesicle gas, and chemical compositions of North Fiji Basin basalt glasses, in order to estimate the contribution of subducted C in back-arc basin basalt quantitatively. The $CO_2/^3He$ and $\delta^{13}C$ trends should be produced by the mixing between mantle component (low-$CO_2/^3He$, high-$\delta^{13}C$, and low-K_2O) and subducted component (high-$CO_2/^3He$, low-$\delta^{13}C$, and high-K_2O), because REE and Sr-Nd isotopic data suggest that the variety of K_2O content of the North Fiji Basin basalt is the result of two-component mixing. Based on the mass-balance calculation of Sano and Marty, we estimate that carbonate and organic C in North Fiji Basin basalts have a ratio of 7:3. Assuming complete decomposition of the subducted organic C, more than 90% of the subducted carbonate survives and may be injected into the mantle in the area studied, since carbonate and organic C in subducting marine sediment through the North Fiji subduction zone should occur in ~20:1 ratio. (From authors' abstract by E.R.)

NIU, Hecai, SHAN, Qiang and **LIN, Maoqing,** 1997, Fluid-melt and fluid inclusions in Mianning REE deposit, Sichuan, southwest China: Chinese J. of Geochem., v. 16, no. 3, p. 256-262 (in Engl.). First author at Guangzhou Inst. of Geochem., Chinese Academy of Sci., Guangzhou, 510640.

Abundant F-M I are found in the aegirine-augite-barite pegmatite and carbonatite veins in the Mianning REE deposit, Sichuan. They were trapped in early stage fluorite and quartz from a salt-M system at T>500°C. FI are also present in large amounts in bastnaesite. Homogenized between 150 and 270°C, these I are thought to be representative of the physico-chemical conditions of REE mineralization. These results show that the Mianning REE deposit is of typical hydrothermal origin developed from a salt-M system. (Authors' abstract)

NIVLET, Philippe, NOGUEIRA, Pedro, CANALS, Martin, AYT OUGOUGDAL, Mohammed and **CATHELINEAU, Michel,** 1997, Statistic and fractal analysis of sets of fluid inclusion planes, implication for the reconstruction of paleopermeability tensors: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 239-240. First author at CREGU, BP 23, 54501 Vandœuvre-lès-Nancy cedex, France; email (nivlet@cregu.cnrs-nancy.fr).

The aim of this study is to estimate, at the microscopic scale, the (paleo)-permeability of granitic rocks by reconstructing a permeability tensor from sets of healed micro-fissures: the FIP. The complexity of FIP features, especially their distribution in space (length, dip and strike) has been treated through fractal and statistic approaches. (From authors' abstract by E.R.)

NOGUEIRA, Pedro, NORONHA, Fernando, CATHELINEAU, Michel and **BOIRON, M.-C.,** 1997, Paleocirculation of gold mineralizing fluids in granitic rocks from NW Portugal: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 241-242. First author at Dep. de Geociências, Univ. de Évora, Apartado 94, 76001 Évora Codex, Portugal.

The aim of this work is to describe the evolution and the pathways of the F that circulated in mineralised areas from NW of Portugal. The 3D geometry of FIP were performed on an image analyser using a software program developed by Nogueira and Noronha (1995).

Two main types of F are present in the quartz veins – H_2O-CO_2, and H_2O. Isochores for aquo-carbonic and aq F reveal significantly distinct P-T conditions. The aquo-carbonic F exhibit isochores suggesting higher T and P with P between 400 MPa and 150 MPa. Aq F are thought to be trapped at lower P than the early stages between 100 MPa and 50 MPa.

The analysis of the FIP sets show that aquo-carbonic F have circulated mainly in cracks striking along NE-SW direction while aq F are observed mainly in younger N-S striking FIP.

The time-space relationships between F circulation and mineral deposition has been deciphered thanks to the integrated study of ores, quartz typology and FIP. The results indicate that aquo-carbonic F are synchronous to later than the deposition of the main sulphides. The circulation of aquo-carbonic F occurs in crack network parallel to the direction of the quartz veins. The sulphur and oxygen fugacities obtained for the aquo-carbonic F agrees with the equilibrium pyrite-pyrrhotite. The data obtained ranges between -6.2 and -9.4 for $\log fS_2$ at 400°C and in the range -26.7 to -27.9 for $\log fO_2$ the same T. (From authors' abstract by E.R.)

NORMAN, D.I., CHOMIAK, Beverly, ALBINSON, Tawn and **MOORE, Joe,** 1997, Volatiles in epithermal systems: The big picture (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-206. First author at Dept. of Earth and Environmental Sci., New Mexico Tech, Socorro, NM 87801; email (dnorman@nmt.edu).

Volatiles were analysed in I from 23 Mexican low sulfidation state epithermal deposits. Analyses total nearly 900. Other data on the samples include FI Th and Tm, ore deposit mineralogy, and Ag/Au ratio. Gas analyses show broad variations from deposit to deposit, but there is no clear association between Ag/Au or FI sal and gas composition. Analyses plotted on N_2-Ar-He and N_2-Ar-CH_4 diagrams indicate each past geothermal system comprised a complex mixing of volatiles from several sources. The N_2/Ar of sulfide mineral I are all above that of air saturated water (ASW), whereas a significant proportion of I in gangue minerals have N_2/Ar ratios near that of ASW. Plots of N_2/Ar vs. H_2S/Ar show a correlation between N_2 and H_2S concentrations. Data plotted on CO_2/CH_4 vs. H_2S diagrams indicate epithermal F, like those in Tiwi and Broadlands geothermal system plots, [sic] in the pyrite or pyrrhotite fields and appear to be approaching py-po-mag from the cold side. In contrast, I volatiles from porphyry systems and The Geysers geothermal system appear to approach the same equilibrium from the hot side.

Our data are consistent with Mexican epithermal systems comprising ground waters and magmatic waters, with a good share of H_2S magmatic in origin. F interactions with iron minerals appear to control the oxidation state and H_2S content of ore F, with all Mexican ore F exhibiting equilibrium concentrations of CO_2-CH_4-H_2S at or somewhat below Th values. This suggests that the geothermal systems were dominated by convective flow of ground waters that accumulated upward fluxing H_2S from a magma. (Authors' abstract)

NORMAN, D.I. and **MOORE, J.N.,** 1997, Gaseous species in fluid inclusions: A fluid tracer and indicator of fluid processes: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 243-244. Authors at New Mexico Tech, Socorro, NM 87801, USA & EGI, Univ. of Utah, Salt Lake City,UT 84108, USA; email (dnorman@mailhost.nmt.edu).

I volatiles are analyzed by thermal decrepitation followed by cryogenic separation (TDCS), and by the cold-crush-fast-scan (CFS) method. Both methods use a quadrupole mass spectrometer to measure the liberated I volatiles. Precision of the TDCS method is 5% or better because there are few interferences in the mass spectrometer measurement and the amount of each fraction cryogenically separated is determined by P measurement. The CPS method [sic, presumably CFS?] analyzes far fewer I than is measured by the TDCS method. Opening a 10 to 20 micron I, or group of smaller I of equivalent volume, provides the ideal amount of volatiles for a CPS analysis.

Examples are given of application to understand F mixing, condensation, and volatile source. (From authors' abstract by E.R.)

NORMAN, D.I., MOORE, J.N. and **ALBINSON, Tawn,** 1997, Variation with time of geothermal fluid sources indicated by fluid inclusion gas analysis: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F745. First author at Dept. of Earth and Env. Sci., New Mexico Tech, Socorro, NM 87801, U.S.A.; email (dnorman@nmt.edu)

FI gas chemistry is used to study the source of volatile species in past and present geothermal systems. Analyses are by the crush-fast-scan method whereby a few I at most are analyzed each analysis. The N_2/Ar ratios of FI volatiles from the Mat 25 well, Tiwi geothermal field, Philippines are mostly between 20 and 100, which can be attributed to a meteoric source of the two species. Ratios of CH_4 to Ar are consistent with additions of CH_4 and N_2 to meteoric waters at a ratio about 9:1 (C/N=4.5). The similarity of the C/N ratio to that in marine sediments suggests meteoric F at Tiwi evolved by interaction with organic-rich turbidites present in the wall rock. I from one fracture have subduction-zone-andesite-magmatic N_2/Ar ratios and low amounts of CH_4 indicating an addition of magmatic volatiles to F along a specific fracture.

Eighty-five FI gas analyses of a cm-size fragment of BR12 well, Broadlands, New Zealand quartz show a broad range of N_2/Ar and N_2/CH_4 ratios that mostly plot on a N_2-Ar-CH_4 diagram between C/N=5 and a magmatic end member composition. Microthermometry indicates F T varied no more than a few degrees C during deposition of the quartz crystal studied.

Zacatecas Mine, Mexico FI in banded ores from the deepest in the mine plot on N_2-Ar-CH_4 diagram along a mixing line between C/N=5 and the magmatic end members. I from the uppermost part of the mine plot near the composition of air saturated water. I analyses from intermediate depths plot between samples from deep and shallow depths. Our interpretation is that deep Zacatecas F contain admixed evolved meteoric and magmatic volatiles that mixed with varying proportions of shallow circulating meteoric F near the paleo surface.

Our analyses indicate that heterogeneity in geothermal system gas chemistry occurs with time and space. Deep geothermal F are admixtures of magmatic volatiles and evolved meteoric water, which mix near surface with shallow circulating meteoric F. The percentage of each component in a fracture may change over the time between trapping separate FI in a growing crystal. Our data indicate that banded "epithermal" mineralization results from the interplay of F that have different gas chemistries, but may be similar in T and amount of dissolved solids. (Authors' abstract)

NORONHA, Fernando, VINDEL, Elena, LÓPEZ, José, DÓRIA, Armanda, GARCIA, Eugenia, BOIRON, M.-C. and

CATHELINEAU, Michel, 1997, Fluids related to tungsten mineralizations in northern Portugal and Spanish Central System: A comparative study: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 245-246. First author at Centro de Geologia da Univ. do Porto, Fac. de Ciências, 4050 Porto, Portugal; email (fmnoronh@fc.up.pt).

A comparative study of P-T-X F evolution in different Iberian tungsten deposits has been carried out on representative test sites, Panasqueira, Borralha (northern Portugal) and several deposits of Spanish Central System (San Rafael, Cabeza Mediana, Cabeza Lijar). The veins are characterised by multistage ore deposition which consists of successive crystallizations of W(Sn-Mo) minerals and Cu-Zn-(Pb) sulphides. Three main types of F have been distinguished: (i) Magmatic hypersaline aq F, (ii) Metamorphic aquo-carbonic F (H_2O-NaCl-CO_2-CH_4 F), and (iii) Aq F (H_2O-NaCl L). Tm CO_2, Tm H_2O, Tm NaCl, Th CO_2, Th, and bulk composition (NaCl, H_2O, CO_2, CH_4, N_2) are given in a table for eleven samples.

The tungsten mineralizations are always characterised by the presence of aq-carbonic F, which are probably F resulting of water-rock interactions within the metamorphic host-rocks. These F belong to the CHON system and are mostly dominated by CO_2-H_2O. A progressive enrichment in water and CH_4 content as well as a decrease in the density of the volatile phase occurs with T decrease.

Results show that the Hercynian granites may be regarded as playing a different role on ore forming processes than already thought. There is especially no evidence of magmatic F contribution, except the earliest stages responsible for the greisen formation. (From authors' abstract by E.R.)

NOTO, Masami and **KUSAKABE, Minoru**, 1997a, An experimental study of oxygen isotope fractionation between wairakite and water: Geochim. Cosmo. Acta, v. 61, no. 10, p. 2083-2093. Authors at Inst. for Study of the Earth's Interior, Okayama Univ Misasa, Tottori-ken 682-01, Japan.

Almost complete oxygen isotopic exchange during the hydrothermal runs indicate that the exchange between wairakite framework oxygen and water is rapid compared to that of the other silicate-water systems. This implies that the $\delta^{18}O$ value of natural wairakite is controlled by retrograde re-equilibration under hydrothermal conditions. (From authors' abstract by E.R.)

NOTO, Masami and **KUSAKABE, Minoru**, 1997b, Oxygen isotope geochemistry of geothermal wairakite: Geochim. Cosmo. Acta, v. 61, no. 10, p. 2095-2104. Authors at Inst. for Study of the Earth's Interior, Okayama Univ Misasa, Tottori-ken 682-01, Japan.

The disequilibrium oxygen isotopic relationship between some calcite-wairakite pairs for the Kirishima geothermal system suggests that the two minerals were precipitated from the waters with different $\delta^{18}O$ values at different stages in the evolution of the system, consistent with paragenetic relations of the minerals.

Oxygen isotopic composition of wairakite can be used as a new, single-mineral isotopic geothermometer for active geothermal systems and be applied to elucidate their thermal evolution. (From authors' abstract by E.R.)

NOVGORODOV, P., MARSHINTSEV, V., ARGUNOV, K., GORYAINOV, S., SAPARIN, G., and **ZINCHUK, N.**, 1997, Pseudosecondary inclusions and a possibility of crack healing in diamond crystal under upper mantle conditions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 247-248. First author at 39 Lenin pr, 677891 Yakutsk, Yakutia, Russia; email (geo@yacc.yakutia SU).

A zoned diamond crystal from the Mir pipe (Yakutia) gave a chance to study for the first time unusual I most similar in their features to PS I described in minerals of mantle origin.

Optical studies and studies by electron and Raman microprobe (EMP, RMP) show that the I (0.1-40 µm) are located on the curvilinear planes in two areas near the periphery of the central zone of the diamond and suddenly terminate at central-outer zone interface.

The crystal (from ultrabasic paragenesis) most probably grew in the presence of a potassium-rich, fluid-containing subliquidus M. During growth, the crystal experienced brittle deformation and subsequent healing of cracks with transformation of the entrapped fragment of the parent M into numerous olivine I in the form of negative crystals. The crystal continued growth after it had experienced brittle deformation. The crystal appears to have had a long time for crack healing in the diamond stability region because the age of most diamond of ultrabasic association is around 3.0-3.3 billion years whereas the time of their arrival to the day surface in Yakutian kimberlites does not exceed 450 million years. (From authors' abstract by E.R.)

O'REILLY, C., FEELY, M., HOLDSTOCK, M.P. and **O'KEEFE, W.G.**, 1997, Fluid inclusion study of the unexposed Kentstown Granite, Co. Meath, Ireland: Trans. Instn. Min. Metall. (Sect. B: Appl. Earth Sci.), v. 107, Jan.-April 1997, p. B31-B37.

The Kentstown Granite was intersected by a borehole at 662.5 m. A petrographic and microthermometric study of FI in the Kentstown Granite, crosscutting quartz (V_1) and calcite + quartz (V_2) veins in the granite and calcite + quartz (V_2) veins in the overlying sediments was performed on samples taken from the borehole.

Aq-carbonic F (types 1 and 2), found only in granite quartz, were the earliest F to have circulated through the granite. The estimated trapping conditions for these earliest F are ca 300-300°C and ca 1.6 kbar. Later low-sal (<9 eq. wt.% NaCl) F of moderate (ca 150-250°C) Th and of probable meteoric origin occur as S I in granite quartz and as P and S I in V_1 vein quartz (type 3). Moderate-sal (ca 10-15 eq. wt.% NaCl), moderate Th (ca 110-200°C) F (type 4) that were trapped as S I in granite and in V_1 vein quartz are of uncertain origin. Low-Th (ca 50-150°C), high-sal (ca 20-27 eq. wt.% NaCl) $CaCl_2$-rich brines (type 5) occur as P I in V_2 vein calcite and quartz and also as S I in V_1 vein quartz and in granite quartz. Comparisons of types 1, 2, and 3 FI populations recorded in the present study with those from other Irish Caledonian granites strongly suggest a similar F evolutionary history. Furthermore, the low-T, $CaCl_2$-rich brines (type 5) of this study, which must be syn- to post-Lower Carboniferous in age, have correlatives both in Irish Caledonian granites and in the Lower Carboniferous base-metal deposits of the Irish midlands. (From authors' abstract by E.R.) *See figure on page 232.*

O'REILLY, C., GALLAGHER, V. and **FEELY,**

M., 1997, Fluid inclusion study of the Ballinglen W-Sn-sulphide mineralization, SE Ireland: Mineralium Deposita, v. 32, p. 569-580. First author at Dept. of Geol., Univ. College, Galway, Ireland.

Scheelite-mineralized microtonalite sheets occur on the SE margin of the end-Caledonian Leinster Granite in SE Ireland. Scheelite, polymetallic sulphides and minor cassiterite occur in veins in microtonalites, disseminated throughout the greisened microtonalite sheets and in the adjacent wallrocks. Two major mineralized vein types occur in the microtonalite sheets: (1) Scheelite±arsenopyrite±pyrrhotite occur in quartz-fluorite veins, and (2) Sphalerite±chalcopyrite±pyrite±galena±cassiterite±stannite in quartz + fluorite veins. Three distinct types of FI have been recognized. P, V rich Type 1 I in quartz from the scheelite-mineralized veins are of H_2O-CO_2-CH_4-N_2±H_2S±NaCl composition and formed between 360-530°C. P and S, L-rich Type 2 FI in the base metal sulphide-mineralized veins are of H_2O-CH_4-N_2±H_2S-NaCl composition and formed between 340-480°C. They also occur as pseudosecondary and S I in scheelite-mineralized veins. Late dilute, low T H_2O-NaCl + KCl FI may be related to late-Caledonian convection of meteoric waters around the cooling Leinster Granite batholith. (From authors' abstract by E.R.)

O'REILLY, C., JENKIN, G.R.T., FEELY, M., ALDERTON, D.H.M. and FALLICK, A.E., 1997, A fluid inclusion and stable isotope study of 200 Ma of fluid evolution in the Galway Granite, Connemara, Ireland: Contrib. Mineral. Petrol., v. 129, p. 120-142. First author at Dept. of Geol., Univ. College, Galway, Ireland.

FI in granite quartz and three generations of veins indicate that three F have affected the Caledonian Galway Granite. The earliest F was a H_2O-CO_2-NaCl F of moderate sal (4-10 wt.% NaCl eq.) that deposited late-magmatic molybdenite mineralised quartz veins (V_1) and formed the earliest S I in granite quartz. Microthermometric data for V_1 indicate lower T, suggesting I volumes re-equilibrated during cooling. The second F was a H_2O-NaCl-KCl, low-moderate sal (0-10 wt.% NaCl eq.), moderate T (270-340°C), high δD (-18±2‰), low $\delta^{18}O$ (0.5-2.0‰) F of meteoric origin. This F penetrated the batholith via quartz veins (V_2) which infill faults active during post-consolidation uplift of the batholith. The sal was generated by F-rock interactions within the granite. Within granite quartz this F was trapped at 0.5-2.3 kbar, having become overpressured. The final F (to enter the granite and its host) was a H_2O-NaCl-$CaCl_2$-KCl F with variable sal (8-28 wt.% NaCl eq.), T (125-205°C), that deposited veins containing quartz, fluorite, calcite, barite, galena, chalcopyrite sphalerite and pyrite (V_3). Correlations of sal, T, δD and $\delta^{18}O$ are interpreted as the result of mixing of two F end-members. (From authors' abstract by E.R.)

OBERTHÜR, T., WEISER, T., AMANOR, J.A. and CHRYSSOULIS, S.L., 1997, Mineralogical siting and distribution of gold in quartz veins and sulfide ores of the Ashanti mine and other deposits in the Ashanti belt of Ghana: Genetic implications: Mineralium Deposita, v. 32, p. 2-15. First author at Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, D-30655 Hannover, Germany.

Multiple quartz veining and growth zoning of the sulfides are interpreted as manifestations of multiple episodes of F infiltration, F flow and mineral deposition. The bimodal occurrence of gold in spatially closely associated quartz vein and sulfide ores indicates a genetic link between these ore types. A model implying a grossly coeval formation of the ores from mesothermal F is proposed. (From authors' abstract by E.R.)

ODLING, N.W.A., GREEN, D.H. and HARTE, B., 1997, The determination of partial melt compositions of peridotitic systems by melt inclusion synthesis: Contrib. Mineral. Petrol., v. 129, p. 209-221. First author at Dept. of Geol., and Geophys., Univ. of Edinburgh, West Mains Rd., Edinburgh EH9 3JW Scotland.

An experimental method of M I synthesis within olivine crystals has been developed to determine the composition of the M present in a partially molten peridotite assemblage. A single crystal of olivine, which had been cut to a disc shape, was included in the sample capsule. The M phase is preserved as homogeneous glass I up to 50 µm in size, trapped in situ in the olivine disc. The M composition obtained is of broadly basaltic character and is close to the trend for dry melting. Trace element, carbon and hydrogen contents of 13 M I have been determined by S ion mass spectrometry (SIMS). The equilibrium M has a C/H of 0.48 by weight. Carbon solubility in partial M is thus significant under reducing conditions in the presence of dissolved "water components" and establishes a major M fluxing role for carbon in the upper mantle. (From authors' abstract by E.R.)

OGASAWARA, Y., LIOU, J.G. and ZHANG, R.Y., 1997, Thermochemical calculation of log fO_2-T-P stability relations of diamond-bearing assemblages in the model system CaO-MgO-SiO_2-C-O_2-H_2O: Russian Geol. and Geophys., v. 38, no. 2, p. 587-598.

Indexed under FI (E.R.)

OHTANI, Tomoyuki, FUJIMOTO, Koichiro, ITO, Hisao, SAWAKI, Takayuki, TANAKA, Hidemi, TOMIDA, Naoto, HIGUCHI, Takayuki and AGAR, S.M., 1997, A fluid inclusion study in minerals from the GSJ Borehole penetrating the Nojima Earthquake Fault, Japan: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F701. First author at Geological Survey of Japan, 1-1-3 Higashi, Tsukuba, Ibaraki, 305, Japan; email (ohtani@gsj.go.jp)

Microthermometry of FI in cores from the GSJ borehole penetrating the Nojima fault, which was activated at the 1995 Hyogoken-nanbu earthquake, have been performed to determine the hydrothermal circulation within the fault zone. The GSJ borehole (746.7 m deep) encountered granodiorite.

In quartz of the granodiorite, L-rich two-phase and monophase aq I occur along healed fracture planes. Th of two-phase I have a bimodal distribution: 260-330°C and 120-250°C. FI of higher Th are observed throughout the hole. These FI were formed in the cooling stage after the granodiorite emplacement. FI of lower Th have a limited distribution within the fault zone. It is assumed that these FI were related to the fault activity. The monophase I were possibly formed from meteoric water of lower T. In a carbonate vein at 375.8 m, Th of FI range from 80 to 200°C. It is also assumed that these I are related to the fault activity.

The present formation T are lower than the minimum Th. This probably shows the formation of these FI were related to the past fault activity at higher T. (From authors' abstract by E.R.)

OHTANI, T., FUJIMOTO, K., TANAKA, H., HIGUCHI, T., SAWAKI, T., ITO, H. and **AGAR, S.M.,** 1997, Microthermometry of fluid inclusions in minerals from GSJ Hirabayashi core drilled through the Nojima fault (abst.): Abstracts of 1997 Japan Earth and Planetary Sci. Joint Meeting, March 25-28, 1997 at Nagoya Univ., (in Japanese, translated by T. Sawaki).

FI in core samples recovered from the GSJ Nojima-Hirabayashi borehole, which had been drilled through the Nojima fault, were studied. Based on the results, the authors considered the history of hydrothermal activity around the borehole. Ranges of Th of I in a carbonate vein at 375.80 m in depth and in quartz of granodiorite at 582.20 m are 88-197°C and 164-319 °C, respectively. These data suggest that three stages of hydrothermal activities can be identified; of 260-300 °C, around 200°C and around 130°C. The hydrothermal activity of 260-300°C possibly occurred after emplacement of the granitic rock, but the others were probably related to the activity of the Nojima fault. (Authors' abstract)

OHTANI, T., FUJIMOTO, K., TANAKA, H., TOMITA, N., HIGUCHI, T., ITO, H., AGAR, S.M. and **SAWAKI, T.,** 1997, Paleo-hydrothermal circulation within the fracture zone using fluid inclusions in minerals from GSJ Hirabayashi drillhole penetrating the Nojima fault: (abst.): Geol. Soc. Japan Annual Meeting, Fukuoka, Oct. 10-12, Program, p. 298 (in Japanese).

OHTANI, T. and **SASADA, M.,** 1997, Analysis of healed microcracks in granite from borehole WD-1a in the Kakkonda geothermal area, NE Japan: (abst.): Geothermal Research Soc. Japan Ann. Meeting, Oct. 6-8, 1997, Sapporo Program, unpaginated, No. B4 (in Japanese).

OHTANI, Tomoyuki, SASADA, Masakatsu and **MATSUNAGA, Isao,** 1997a, Timing of fracture development deduced from microthermometry of fluid inclusions in minerals from the Hijiori geothermal area, Yamagata Prefecture, Japan: J. of the Geothermal Research Soc. of Japan, v. 19., no. 4, p. 217-227. First author at Geological Survey of Japan 1-1-3 Higashi, Tsukuba, Ibaraki 305, Japan.

The microthermometric measurements of FI in quartz in granodiorite, and hydrothermal anhydrite and adularia were examined to determine the timing of fracture development in the Hijiori hot dry rock test site, Yamagata Prefecture, Japan. Two stages of fracturing are distinguished by the type of host mineral.

The first stage is recorded as healed microcracks (FI planes) in quartz of the granodiorite, and in anhydrite veins cutting the granodiorite. This stage is characterized by (1) Th inconsistent with the formation T measured by borehole logging at sampling depths, (2) sal ranging from 3.5 to 5.0 wt.% eq. NaCl. The minimum sal close to that of sea water suggests that this stage was related to Miocene submarine volcanic activity.

The second stage is recorded in hydrothermal anhydrite and adularia. This stage is characterized by (1) the T-depth profile obtained from vein fillings close to profile measured after drilling, and by (2) sal ranging from 0.0 to 2.9 wt.% eq. NaCl similar to modern brine. These characters possibly indicate that this stage is related to Holocene volcanic activity. (Authors' abstract)

OHTANI, Tomoyuki, SASADA, Masakatsu and **MATSUNAGA, Isao,** 1997b, Paleostress analysis using fluid inclusion planes in the Hijiori geothermal area, NE Japan: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 249-250. First author at Geological Survey of Japan, Higashi, Tsukuba 305, Japan; email (ohtani@gsj.go.jp).

Patterns from FIP were analyzed to deduce the relationship between FIP and regional paleostress field. A total of 535 FIPs from two samples were measured. Microthermometry showed no differences in Th of sal between the [two] preferred FIP orientations. This study demonstrates that two preferred FIP orientations could form during one hydrothermal event and during a single deformation event. (From authors' abstract by E.R.)

ORTEGA, Lorena, 1993, Characterization of the hydrothermal processes in the Mari Rosa and El Juncalón Sb mineralizations (Central Iberian Zone): Ph.D. thesis, Univ. Complutense de Madrid (in Spanish, Engl. abst.).

The Central Iberian Zone of the Hesperian Massif hosts a series of Sb-vein type deposits of late Hercynian age. Among them, Mari Rosa and El Juncalón (some 200 km distant) display similar and also contrasting features which make them suitable for a case study-type research. Host rocks of the mineralizations are metagreywackes and slates that record three episodes of folding and associated schistosity.

The veins of Mari Rosa and El Juncalón display contrasting structural styles, and the mineral paragenesis developed along three hydrothermal episodes. At Mari Rosa it is characterized by the following episodes: 1) arsenopyrite, 2) stibnite-(gold) and 3) pyrite-pyrrhotite-galena-sphalerite-chalcopirite-tetrahedrite-boulangerite-stibnite. Of these only the second episode was of some importance and led to the deposition of massive stibnite. At El Juncalón only the second stage resulted in stibnite deposition. The first and third stages were barren (quartz). Hydrothermal alteration at Mari Rosa is of minor importance and consists of a mild sericitization, chloritization and carbonatization. Under the chemical point of view this alteration process is characterized by an increase in the ratio K_2O/Na_2O, a decrease in the ratio SiO_2/volatiles, and an increase of Sb, Mo correlations are found in both ore deposits.

F associated to ore deposition lie in the H_2O-NaCl-CO_2-CH_4-N_2 compositional system, with the exception of CO_2 [which is] absent in El Juncalón mineralized areas. They evolved with a progressive cooling from initial circulation T close to 400°C in the early stages to around 150°C in the late episodes. Along with it, the composition evolution is characterized by a progressive increase in the global water content of the F, along with an increase in relative proportion of N_2 respect to CH_4 and CO_2 in their volatile fraction. Nitrogen in these F probably originated in contact metamorphic aureoles due to the release of ammonium stored in pelitic rocks. At Mari Rosa, massive stibnite deposition resulted from a boiling process developed at 300°C and 0.9-1.0 kb. Unmixing of the F was induced by sudden P drops in Vo dilational jogs during the low-angle faults movement. P conditions are estimated to be lithostatic, which implies a depth of 3.5-4.0 km for ore deposition. Regarding El Juncalón, cooling of the F was the driving mechanism for stibnite deposition around 250°C.

Sulfur isotopic composition of stibnite around 0‰, high correlation of the Sb-Mo pair, and striking spatial relationships support a genetic link between the antimony mineralizations and the granitic intrusions in the area. The presence of minor amounts of Mo in Mari Rosa suggests some telescoping in the metal distribution aureoles around the Alburquerque batholith. (From author's abstract by E.R.)

This abstract is included here, in spite of the late date, because it was missed earlier. Dr. Ortega has informed me that several later papers, cited in FIR volumes, have grown out of it. Since FIR missed the thesis, we thought it best to "close the loop" by listing these. They are in FIR v. 22, p. 280 (2 items); v. 24, p. 152 (2 items); v. 27, p. 103; v. 28, p. 119 and 120, and see Ortega, Vindel and Gallego, 1990, next item. (E.R.).

ORTEGA, Lorena, SIERRA, Josefina, OYARZUN, Roberto and **LUNAR, Rosario,** 1997, Fluid signature of copper stratabound deposits of the Talcuna district, northern Chile: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 251-252. First author at Dept. Cristalografía y Mineralogía, Facultad de Ciencias Geológicas, Univ. Complutense, 28040 Madrid, Spain; email (lortega@eucmax.sim.ucm.es).

The Talcuna copper deposits comprise both manto- and vein-style mineralizations. The manto-type mineralizations occur as cement of volcaniclastic host rocks and veinlets within the mantos and show increasing copper grades when approaching to the veins. Two types of FI have been identified in calcite from mineralized veins and mantos, two-phase L-rich aq I with 7 to 27 wt.% eq. NaCl and Th between 70 and 165°C, and V monophase I, indicating that they are not the result of necking-down (Bodnar, et al., 1985). They occasionally share the same trail with the L-rich I previously described, suggesting the entrapment of both FI types from a boiling F.

Manto- and vein-type mineralizations are considered to be genetically related and represent two different expressions of the same mineralizing process. In this context, veins played as a system of interconnected ore-F channels. When intersecting favorable stratigraphic levels (i.e. units of high porosity), the F extended laterally and developed manto-type mineralizations. The mantos have mineralogy and FI indistinguishable from the veins. Major mineral deposition took place within an epithermal environment as consequence of boiling, as indicated by FI evidence, mineral assemblage, and the presence of mineralized hydraulic breccias. (From authors' abstract by E.R.)

ORTEGA, L., Vindel, E. and **GALLEGO, M.,** 1990, Studies of the fluid inclusions in the antimony ore of El Juncalon, (Anchuras do (os Montes, Ciudad Real): Spanish Mineralogical Society Meeting, 1990, Oriedo, Spain (abst.). (E.R.)

OU, Guangxi and **FAN, Guang,** 1997, Fluid inclusion study and petroleum evaluation to middle Ordovician series from Cangcan-1 well and Konggu-3 well: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 12 (in English). Authors at Beijing Research Inst. of Uranium Geol., Beijing, 100029.

Our study shows that the calcites of middle Ordovician rocks in the Cangcan-1 well of Cangxian Uplift contain a lot of FI. The I can be divided into three types: 1) saltline solution I, [sic] 2) CO_2 I, 3) hydrocarbon I. Th of the I is 107-210°C, light hydrocarbon are mainly composed of C_1-C_5 with $\Sigma C_{1\text{-}5}$ is 0.29 ~0. 89 μl/g, C_{2+}/C_1 is 0.25 ~1.90. The other samples from middle Ordovician in the Konggu-3 well of Huanghua Depression only contain type 1 and 2 FI, in which the Th is 121°C, $\Sigma C_{1\text{-}5}$ is 1.83-7.01 μl/g, C_{2+}/C_1 is 1.27-1.59. By comparison of FI to Cangcan-1 well and Konggu-3 well and based on the oil-gas characteristics reflected by the light hydrocarbon components of FI, it is suggested that the middle Ordovician carbonate rocks of Cangxian Uplift have not only good prospect to form petroleum, but is also abundant in oil and G resource. (Authors' abstract)

ÖZGÜR, N., HALBACH, P., PEKDEGER, A., JARMERSTED, C.S.-V., SÖNMEZ, N., DORA, O.Ö , MA, D.-S., WOLF, M. and **STICHLER, W.,** 1997, Epithermal antimony, mercury, and gold deposits in the continental rift zone of the Kücük Menderes, western Anatolia, Turkey: Preliminary studies: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 269-272. First author at FR Rohstoff-und Umweltgeologie, Freie Universität, Berlin, Germany.

The present-day Hg, Sb, and Au deposits of Haliköy, Emirli, and Küre in the rift zone of the Kücük Menderes within the Menderes Massif, western Turkey can be considered as extinct deposits of formerly active geothermal systems due to various similarities of parameter with the active geothermal systems. The ore metals originated from the host rocks are transported in a F environment in which $(HS)_2^-$ complexes dominate. The precipitation of metals depends upon T, P, pH, and redox potential of the system as well as sulfur concentration. (Authors' abstract)

We [Nanjing Univ.] have analysed the F in the quartz samples to $\delta^{18}O$ and δD by mass spectrometer, K^+, Na^+, Ca^{2+}, Mg^{2+}, Fe^{3+}, and Al^{3+} by ICP emission spectrometer (JY38S), F^- by anion-selective electrode, Cl^- by mercury thiocyanade colorimetric analysis, SO_4^{2-} barium sulfate turbimetric analysis and HCO_3^- by acid-basic capacity titration. The gas composition was also analysed by gas chromatography there. Th ranged from 150 to 300°C; Tm_{ice} ranged from 0 to -9°C. (From authors' text by E.R.)

PAGEL, Maurice, BRAUN, J.J., DISNAR, J.R., MARTINEZ, Luis, RENAC, Christophe and **VASSEUR, Guy,** 1997, Thermal history constraints from studies of organic matter, clay minerals, fluid inclusions, and apatite fission tracks at the Ardeche paleo-margin (BA1 drill hole, GPF Program), France: J. of Sedimentary Research, Sect. A: Sedimentary Petrol. and Processes, v. 67, no. 1, p. 235-245.

PAKHOMOVA, Vera, SOLYANIK, Valentina, POPOV, Vladimir and **LOGVENCHEV, Peter,** 1997, Fluid inclusions in the local metallogenic prognostication: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 253-254. First author at Far Eastern Geological Inst., Branch of Russian Acad., Russia; email (fegi@visenet.iasnet.com).

There has been dispute concerning the relationship between magmatic rocks and the Fasolnoe Ag-Pb-Zn deposit in the Shcherbakovskoe ore field (East-Sikhote-

Alin). The ores are veined bodies with silver-magnetite-polymetallic mineralization. Homogenization and cryometry of FI of quartz phenocrysts and matrix quartzes from granite and ore were executed. Early-magmatic quartz from granite-porphyry contains the P MI with Th 850 to 835°C. The final stage of M crystallization shows T_{hom} of MI from 765 to 740°C. Indications of separation of water-brine L from crystallizing magma are distinguished. The brines have Te of -55 to -52°C and evidence of iron chloride and solid hematite. V phase consists of high-dense carbonic acid. Ore minerals crystallized from highly concentrated solutions (37 wt.% eq. NaCl) at 500 to 340°C and under P of 1200-860 bar. The frequent presence of carbonic acid in syngenetic I of heterogeneous origin indicates the episodic boiling of solution. Data above cited reliably prove that metal-bearing hydrothermal solutions which have formed the deposit, were the produce of granite intrusion distillation. (From authors' abstract by E.R.)

PALACIOS, C., PARADA, M.A. and **LAHSEN, A.,** 1997, Upper Jurassic Au-Zn mineralization in El Faldeo district, Chilean Patagonia: Geologische Rundschau, v. 86, no. 1, p. 132-140.

Indexed under FI (E.R.)

PALIN, J.M., SHELLEY, J.M.G., LOUCKS, R.R. and **CAMPBELL, I.H.,** 1997, Development of the Laser Ablation Stable Isotope Ratio Micro-Analysis System (LASIRMAS): (abst.) The Australian National Univ. Research School of Earth Sci., Annual Report 1997, p. 160-161.

PALMER, D.A.S. and **WILLIAMS-JONES, A.E.,** 1997, Preliminary investigation of fluid evolution in the cupriferous Phalaborwa carbonatites, South Africa (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A111. First author at McGill Univ., Earth and Planet. Sci., 3450 University St., Montreal, Quebec H3A 2A7.

Although much work has been done on the petrogenesis of carbonatites, little is known about the F which are exsolved prior to, or during, their emplacement. In many cases it is these F which are responsible for the ore deposits associated with the carbonatite complexes. The Phalaborwa carbonatite complex, which hosts 400 Mt of 0.7 wt.% copper ore, is one such example. Although much is known about its petrology, the source of the copper is unknown and the controls of copper mineralization poorly understood. The ultimate goal of this study is to characterize the F evolution of the carbonatite and to develop a genetic model for the deposit.

In order to properly characterize the F present during carbonatite emplacement, a number of destructive and nondestructive FI methods were employed to determine the P-T-X conditions of these F. As well, major and trace element geochemistry was used to calculate relative proportions of components exchanged between exsolved F and fenitized country rock.

Preliminary data indicate that two separate F, represented by solid-bearing and solid free FI, were present during the emplacement of the carbonatites. SEM analysis of decrepitate residues identify these as a high sal F and a low sal, sulfur-rich F. Microthermometry indicates that I representing the two F homogenized at similar T, 300-320°C. Fenitization which accompanied carbonatite emplacement involved major additions to the rock of Cu, Fe, K, Al, Sr, Mg and P, and removal of Si and Na. (From authors' abstract by H.E.B.)

PANIAGUA, A., LOREDO, J., FENOLL [HACH-ALI], P. and **RODRIGUEZ-PEVIDA, L.S.,** 1997, Extrapolation at low temperatures of the arsenopyrite geothermometer contrasting with fluid inclusion data: The example of Salamon (Spain): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 255-256. First author at Depto. de Ciencias de la Tierra, Univ. de Zaragoza, Pedro Cerbuna, 12, E-50009, Zaragoza, Spain; email (paniagua@posta.unizar.es).

The aim of this paper is to verify the validity of the arsenopyrite geothermometer at low T by means of FI data in a carbonate-hosted disseminated epithermal gold deposit from the northwest of Spain, the Salamon gold prospect.

Application of the arsenopyrite geothermometer to arsenopyrite buffered by pyrite gives T from 140 up to 357°C, assuming the modification of Sharp et al. (1985) -vertical compositional isopleths in $f(S_2)$-T space-relative to a constant T for a constant composition. The mode is 245°C. P FI in authigenic quartz cogenetic with arsenopyrite and pyrite are almost purely aq (H_2O-NaCl). Th (105 measurements) are in the range 148-241°C, with a mode at 218°C. Freezing point depression varies from -1.0 up to -7.7°C, indicating low to moderate sal (mode 9.2% NaCl eq.). The differences [in T are] not very significant, taking account that Th are minimum Tt. Assuming the arsenopyrite T to be correct, a P slightly higher than 300 bars can be inferred, in agreement with nearly hydrostatic conditions of deposition. (From authors' abstract by E.R.)

PANIAGUA, A., PRIETO, M. and **LOREDO, J.,** 1997, Symplectite stibnite-cinnabar as breakdown product of livingstonite at Pedrosa del Rey (Spain): Evidences from mineralogical, fluid inclusion and sulfur isotopic data: 1 257-258. First author at Depto. de Ciencias de la Tierra, Univ. de Zaragoza, Pedro Cerbuna, 12, E-50009, Zaragoza, Spain; email (paniagua@posta.unizar.es).

Mercury deposits in the Cantabrian Mountains seem to be the shallower manifestation of deep hydrothermal systems involving copper-bismuth-gold skarns as well as epithermal igneous and carbonate hosted As-Sb-Au deposits. The Pedrosa del Rey mines consist of an As-Sb-Au deposit hosted by dikes of diorites and siliciclastic rocks, and a nearby Hg-(Sb-As) deposit hosted by bituminous limestones. The rare mineral livingstonite, $HgSb_4S_8$, is present, mostly replaced by stibnite and cinnabar. In several samples an epitaxial intergrowth formed by composite crystals of cinnabar and stibnite with symplectitic texture is observed.

The late-stage quartz, calcite and fluorite show in general terms aq F I, with Th in the 120-245°C interval, and moderate sal in the range 5-12% eq. NaCl. I in quartz and carbonate coeval of livingstonite show Th in the range 130-195°C, whereas I in quartz and calcite which coexist with the symplectites show Th in the range 170-245°C, with a maximum at 210°C.

Sulfur isotopic data show values of $\delta^{34}S$=5.0‰ for livingstonite, $\delta^{34}S$ of 6.6/7.5‰ for the symplectitic assemblage of cinnabar+stibnite, 9.5 for cinnabar associated to the symplectites, 14.2‰ for late stibnite, 15.0‰ for late cinnabar, and 23.7/30.0 for late barite. The FI data indicate that the symplectites could be a breakdown product of livingstonite related to an increase in T and a subsequent decrease of relative sulfur activity. (From authors' abstract by E.R.)

PANIGRAHI, M.K. and **MOOKHERJEE, A.**, 1997, The Malanjkhand copper (+ molybdenum) deposit, India: Mineralization from a low-temperature ore-fluid of granitoid affiliation: Mineralium Deposita, v. 32, p. 133-148. Authors at Dept. of Geological Sci., Jadavpur Univ., Calcutta 700 032, India.

Copper and subordinate molybdenum mineralization at Malanjkhand occurs within a fracture-controlled quartz-reef enclosed in a granitoid body. Four types of P I were encountered in quartz from ore samples: (1) type I-aq-biphase (L+V); (2) type II-aq-carbonic (L_{aq} + L_{carb}±V_{carb}); (3) type III-pure-carbonic (L_{carb}±V_{carb}), and (4) rare polyphase (L_{aq} + V_{aq} + calcite/gypsum) I. Quartz in granitoids contain P type I inclusions only. Type I inclusions from ore samples furnish a T range of 150-275°C and 4-12 wt.% NaCl eq. This is inferred to represent the signature of the major component (F2) of the ore F. Composition of syn-ore chlorites furnished a T range of 185-327°C, which conforms to the FI microthermometric data. P estimates vary from 550 to 1790 bar in the stringer ores. Observed T-sal/density relationships are best explained by a two-stage evolution model of the ore F: the first stage witnessed mixing of the two components, F1 and F2 in unequal proportion, bringing about mineralization. The second stage of evolution was marked by the separation of a carbonic component on continued sulfide precipitation and attendant increase in sal of the F. The FI component emerged as a distinct, heated and (CO_2 + S)-charged entity due to steam-heating and contamination of the early-ingressed F2 F at the fracture zone. The pervasive F phase in the surrounding granitoids contributed the F2 component. (From authors' abstract by E.R.)

PANINA, L.I., 1995, Physico-chemical conditions of crystallization of low-titanium lamproites of Aldan (Siberia): Sixth Internat'l. Kimberlite Conference, Extended Abstracts, Russia, 1995, p. 421-423. Author at Inst. of Mineral. and Petrog., Novosibirsk, 630090, Russia.

A review, with 8 references, of published work by the author and others (see earlier volumes of FIR) (E.R.).

PANINA, L.I., 1997a, Low-titanium Aldan lamproites (Siberia): Melt inclusions in minerals: Geol. and Geophys., v. 38, no. 1, p. 112-122 (in Russian; Engl. abst.) [from paper given at 6th Int'l. Kimberlite Conference]

The geology and composition of the Aldan lamproites from the Little Murun, Ryabinovyi, and Yakokut massifs, from the Upper-Yakokut Trough and Molbo River have been characterized. According to the mineral crystallization T established in a study of M I, the Aldan rocks are similar to common lamproites and K-basaltoids. Crystallization of pyroxene and apatite in them occurred at 1,280-1,170°C and 1,150-1,030°C, respectively, while olivine crystallized at T greater than 1,200°C. In contrast, according to their major element composition (Mg, Al, Ti), (K_2O + Na_2O)/Al_2O_3, SiO_2/Al_2O_3, and 100FeO/(FeO + MgO + TiO_2) ratios, the Aldan lamproite rocks are intermediate between common lamproites and K-basaltoids. Because of variable alkali-to-alumina ratios derivative M had either agpaitic or miaskitic characteristics. Decreasing concentrations of Mg at nearly constant Ti favored a significant increase in 100FeO/(FeO + MgO + TiO_2) to 40-60 mol% in differentiated M. The P F component of the M was nitrogen: at the time of olivine crystallization, this is estimated as 60 mol% (with 39% CO_2) and during pyroxene crystallization, as 100 mol%. The volatiles F, Cl, and SO_3 were also significant components of the F.

It is concluded that the Aldan lamproites cannot be direct derivatives formed by crystallization of common lamproitic or K-basaltoid M. Most probably, they either result from mixing of these magmas or reflect a higher level of melting as compared with common lamproites. Low-P crystallization could lead to depletion of Ti and Zr in the M, while mixing of M could explain the similarities betwee the Aldan lamproites and derivatives of K-basaltoid magma. (Author's abstract)

PANINA, L.I., 1997b, Low-titanium Aldan lamproites (Siberia): Melt inclusions in minerals: Russian Geol. and Geophys., v. 38, no. 1, p. 112 (in Russian; Engl. abst.).

The geology and composition of the Aldan lamproites from the Little Murun, Ryabinovyi, and Yakokut Massifs, from the Upper-Yakokut Trough and Molbo River have been characterized. According to the mineral crystallization T established in a study of MI, the Aldan rocks are similar to common lamproites and K-basaltoids. Crystallization of pyroxene and apatite in them occurred at 1,280-1,170°C and 1,150-1,030°C, respectively, while olivine crystallized at T>1,200°C. In contrast, according to their major element composition (Mg, Al, Ti), (K_2O + Na_2O)/Al_2O_3, SiO_2/Al_2O_3, and 100FeO/(FeO + MgO + TiO_2) ratios, the Aldan lamproite rocks are intermediate between common lamproites and K-basaltoids. Because of variable alkali-to-alumina ratios derivative M had either agpaitic or miaskitic characteristics. Decreasing concentrations of Mg at nearly constant Ti favored a significant increase in 100FeO/(FeO + MgO + TiO_2) to 40-60 mol.% in differentiated M. The P F component of the M was nitrogen: at the time of olivine crystallization, this is estimated as 60 mol.% (with 39% CO_2) and during pyroxene crystallization, this is estimated as 60 mol.% (with 39% CO_2) and during pyroxene crystallization, as 100 mol.%. The volatiles F, Cl, and SO_3 were also significant components of the F.

It is concluded that the Aldan lamproites cannot be direct derivatives formed by crystallization of a common lamproitic or K-basaltoid M. Most probably, they either result from mixing of these magmas or reflect a higher level of melting as compared with common lamproites. Low-pressure crystallization could lead to depletion of Ti and Zr in the M, while mixing of M could explain the similarities between the Aldan lamproites and derivatives of K-basaltoid magma. (Authors' abstract)

PANINA, L.I., MOTORINA, I.V., MAMEDOV, M.N. and **MAKHMUDOV, S.A.**, 1997, Physicochemical conditions of the development of the Tertiary trachybasalt-phonolite formation in the Talysh zone (Azerbaijan): Geol. and Geophys., v. 38, no. 4, p. 713-828 (in Russian, Engl. abst.).

It has been established by mineral thermobarogeochemistry that the magmas initial of the trachybasalt-phonolite series in the Talysh zone were crystallized according to Bowen's scheme at the following T and order of phenocryst formation: Ol (>1350°C) → Cpx (1280-1170°C) → Ap (1240-1030°C) → Pl (1190-1035°C). The F phase at the time of olivine phenocryst crystallization was composed of 90 mol.% CO_2 and 10 mol.% N_2, while at the pyroxene and plagioclase formation it was 100 mol.% N_2. A drastic change in F composition is related to a discontinuity in time and place of phenocryst formation: olivine crystallization in deep-seated conditions, and formation of pyroxene and plagioclase in shallow depth of the Earth's crust.

A microprobe study of silicate M I has shown that the evolution of the initial magma proceeded by means of differentiation and fractionation of minerals. In the process of crystallization the derivative M were enriched in SiO_2 (up to 64%), Al_2O_3 (up to 21%), alkalies (up to 10-11 wt.%) and were depleted in femic components (totalled to a few per cent). Residual rhyolite-dacite alkali-enriched M (67-73% SiO_2, 14-17% Al_2O_3, 4-8% alkalies) appeared in the final stages of magma evolution. The presence of alkalies brings us back to the problem of the mantle "basalt", origin of some siliceous rocks, as well as of the possibility to overcome an "impassable" barrier between quartz-normative acid M and alkaline leucite-bearing rocks. (Authors' abstract)

PAPALE, Paolo, 1997, Modeling of the solubility of a one-component H_2O or CO_2 fluid in silicate liquids: Contrib. Mineral. Petrol., 1997, no. 126, p. 237-251.

PAPUNEN, Heikki, ed., 1997, Mineral Deposits: Research and Exploration. Where do They Meet?: Proceedings of the Fourth Biennial SGA Meeting Turku/Finland/11-13 August 1997. Balkema, Rotterdam, ISBN 90 5410 889 4: Author at Dept. of Geol., Univ. of Turku, Finland.

PAREDES, M.M., 1994, A fluid inclusion, stable isotope, and multi-element study of the Golden Sunlight deposit, Montana: Thesis, Iowa State Univ.

See Spry et al (this volume) (E.R.).

PARENTE, Giovanni, BONI, Maria and **DE VIVO, Benedetto,** 1997, Hydrothermal dolomitization in SW Sardinia (Italy): Fluid inclusions evidence of a post-Hercynian fluid flow: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 259-260. First author at Dpto. di Scienze della Terra, Univ. degli Studi di Napoli "Federico II", Largo San Marcellino 10, 80138 Napoli, Italy.

Epigenetic dolomite, mostly of the "saddle" type, replaces Cambrian limestones and early diagenetic dolomites in large areas of the Iglesiente-Sulcis mining district.

Isotopic data (Sr, Pb, O and C isotopes) suggest that epigenetic dolomitization is geochemically related to some of the low-T post-Hercynian base metal deposits of the Iglesiente district. Sr and Pb isotopic values, however, are also similar to the isotopic composition of the Cambrian stratabound ores. O and C isotopes have confirmed the hypothesis on the hydrothermal origin of the dolomite. Recently FI studies of the epigenetic dolomite and sphalerite show Th of 70 to 140°C and sal from 16 to 26 wt.%. The Th values show a gradient decreasing from east to west. This gradient suggests the F flow direction and the probably source of hydrothermal F. (From authors' abstract by E.R.)

PARILOV, Yu.S. and **AILERU, O.O.,** 1997a, Physicochemical conditions of formation of hydrothermal-sedimentary sulphide ores of Kazakstan: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 261. Authors at Inst. of Geological Sci., 69 a Kabanbay Batyr Street, Almaty 481000, Republic of Kazakstan.

Hydrothermal-sedimentary ores are widely distributed at lead-zinc deposits of Kazakstan. The sulphides accumulated as a result of sedimentation caused by the eruption of thermal springs in shallow basins. In quartz and carbonates that were formed at the same time with sulphides, small L I indicate crystallization of sulphides at 40-90°C. Sal=3-27%. Galena and sphalerite were deposited close to places where thermal springs erupted from brines with an increased amount of salts (17-27%) represented by halides of Na^+, K^+ and NH_4^+. Pyrite gave extensive halos of disseminated mineralization along the periphery of lead-zinc ores. Iron is capable of being in the solution during the deep oxidation of F and their mixture with sea water. (From authors' abstract by E.R.)

PARILOV, Yu.S. and **AILERU, O.O.,** 1997b, Physicochemical processes of formation of massive sulphide ores (based on the study of fluid inclusions at Kazakstan's deposits): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 262-263. Authors at Inst. of Geological Sci., 69 a Kabanbay Batyr Street, Almaty 481000, Republic of Kazakstan.

FI in quartz, barite and carbonates that were formed at the same time with massive sulphides are small (often <1 μm) and consist of 50-90% solid phases, one or two L, and a gas bubble. The phase ratio is variable. Studies of the chemical composition of F in I have shown that they contain a little amount of water but a larger amount of salts.

A table is presented of six average analyses (methods unstated; individual n=5 to 29), from various polymetallic deposits, showing (mass%): H_2O 2-28; H_2S+SO_3 1-20; CO_2+CO 3-25; NH_3 1-4; N_2+Ar <1-3; $Na+K+NH_4$ 3.5-17; SO_4 13-45; plus minor others. [Some show gross cation/anion unbalance (E.R.)]. It is concluded that the ore F were salt M with H_2O and CO_2 and sulfides (E.R.).

PARK, H.-I., LEE, Insung and **PARK, K.-H,** 1997, Hydrogen and oxygen isotope compositions of ore fluid in the Dongyang talc deposit, Korea: Proc. 30th Int'l. Geol. Congr., v. 9, p. 91-100, H. Yunhui and C. Yawen, eds.

See FIR 29, p. 160 (E.R.)

PARNELL, John, 1997, Fluid migration history in the north Irish Sea – North Channel region: in Meadows, N.S. Trueblood, S.P. Hardman, M. & Cowan, G. (eds), 1997, Petroleum Geol. of the Irish Sea and Adjacent Areas, Geological Soc. Special Pub. no. 124, p. 213-228. Author at School of Geosci., Queen's Univ., Belfast BT7 1NN, UK.

Basins in the north Irish Sea region have experienced numerous stages of F migration. Carboniferous and Permo-Triassic sandstones both experienced rapid cementation due to high sedimentation/burial rates. Both successions also experienced syn-sedimentary faulting which focused cement precipitation and created permeability barriers. Further fracture-based diagenesis occurred post-lithification, and accompanying hydrothermal activity associated with Tertiary intrusions. The extensional activity which helped to define Permo-Triassic basins in the southern Uplands terrane also channelled mineralizing F in the same terrane. These F included hydrocarbons in at least two districts. Along the North Solway Fault Zone, basinal F from the Carboniferous Solway Basin interacted with metalliferous groundwaters to precipitate metalliferous bitumens. The Solway Carboniferous outcrop also contains intergranular oil residues. (Author's abstract)

FI data presented and discussed to document the nature and conditions of migration. (H.E.B.)

PATRIER, Patricia, BEAUFORT, Daniel, BRIL, Hubert, BONHOMME, Michel, FOUILLAC, A.M. and **AUMÂITRE, Roland,** 1997, Alteration-mineralization at the Bernardan U deposit (western Marche, France): The contribution of alteration petrology and crystal chemistry of secondary phases to a new genetic model: Econ. Geol., v. 92, p. 448-467. First author at E.R.M., B.P. 25 "Mérovée," 86320 Civaux, France ESIP, 40 avenue du Recteur Pineau, 86022 Poitiers CEDEX, France.

The Bernardan uraniferous district contains disseminated uranium deposits as episyenitic pipes: vuggy granites that resulted from quartz leaching. The physicochemical conditions of alteration events are supported by detailed alteration petrography, FI studies, stable isotope data, and rare earth element contents.

From the petrography of episyenites, three successive crystallization stages are evident:

1. crystallization of S K feldspars±quartz + dolomite±fluorite occurred in all types of episyenitic pipes. S minerals began to form from saline and ^{18}O-rich F at high T, up to 360°C for dolomite.
2. The second stage consisted of argillization of some episyenitic pipes in response to infiltration of ^{18}O-rich F at 100°C that originated in sedimentary basins.
3. The third stage was supergene mobilization.

(From authors' abstract by E.R.)

PAULY, H. and **PETERSEN, O.V.,** 1997, Red-brown Th-bearing fluorite from the cryolite deposit, Ivigtut, south west Greenland: N. Jb. Miner. Mh., 1996, no. 11, p. 483-490.

The red-brown fluorite in black cryolite was found in the siderite-cryolite, and formed in the upper part of the T interval 500-600°C of the formation of the siderite-cryolite. In contrast,the formation of the major part of the fluorite in the cryolite occurrence took place in the last stage of the formation of the deposit. (From authors' abstract by E.R.)

PEARSON, K. and **JEFFREY, C.A.,** 1997, Low temperature mineralization of the sub-Triassic unconformity surface and alteration of the underlying intrusions of southern Leicestershire, England: Explor. Mining Geol., v. 6, no. 2, p. 139-152. Authors at Dept. of Geol., Univ. of Leicester, Univ. of Leicester, LE1 7RH, U.K.

The Croft diorite in central England belongs to a suite of Caledonian igneous rocks collectively known as the South Leicestershire diorite complex. Although the intrusions occupy separate outcrops, they are linked at depth to form a single pluton, buried beneath a cover of Triassic sediments (Le Bas, 1972; 1982, Allsop and Arthur, 1983). Both the Caledonian diorites and the overlying sub-Triassic unconformity have been affected by a complex history of alteration and mineralization which can be subdivided into four stages: (1) deuteric effects, caused by the release of volatiles during magmatic cooling; (2) albitization through sodic enrichment; (3) formation of low-T laumontite, analcime and calcite veins with associated wall-rock alteration to prehnite and pumpellyite; and (4) sub-Triassic unconformity-hosted base metal, manganese and palygorskite mineralization. Zeolite mineralization occurred some 200 Ma later than the intrusion itself, during post-Triassic times, as indicated by the presence of a single vein of laumontite and microcrystalline calcite which cross-cuts the sub-Triassic unconformity surface and enters the overlying Triassic sediments. Evidence from FI work indicates that two F were involved in the deposition of the zeolite veins. One F was initially of relatively high T (~100 to 320°C) and low sal (~0.2 to 5.9 wt.% NaCl eq.), and was probably meteoric in origin, whereas the other was of relatively low T (~41 to 165°C) and high sal (~0.4 to 16.72 wt.% NaCl eq.), and is interpreted to represent a basinal brine. During Triassic rifting, thinning and fracturing of the crust, with the possible rise of associated magmas (Halliday and Mitchell, 1984), could have increased permeability and heat flow, initiating the circulation of hydrothermal F. Triassic unconformity-hosted base-metal mineralization in Central England is similar to other Triassic-Jurassic mineralization in Europe (Mitchell and Halliday, 1986). (Authors' abstract)

PERETTI, Adolf and **MULLIS, Joseph,** 1997, Distinction of natural and synthetic rubies by fluid inclusion analyses: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 264-265. First author at GemResearch Laboratory AG, PO Box 6002, Lucerne, Switzerland; email (a.peretti@mail.tic.ch). Mong Hsu (Myanmar) rubies from a newly discovered deposit occur in calcite-fuchsite-mica-dravite veins which are encountered in dolomite-marbles. Fuchsite, dolomite, white mica and fluorite are found as solid I, and various populations of P, PS and S FI. These show, at room T, CO_2-L, CO_2-rich V and one dm (diaspore), in similar L/V ratios, showing that there had been initially a very homogeneous F. Th L-V (L) = 24-31°C; Tm_{CO_2}~65°C. Due to the chemical composition of the accompanying minerals (F-dravite and F-tremolite) and the presence of fluorite I, HF may also be present. Approximately 5-10 vol% H_2O must have been present (to form the dm diaspore).

Synthetic rubies and sapphires are produced in Novosibirsk by hydrothermal methods in steel autoclaves at elevated T and P and marketed in Bangkok (Thailand) through a joint venture between a Thai company and the RAS in Novosibirsk, called TAIRUS. Typical solid I are various types of copper-alloys, but also three-phase tubular I, imitating Burmese rubies. They are composed at room T of a L, a V and solid dm of $KHCO_3$ or other phase.

It is concluded that FI in the natural and synthetic rubies produced by hydrothermal methods can be distinguished by heating and freezing experiments in the range between -10 and +40°C. (From authors' abstract by E.R.)

PERETTI, A., MULLIS, J., MOUAWAD, F. and **GUGGENHEIM, R.,** 1997, Inclusions in synthetic rubies and synthetic sapphires produced by hydrothermal methods (TAIRUS, Novosibirsk, Russia): J. of Gemmology, v. 25, no. 8, p. 540-561. First author at GRL Gemresearch Laboratory AG., Lucerne, Switzerland.

Synthetic rubies and synthetic sapphires are produced by hydrothermal methods in Novosibirsk (Siberia, Russia) by TAIRUS, a joint venture of the Russian Academy of Sciences and Pinky Trading Company, Bangkok, Thailand. The rubies and sapphires are grown at high T and P in steel autoclaves from complex carbonate- and chlorine-bearing aq solutions. The different colour varieties imitate Burmese, Thai, Sri Lankan and Australian gems. Diagnostic F (three-phase I) and solid (copper) I are present. A simple heating and freezing test is provided to enable the gemmologist to distinguish the three-phase I in synthetic rubies from their counterparts in natural rubies. (Authors' abstract)

PERYT, T.M. and **KOVALEVICH, V.M.,** 1997, Association of redeposited salt breccias and potash evaporites in the lower Miocene of Stebnyk (Carpathian foredeep, west Ukraine): J. of Sedimentary Research, v. 67, no. 9, p. 913-922. First author at Panstwowy Instytut Geologiczny, ul. Rakowiecka 4, 00-975 Warszawa, Poland.

Potash evaporites of the lower Miocene Vorotyshcha Suite are sandwiched in salt breccias in the Ukrainian part of the Carpathian foreland basin. These breccias have traditionally been interpreted as tectonically deformed units related to the overthrust nappes of the Carpathians. Most clasts consist of intrabasinal sandstone, marlstone, halite, and anhydrite, but exotic clasts consisting of rocks that are characteristic of the Carpathian flysch rocks are also present. Breccia beds are intercalated with salt layers containing chevron crystals and cubic hopper crystals, and some layers are composed of detrital salt. These salt layers rarely display graded bedding or cross-lamination, and continue over great distances. There are also slump structures associated with the bedded salts.

The sal in the Vorotyshcha Basin was extremely high, but intermittent inflows caused brine dilution so that it could maintain halite precipitation for a long time. During long periods of evaporative concentration and reduced inflow, brines in the basin could reach the sylvite saturation level so that potash chlorides and sulfates started to precipitate. The potash precipitated subaqueously. On the basis of evidence from the study of FI, the depth of the brine is interpreted to have been 20-30 m, in agreement with the supposed brine stratification in a basin subjected to influxes of sediment-laden waters.

The breccias are debris-flow deposits. They are commonly tectonically deformed, but analysis of the relation of breccias to evaporites suggests that both were formed in water ten to a few tens of meters deep. It therefore seems that halite breccias in other foreland basins could have had a sedimentary origin. (Authors' abstract)

PETERSEN, J.S., KALTOFT, Kristian and **SCHLATTER, Denis,** 1997, The Nanortalik gold district in south Greenland: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 285-288. First author at Dept. of Earth Sci., Aarhus Univ., Denmark.

The Nalunaq gold deposit is one of several gold occurrences found recently in metabasic rocks of the Nanortalik district in south Greenland. The area belongs to the Ketilidian mobile belt and is located along the southern margin of the Julianehaab Granite Belt, where a sequence of metapelites and metabasic rocks as a nappe sheet overlies marginal molasse- type sediments of the orogenic belt. The gold mineralization is epigenetic and occurs in quartz-veins and in calc-silicate altered shear-zones subparallel to foliation. At Nalunaq, gold is remarkably abundant and associated with löllingite and traces of Bi-Sb sulphosalts. FI reveal high sal of 14-35 wt.% NaCl eq. and initial ice-melting T of about -60°C. Th of the saturated I vary between 145 and 260°C. The calc-silicate alteration resulted from reaction between metabasic rocks and F presumably derived from late-post-kinematic granites. The gold mineralization seems to be associated with the infiltration of exceptionally saline, calcic F into preexisting planar fractures of the metabasic rock pile. (Authors' abstract)

PETKO, C.E., 1997, Epidotizing fluid temperature and composition at the sheeted dike-plutonic contact, Troodos ophiolite, Cyprus: Tenth Keck Research Symposium in Geology Proceedings, The College of Wooster, Wooster,Ohio, April 1997, p. 77-80. Author at Dept. of Geol., College of Wooster, Wooster, Ohio 44691.

The epidote found in plagiogranite bodies of the Troodos ophiolite was formed by a F with an uncorrected T [FI data] ranging from 242 to 393.3°C. Although the exact composition of the F cannot be determined, the lack of three phase I containing halite dx makes it reasonable to assume that the F from which the epidote formed had a low sal and was seawater derived. (From the author's text by H.E.B.)

PETRICHENKO, O.I., PERYT, T.M. and **POBEREGSKY, A.V.,** 1997, Pecularities of gypsum sedimentation in the Middle Miocene Badenian evaporite basin of Carpathian Foredeep: Slovak Geol. Mag. 3, no. 2, p. 91-104. Authors at Inst. of Geol. and Geochem. of Combustible Minerals, Nat'l. Acad. of Sci. of Ukraine, Naukova 3a, 290053 Lviv, Ukraine.

Based on the Badenian evaporite sequence as recorded in the borehole Hucul 1 near Kosiv (Ukraine), we assume that gypsum deposits in the marginal parts of the basin would correspond to the upper part of the evaporite sequence in the basin center. The study of P FI in gypsum showed a low concentration of brine I which was 27 g/l on average. The obtained data on chemical composition of brine I indicate that the Badenian water during gypsum precipitation essentially differed from modern seawater and shows some similarity to some continental and continental-marine basins, such as the Aral Sea. Accordingly, the chemical composition of Badenian waters, especially in the northwestern part of the basin, is a mixture of relict seawater (depleted in NaCl), underground water (enriched in calcium sulfate) and surface run-off. (Authors' abstract)

PETTKE, Thomas and **DIAMOND, L.W.,** 1997, Oligocene gold quartz veins at Brusson, NW Alps: Sr isotopes trace the source of ore-bearing F to over a 10-km depth: Econ. Geol., v. 92, no. 4, p. 389-406. Authors at Mineralogisch-Petrographisches Inst., Gruppe Isotopengeologie, Univ. Bern, Erlachstrasse 9a, CH-3012 Bern, Switzerland.

The genesis of late metamorphic gold lodes in the northwestern Alps has remained enigmatic. In order to trace the source of the ore-bearing F at the Brusson locality and to test current genetic models, 130 Rb-Sr isotope measurements have been performed on hydrothermal vein minerals, their FI, and their unaltered country rocks.

These analyses demonstrate that F flow in the hydrothermal system was upward and must have derived from at least 10 km below the present outcrop level. We conclude that hydrothermal systems which produce Tertiary lode gold deposits in orogenic belts may have large vertical extents, perhaps up to the range recently reported for equivalent Archean deposits.

When combined with published FI compositions and Pb and He/Ar isotope data, our results rule out three of the previously proposed sources for the Brusson F: (1) metamorphic devolatilization of paragneisses and metagranites, (2) F escape from coeval lamprophyres and (3) incursion of meteoric water.

Our genetic scenario, in accord with the timing of orogenic events, is that regional Meso-Alpine metamorphism liberated CO_2-H_2O-NaCl-KCl-H_2S F from the deep seated Piemonte calc-schists via devolatilization reactions and that gold was extracted as the F reacted with the intercalated Piemonte metabasites prior to rising through the Monte Rosa nappe to the sites of gold deposition. (From authors' abstract by E.R.)

PETTKE, Thomas, FREI, Robert, KRAMERS, J.D. and **VILLA, I.M.,** 1997, Isotope systematics in vein gold from Brusson, Val d'Ayas (NW Italy) 2. (U + Th)/He and K/Ar in native Au and its fluid inclusions: Chem. Geol., v. 135, p. 173-187. Authors at Gruppe Isotopengeologie, Univ. Bern, Erlachstrasse 9a, CH-3012 Bern, Switzerland.

(U + Th)/He and K/Ar isotope systematics in Oligocene hydrothermal vein gold from the Monte Rosa Gold District (NW Italy) are presented. Free gold yielded significant amounts of He and Ar, composed of a major trapped component and a minor in-situ one. Assuming complete retentivity of ^{4}He*, our native gold contains at least 98% of trapped He and Ar.

The He-Ar isotope composition of the auriferous hydrothermal F can be explained as a binary mixture of a dominant crustal component enriched in He, and a subordinate mantle component. The latter may originate either from meta-ophiolites at depth, or, less likely, from Oligocene plutons such as are known to exist ~25 km to the southeast. The He-Ar isotope signatures and the low ^{36}Ar abundance suggest that no water with an atmospheric exchange history was ever present in the gold depositing hydrothermal F. Therefore, the metamorphic model of vein genesis with metamorphic dehydration of large rock volumes at depth as the F source appears to be most plausible. Noble gas isotope systematics of vein gold and possibly other native metals appear to be poor as a dating tool but promising as a F-geochemical tracer, and step-wide degassing may resolve different trapped components, hence may reveal possible processes such as boiling which can have triggered gold deposition. (From authors' abstract by E.R.)

PHILIPPOT, P., MÉNEZ, B., DRAKOPOULOS, M. and **SNIGIREV, A.,** 1997, High-resolution microprobe analysis of "geofluids": An economic perspective. 5Olème anniversaire du rayonnement synchrotron, ESRF, Grenoble, Novembre 97.

PHILIPPOT, P., RUFFET, R., FÉRAUD, G., BANTIGNIES, J.-L. and **BOIRON, M.-C.,** 1997, Excess argon versus fluid composition and density variability in the eclogitic mica schists surrounding the Biella pluton, Oropa, Sesia Zone, Italy: Abs Vol 3rd Workshop on Alpine Geological Studies, Oropa-Biella, p. 92-93.

PILI, Eric, SHEPPARD, S.M.F., LARDEAUX, J.-M., MARTELAT, J.-E. and **NICOLLET, Christian,** 1997, Fluid flow vs. scale of shear zones in the lower continental crust and the granulite paradox: Geology, v. 25, no. 1, p. 15-18.

PINHO, F.E.C. and **FYFE, W.S.,** 1997, The Alto Jauru Greenstone Belt, Brazil, a vast camp for exploration of gold associated with VMS deposits (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A119. First author at Univ. Federal de Mato Grosso, Dept. de Recursos Minerais, Cuiabá-MT, Brazil.

The Alto Jauru Greenstone Belt is located in the southern part of the Amazonian Craton, Brazil. Volcanogenic massive sulfide deposits occur in the eastern belt (Cabaçal Belt). The selenides, native Bi and Au-Ag and Au-Bi alloys are important ore minerals. Among the most important sulfides are chalcopyrite, pyrite, sphalerite and galena. Gold occurs as I in sulfides and in silicates. The association of gold with Bi and Se is common.

FI and carbon and oxygen isotopic analyses in carbonate and quartz veins identified P FI of low sal with Th between 240 and 340°C. The $\delta^{18}O$ values are between -2.85 to +2.3‰ (using the Matsuhisa et al., 1979 quartz-water fractionation equation).

The genetic process suggested by the Cabaçal deposit makes the south portion of the Amazonian Craton an interesting region for exploration of sulfide and gold deposits. (From authors' abstract by H.E.B.)

PINTEA, Ioan, 1997, The significance of the liquid homogenisation temperature in salt melt inclusions. A case study in Neogene porphyry copper ore deposits from Metaliferi Mountains (western Romania): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 266-267. Author at Geological Inst. of Romania, 3400, Cluj-Napoca, 1, PO Box 181, Romania.

A review of the homogenization behavior of four types of salt MI from several porphyry copper ore deposits from Metaliferi Mountains. The four types of salt MI are as follow: Silicate glass+salt crystals (+/-silicate crystals)+V; halite+sylvite+K-Fe(Pb, Zn, Mn...)Cl-complexes+silicate crystals+anhydrite+opaque (pyrite, chalcopyrite, magnetite, hematite...)+V; halite+sylvite+K-Fe(Pb, Zn, Mn...)Cl complexes +/- silicate minerals+anhydrite+opaque (pyrite, chalcopyrite, hematite...)+V+L; and halite+sylvite+K-Fe(Pb, Zn, Mn...)Cl- complexes+silicate minerals+anhydrite+opaque (hematite, pyrite, chalcopyrite, magnetite...)+V+L.

Our observations suggest a continuous magmatic-hydrothermal evolution line of the salt M, starting by immiscibility from the residual silicate M and finishing via successive boiling episodes (i.e. halite trend solutions) to a dilute aq solution state. The real T of the F phase separation by immiscibility is estimated around 1000-1100°C, based upon the correspondence of the V bubble disappearance in silicate MI and the formation T of the silicate M in the coeval salt MI. (From author's abstract by E.R.)

PINTI, D.L., MARTY, Bernard and **ANDREWS, J.N.,** 1997, Atmosphere-derived noble gas evidence for the preservation of ancient waters in sedimentary basins: Geol., v. 25, no. 2, p. 111-114.

PIRAJNO, Franco, BAGAS, Leon, HICK-

MAN, A.H. and Gold Research Team, 1997, Gold mineralization of the Chencai-Suichang uplift and tectonic evolution of Zhejiang Province, southeast China: Ore Geol. Reviews, v. 12, p. 35-55. First author at Geological Survey of western Australia, 100 Plain Street, East Perth, WA 6004, Australia; email (f.pirajno@dme.wa.gov.au).

A metallogenic model is proposed, related to plate interactions along the Pacific margin with southeast Asia. (From authors' abstract by E.R.)

Several FI studies from the literature are cited. (E.R.)

PIRONON, Jacques, BARRES, Odile, and **de DONATO, Philippe,** 1997, Fluid inclusion FTIR spectroscopy at varying temperature: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 268-269. First author at CNRS-CREGU, EP 578, BP 23, 54501 Vandœuvre-lès-Nancy, France; email (pironon@cregu.cnrs-nancy.fr).

A Linkam FT-IR 600 stage has been adapted to the Bruker microscope linked to a Bruker IFS-55 spectrometer. This assemblage permits recording IR spectra from -196°C (T of L nitrogen) to +600°C. Applications of the coupling of FT-IR microspectrometry and heating and freezing stage concern both mineral and F phases. Very low T induce narrowing of the infrared abssorption bands which then facilitates assignment and [deconvoluting]. In addition, FT-IR spectroscopy can be applied to compounds which fluoresce under Raman conventional exciting sources.

The changes in spectra with T are illustrated for a CO_2-H_2O I (E.R.). (From authors' abstract by E.R.)

PIRONON, Jacques, CANALS, Martin, DUBESSY, Jean, WALGENWITZ, Frédéric and **LAPLACE-BUILHE, Corinne,** 1997, Volumetric analysis of hydrocarbon inclusions: New data for P,T,X reconstruction of petroleum reservoirs: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 270-271. First author at CNRS-CREGU, EP 578, BP 23, 54501 Vandœuvre-lès-Nancy, France; email (pironon@cregu.cnrs-nancy.fr).

P and T determination of hydrocarbon trapping in FI needs the knowledge of the hydrocarbon composition. However, oils in I are complex mixtures and I are not always identical in a given crystal. Individual analyses I have various limitations which are not enough informative for quantitative estimates. We have focused our study on volume determination which can help to deterine the bubble-point curve of the oil. This data is necessary for the interpretation of the Th of hydrocarbon I. Confocal Laser Scanning Microscopy (CLSM) has been applied to obtain a 3D volume calculation. However, 3D reconstruction of the gas bubble does not fit with the supposed spherical shape of the gas phase. Light refraction and reflection phenomena, induced by the high refractive index contrast between oil and gas, explain the resulting deformed image. With these data, the Gas Oil Ratio (GOR) of the I at given T can be calculated by measuring the diameter and hence the volume of the spherical gas bubble. (From authors' abstract by E.R.)

PITMAN, J.K., GOLDHABER, M.B. and **SPOEETL, Christoph,** 1997, Regional diagenetic patterns in the St. Peter Sandstone; implications for brine migration in the Illinois Basin: U.S. Geological Survey Bull. 2094A, p. A1-A17.

This study documents the mineralogy and diagenetic history of the Ordovician St. Peter Sandstone in the Illinois Basin. Stable isotope geochemistry, burial-thermal reconstructions, and FI paleothermometry reveal that burial diagenesis was influenced by a low T hydrothermal F-flow event associated with the Ouachita Orogeny during late Paleozoic time. (Authors' abstract)

POKROVSKII, V.A. and **HELGESON, H.C.,** 1997, Calculation of the standard partial molal thermodynamic properties of KCl^0 and activity coefficients of aqueous KCl at temperatures and pressures to 1000°C and 5 kbar: Geochim. Cosmo. Acta, v. 61, no. 11, p. 2175-2183.

POLLIAND, Marc and **MORITZ, Robert,** 1997a, Late alpine polymetallic quartz-barite veins in the "Montagne de Pormenaz", Aiguilles Rouges Massif, France: Fluid inclusion and isotope (S, Sr) constraints: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 272-273. Authors at Dép. Minéralogie, Univ. de Genève, rue des Maraîchers 13, 1211 Genève 4, Switzerland; email (pollian1@sc2a.unige.ch).

The "Montagne de Pormenaz" contains several subvertical polymetallic-Ag mineralized quartz-barite veins. The monzonite host rock probably underwent a late-Hercynian deformation. Two different mineralisation stages have been recognised: (i) a main stage consisting of quartz and barite, with pyrite, chalcopyrite, tetrahedrite, bournonite, chalcostibnite and galena; and (ii) a minor and probably later stage composed of quartz and stibnite. Two different types of FI have been recognised: Two-phase L-rich H_2O-NaCl in quartz and barite, constant sal around 9 wt.% eq. NaCl and Th_{tot} between 166 and 227°C. The same FI type has been recognised in barren regional quartz veins, and in Alpine quartz-filled fissures in the Aar, Gotthard and Mont Blanc massifs.

The second type is H_2O-CO_2-NaCl FI in quartz intimately associated with the minor quartz-stibnite mineralization stage. Sal based on clathrate melting T range between 2.4 and 8.2 wt.% eq. NaCl, and Th_{tot}(L) fall between 210 and 300°C.

We conclude that the polymetallic mineralized quartz-barite veins were emplaced during Alpine sinistral transpression as tension fracture fillings. Cooling of a moderately saline H_2O-NaCl F with a $\delta^{34}S$ close to 1.8‰ was responsible for their precipitation. Sulfur and barium are most likely derived locally from the monzonite host rock, while ^{87}Sr-enriched strontium comes from Mesozoic sedimetary rocks at depth. The quartz-stibnite stage belongs to a late event associated with a distinct CO_2-bearing F. (From authors' abstract by E.R.)

POLLIAND, Marc and **MORITZ, Robert,** 1997b, Late Alpine polymetallic quartz-barite veins in the 'Montagne de Pormenaz', Aiguilles Rouges Massif, France: Structural, fluid inclusion and isotope (S, Sr) constraints: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 837-840. Authors at Département de Minéralogie, Université, Switzerland.

The Alpine basement-hosted mineralized quartz-barite veins of the "Montagne de Pormenaz" were emplaced during Alpine sinistral transpression as tension fracture fillings. The cooling of a moderately saline aq F with a δ^{34}S around 1.8‰ was responsible for their precipitation. The veins were emplaced at T of 336 to 260°C at a mean depth of 6 km. In the mineralized veins, sulfur and barium are most likely derived locally from the monzonitic host-rock, while ^{87}Sr-enriched strontium came from Mesozoic rocks at depth. A quartz-stibnite minor phase, probably late stage, is associated with a distinct CO_2-bearing F. (Authors' abstract)

POOLE, P.H., GRANDE, Tor, ANGELL, C.A. and McMILLAN, P.F., 1997, Polymorphic phase transitions in liquids and glasses: Science, v. 275, p. 322-323. First author at Dept. of Applied Mathematics, Univ. of Western Ontario, London, Ontario N6A 5B7, Canada; email (poole@yorick.apmaths.uwo.ca)

Of pertinence to the problems of enigmatic phase transitions in FI (E.R.)

PORITSKIY, M.S., KOTOV, N.V., PORITSKAYA, L.G. and BUYKO, A.K., 1997, Geological setting and mineral assemblages of the May gold deposit, northern Karelia, Russia: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 289-291. First author at St. Petersburg State Univ., Russia.

New geological data of the gold-quartz type deposit May in Karelia, Russia, will be presented. The major ore minerals are sulphides, tellurides, selenides and native gold. FI data of gold-bearing quartz testify that ore-forming metasomatic processes operated at T as high as 500°C and at P of 50 MPa. (Authors' abstract)

PORTNYAGIN, M.V., DANYUSHEVSKY, L.V. and KAMENETSKY, V.S., 1997, Coexistence of two distinct mantle sources during formation of ophiolites: A case study of primitive pillow-lavas from the lowest part of the volcanic section of the Troodos Ophiolite, Cyprus: Contrib. Mineral. Petrol., v. 128, p. 287-301. First author at Vernadsky Inst. of Geochem., Kosigin str., 19 Moscow 117975, Russia.

We present a detailed mineralogical, petrological and M I study of unusually fresh, primitive olivine + clinopyroxene phyric Lower Pillow Lavas (LPL) found in the Troodos ophiolite (Cyprus). The fractionation path of LPL parental M is characterized initially by olivine + clinopyroxene cotectic crystallization joined by plagioclase at ~9 wt.% MgO, whereas the Upper Pillow Lavas (UPL) parental melts experienced a substantial interval of olivine-only crystallization. Our new data on the LPL coupled with existing data for the UPL support the existing idea that the LPL and UPL P M originated from distinct mantle sources, which cannot be related by progressive source depletion. (From authors' abstract by E.R.)

POTTER, J., RANKIN, A.H., TRELOAR, P.J., NI, P. and NIVIN, V., 1997, Hydrocarbons associated with alkaline rocks of the Kola Peninsula; origin and significance based on preliminary fluid inclusion studies: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 274-275. First author at School of Geological Sci., Kingston Univ., Kingston-Upon-Thames, Surrey, KT1, 2EE, U.K.

A notable feature of these complexes is the occurrence of anomalous concentrations of hydrocarbons in several (Khibiny, Lovozero and Kovdor). These may occur as rare solids, large volumes of hydrocarbon gases in boreholes, or evolved from crushed or heated rock samples. The source of these hydrocarbons is the subject of much controversy because of the apparent absence of organic-rich material in the Archeaen basement rocks. Four main types of I are recognised. Type 1 inclusions are high T (Th>700°C) silicate MI. Type 2 inclusions are CO_2-H_2O-rich with low sal (Th=280 to 450°C). Type 3 inclusions are H_2O-NaCl-$NaHCO_3$-rich (sal from 8-12 wt.% eq. NaCl, Th=220-580°C). Type 4 comprise pure methane (Th to V and L from -82 to -105°C, mean density=0.1 g/cm^3). At present we do not have a clear understanding of the precise relationship between the CO_2-rich and CH_4-rich F. However, there is strong evidence to suggest that CH_4-F are the result of a post-magmatic buffering of a CO_2-rich F involving the Fischer-Tropsch reaction; $CO_2+4H_2O \Leftrightarrow CH_4+2H_2O$, especially in the presence of magnetite. The generation of higher order hydrocarbons through polymerisation to form complex organic structures is also thought to be linked to these processes. To date there is little evidence to support a P magmatic source for any of the hydrocarbon phases observed at Khibiny or Kovdor, although they are probably abiogenic in origin. However the enigmatic link between these reduced F phases and associated magnetite, apatite and sulphide mineralization still needs to be explained. (From authors' abstract by E.R.)

POTTORF, R.J., GRAY, G.G., KOZAR, M.G., FITCHEN, W.M., RICHARDSON, Mark, CHUCHLA, R.J. and YUREWICZ, D.A., 1997, Paleothermometry techniques applied to burial history and hydrocarbon migration analyses, Tampico-Misantla Basin, Mexico: Annual Meeting Abstracts-American Assoc. of Petroleum Geologists and Soc. of Economic Paleontologists and Mineralogists, v. 6, p. 94.

To constrain the complex burial and migration history of the Tampico segment of the Sierra Madre Oriental fold-thrust belt, we applied integrated paleothermometry, including smectite/illite transformation, illite age analysis, FI thermometry, vitrinite reflectance, kerogen maturation, and apatite fission track analysis. FI Th show that the El Abra reached maximum T of 170°C during burial of approximately 5 km of Lower Tertiary sediments. Apatite fission track data suggest that the Sierra de El Abra was uplifted between 30-60 Ma. Uplift timing and the formation of a free gas cap within the paleo-oil field is also confirmed by immiscible trapping of hydrocarbon I. (From authors' abstract by E.R.)

POTY, Bernard, 1997, Alpine fluids in the Alps: A review: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 276-277. Author at CREGU and EP 578, BP 23, F-54501 Vandœuvre-lès-Nancy, France; email (poty@cregu.cnrs-nancy.fr).

Quartz crystals from alpine fissures have been key material for the development of FI studies: Koenigsberger, Laemmlein, Ermakov, Deicha, and in a nearer past (from the sixties): Stalder, Poty, Touray, Mullis, etc. This material has also been a key material for the development of many techniques used in FI studies. The occurrence and habits of the crystals, and their FI, are reviewed.

Despite the quantity of works which have been performed in more than one century on these crystals a lot of problems are still not resolved. Origin of the F, leaching of surrounding rocks, and crystal growth in the fissures are not totally understood. Quantitative chemical and physical modelling will help in this matter, but they are only beginning.

The origin of F is only assumed: they come probably from the sediments over which granites or crystalline rocks are overthrusted (nappes). Stable isotope studies do exist, but they are yet too scarce to help strongly. (From author's abstract by E.R.)

PROCHASKA, W., 1997, Formation of different siderite provinces during the Alpine tectono-metamorphic event in the Eastern Alps of Austria: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 845-848. Author at Dept. of Geosci., Univ. of Leoben, Austria.

On the basis of I F chemistry determined by crush-leach analyses of mineral separates two different iron ore provinces can be distinguished in the Eastern Alps. The Erzberg siderite province is characterized by siderite/hematite veins and metasomatic stock mineralizations in the Greywacke Zone. Timing of the hydrothermal event is between Permian and the Eoalpine event. According to their soluble salt contents the F were originally formation waters, though an influence of Mesozoic evaporitic brines cannot be excluded. After the Eocene compression mineralized quartz-siderite-hematite veins were formed in the Austroalpine Crystalline Complex during an extensional phase due to escape tectonics and subsidence of the intramontane basins. F chemistry indicate surface F that means seawater and/or meteoric water was incorporated into a hydrothermal system depending on the corresponding position of the mineralization. Hydrothermal activity was possibly related to Tertiary metamorphism of the underlying Penninic Unit. (Author's abstract)

PROHL, Hansjörg, SIEMANN, M.G. and DUBESSY, Jean, 1997, The radioactive decay of potassium as a possible source for hydrogen in gas bearing fluid inclusions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 278-279. First author at Dept. Geochem., Tech. Univ. of Clausthal, 38678 Clausthal-Zellerfeld, Germany; email (prohl@immr.tu-clausthal.de).

Up to 30 mol% H_2 has been found in analysis of the gases in Zechstein evaporites, particularly in K minerals. This might be from radiolysis of H_2O. Many parameters are involved, but a model is developed to calculate the expected production of H_2O in a FI in sylvite (E.R.).

PROKOFYEV, V.Yu. and MATEL, N.L., 1997, Solubility of gold in high-CO_2-CH_4 and H_2S hydrotherms (abst.): in N.P. Laverov, ed. Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 (Betekhtin Symposium), p. 59-60 (in Russian). ISBN 5-88918-002-9.

PROKOF'EV, V.Yu., 1997, Main principles of hydrothermal deposit typification based on fluid inclusion study: The case of gold: Dokl. Ross. Akad. Nauk, v. 354, no. 1, p. 93-95 (in Russian, translated in Trans. (Dokl.) of the RAS/Earth Sci. Sections, v. 354, no. 1, p. 553-555). Author at Vinogradov Inst. of Geochem., Siberian Div., RAS, ul. Favorskogo 1a, Irkutsk, 664033 Russia.

Experience in the study of individual FI in minerals from numerous hydrothermal deposits, including 17 deposits with economic gold mineralization and some other types, allowed the author to formulate a number of important principles of thermobarogeochemical research concerning hydrothermal objects. One "important principle "of thermobarogeochemical research dictates the necessity of FI study on a mass scale – from a few hundreds to a few thousands of individual I per object." [sic] (From author's text by E.R.)

PROKOF'EV, V.Yu., SPIRIDONOV, A.M., KUZ'MINA, T.M., GNILUSHA, V.A. and KOVALEVA, V.F., 1997, Physicochemical conditions of mineralizing processes at the Kariiskoe gold deposit, eastern Transbaikalia: Geokhimiya, 1997, no. 4, p. 423-434 (in Russian; translated in Geochem. Internat'l., v. 35, no. 4, p. 368-378). Authors at Vinogradov Inst. of Geochem., Siberian Div., RAS, ul. Favorskogo 1a, Irkutsk, 664033 Russia.

Detailed cryo- and thermometric studies of F and M I confirmed the genetic links established earlier between the gold mineralization and granitic rocks of the Amudzhikan-Sretenskii Complex. The results made it possible to constrain the boundary physicochemical parameters of the ore-magmatic system. The granitic M was rich in water (up to 11.3 wt.%) and chlorine (up to 0.48 wt.%) and crystallized at T of 800-690°C and water P of 4.8-4.2 kbar. The conditions under which the hydrothermal ore mineralization formed varied over wide ranges of parameters: T 575-85°C, P 2820-85 bar, and solution sal 56-0.5 wt.% NaCl eq., with carbon dioxide playing a significant role in the process. During the initial stages of the hydrothermal activity, the solution boiled off, which resulted in an increase in its sal and enrichment in ore-forming components. The F sal rapidly decreased at T<350°C, probably because of the opening of fractures and addition of meteoric waters to the system. These processes brought about massive ore deposition. (Authors' abstract)

PROKOFIEV, V.Y. and ZORINA, L.D., 1996, Fluid regime of the Darasun ore-magmatic system according to data on fluid inclusions (eastern Transbaikalia): Russian Resource Geol. and Geophysics, v. 37, no. 5, p. 48-xx.

QIN, Huaning, ZHU, Bingquan, CHANG, Xiangyang and SUN, Duzhong, 1997, ^{40}Ar-^{39}Ar dating for quartz sample by crushing in vacuum and by stepped heating on its powder: Chinese Acad. of Geological Sci., Beijing, China.

Indexed under FI (E.R.)

QIU, Huaning, SUN, Dazhong, ZHU, Bingquan and CHANG, Xiangyang, 1997, Isotope geochemistry study of Dongchuan copper deposits in central Yunnan Province, SW China; II, Dating the ages of mineralizations by Pb-Pb and ^{40}Ar-^{39}Ar methods: Geochimica (Diqiu Huaxue), v. 26, no. 2, p. 39-45.

In this study, we dated the copper ores from the Luoxue Formation of the Kunyang Group in Tangdan, Dongchuan, using the Pb-Pb isochron method, and determined the FI in a quartz sample from a copper-quartz vein from the same formation by the ^{40}Ar-^{39}Ar crushing in vacuo technique. The Pb-Pb isochron age of the copper ores (794±73) Ma, may indicate that the copper deposit in the Luoxue Formation was formed or reworked in the Jinning-Chengjiang period. The data yield an isochron on the $^{40}Ar/^{36}Ar$-$^{39}Ar/^{36}Ar$ diagram with the isochron age of (712±33) Ma. (Authors' abstract)

QIU, Ruizhao, ZHOU, Su, CHANG, Hailiang, DU Shaohua and PENG, Songbai, 1997, Role of the supercritical fluid in the process of granitic rock-forming and mineralization and taking the granitic Nb-Ta deposit in Xianghualing area as an example: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 4 (in English). Authors at Yichang Inst. of Geol. and Mineral Resources, CAGS, Yichang, 443003.

Mineralization and rock-forming are a successive process in which fractional crystallization of magma and metasomatism and resorption coexist, and precipitation and dissolution take place alternatively. The formation of granitic Nb-Ta deposit in Xianghualing area is in fact a process of differentiation or self-organization in magmatic system under the action of supercritical F. Mineralization comes out in the generalized magmatism and granitic Nb-Ta deposit is belong to magmatic genesis. [sic]. (From authors' abstract by E.R.)

QUÍLEZ, Encarnación, MORALES-RUANO, Salvador, BOIRON, M.-C. and CATHELINEAU, Michel, 1997a, The thermochemical evolution of complex-aqueous-carbonic fluid inclusions and their relation with the style of mineralization in W-Mo-sulphide deposits (Spanish Central System): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 280-281. First author at Centro de CC. Exp. y Técnicas, Univ. San Pablo-CEU, 28668 Boadilla del Monte, Madrid, Spain.

The three W-(±Mo)-sulphides-bearing veins, Garganta de los Montes, Cabeza Lijar and El Estepar (EE) show different geological settings. Data on $TmCO_2$, Tmclath, $ThCO_2$, Th, sal, and density are tabulated for the five types of FI in each of the three deposits. The earliest F were high in sal, density, and T; these formed greisens. Next came complex carbonic solutions, which changed with time, and deposited W and Mo. Last, moderate sal, density and T solutions formed the Cu-Zn sulfides (E.R.).

QUÍLEZ, E., MORALES-RUANO, S., BOIRON, M.C. and CATHELINEAU, M., 1997b, An integrated model from a comparative study of three W-(±Mo)-sulphide mineralizations in the Spanish Central System: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 961-xxx. First author at Centro de CC, Experimentales y Técnias, Universidad San Pablo-CEU, Madrid, Spain.

A comparison, from a paragenetic and FI study, of three main W-Mo-sulphides deposits related to granites of Spanish Central System is presented. Attention is focused on the relationships between "hot" complex carbonic-aq solutions and W-bearing mineralizations. (Authors' abstract)

RAIA, Federica, WEBSTER, J.D., DeVIVO, Benedetto and BELKIN, H.E., 1997, Pre-eruptive volatile and trace element contents of Somma-Vesuvius magma: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F779. First author at Earth and Planetary Sci., AMNH, Central Park West 79th St., New York, NY, 10024, U.S.A.; email (raia@amnh.org)

We analyzed silicate MI, hosted in phenocrysts, from the Italian Somma-Vesuvius magmatic system during the 79-1944 A.D. activity, by EMPA, FTIR and SIMS, after heating at 1 atm. to 1150 to 1200°C and quenching. MI are generally small (<70 micrometers) and contain silicate glass and a shrinkage/gas bubble. Many MI contain small residual apatite and/or oxide crystals. Preliminary results from the 1631-1944 Somma-Vesuvius MI indicate that magmas were strongly and variably enriched in F (from 0.16 to 0.50 wt.%) and Cl. Although Cl contents of MI show a wide range from 0.2 to 1 wt.%, the average value is very similar to the average Cl abundance in the bulk rock content. Sulfur was also found to be enriched in the M (e.g., up to 0.8 wt.% SO_2). The S, F and Cl contents seem unrelated to the age of the sample

We believe that acquiring information on the pre-eruptive abundances of volatile and mobile trace elements in M, by these techniques, allows us to constrain these characteristics and address key questions involving processes of volcanic eruption. (From authors' abstract by E.R.)

RAJESH, H.M. and SANTOSH, M., 1997, Metamorphic characteristics of fluid-controlled granulite formation – A case study from the Kerala Khondalite Belt (KKB), south India: J. of Geosci., Osaka City Univ., v. 40, no. 5, p. 69-96. First author at Dept. of Geosci., Faculty of Sci., Osaka City Univ., Sugimoto 3-3-138, Sumiyoshi-ku, Osaka 558, Japan.

Dark orthopyroxene-bearing granulites (charnockite with or without cordierite) have formed from light grey garnet-biotite gneiss via several mineral reactions.

FI data in conjunction with the mineral reactions show that the granulites of the present study area followed an isothermal decompression path with F entrapment conditions at ca. 600-700°C and 3-4 kbar. FI studies on minerals associated with alkaline pegmatites occurring in the same area revealed the presence of high density CO_2-rich F. The wide occurrence of similar pegmatite dykes adjacent to the incipient charnockites in many localities in KKB suggest that the F expelled from the alkaline magmas upon their freezing were channeled along faults/shears affecting dehydration along the F pathway and generating incipient charnockites through CO_2-induced metasomatism. These pegmatites possibly represent part of an alkaline magmatic phase with abundant volatile activity, correlatable with the Pan-African alkaline magmatism widely recognized in the southwestern Indian shield. We propose that incipient charnockite formation in KKB is intimately related to magmatic processes, in that the heat and volatiles were derived from CO_2- and volatile-enriched magmas. (From authors' abstract by E.R.)

RAMBOZ, C., BRIL, H., LEOST, I. and RENAC, C., 1997, A time-constrained two-dimensional reconstruction of mass transfers around the Uzer growth fault (western margin of the SE basin of France): The missing link between geopressuring and Zn-Pb mineralization?: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J.

Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 282-283. First author at CRSCM-CNRS, 1A rue de la Férollerie, F45071 Orléans-la-source cedex 2; email (cramboz@cnrs-orleans.fr).

The Cevenole margin is the largest Zn-Pb district in Europe. It appears unconventional with reference to the Mississippi Valley Type model in several respects. In order to characterize the F transfers along a deeply-rooted growth fault, an investigation of two cores was undertaken, together with related FI measurements. We summarize the reconstructed F paths around the fault that can be inferred from these data and referring to petrographic, geochemical, structural schemes previously published. (From authors' abstract by E.R.)

RAMPONE, E., PICCARDO, G.B., VANNUCCI, R. and **BOTTAZZI, P.,** 1997, Chemistry and origin of trapped melts in ophiolitic peridotites: Geochim. Cosmo. Acta, v. 61, no. 21, p. 4557-4569. First author at Dipartimento di Scienze della Terra, Corso Europa 26, 16132 Genova, Italy.

M impregnation and peridotite-M interaction are ubiquitous phenomena in the oceanic-type lithospheric mantle. Nevetheless, the nature of the infiltrating M is still poorly understood. We performed detailed textural and chemical investigations on: ophiolitic peridotites from the Internal Ligurides (northern Apennine, Italy) and Mt. Maggiore (Corsica), and olivine cumulates from magmatic pods intruded within the Mt. Maggiore peridotites. The results of this study suggest that the impregnating M originated at deeper mantle levels and presumably represented the last M increments of a fractional melting process. Such a process has been increasingly invoked in studies of M/rock reaction zones from ophiolitic peridotites. (From authors' abstract by E.R.)

RAMSEYER, Karl, HARTMAN, B.H., HOPPE, Peter, BODNAR, K.J., KROGER, Yves and **MATTER, Albert,** 1997, Source-sink relationships during quartz cementation; a case study from the Haushi Group sandstones, Sultanate of Oman: Annual Meeting Abstracts-American Assoc. of Petroleum Geologists and Soc. of Economic Paleontologists and Mineralogists, v. 6, p. 96.

The sediments presently are at maximum burial and range in depth from outcrop to almost 5000 m. This variation allows the study of quartz cementation over a wide depth range. Evidence from CL, stable isotopes, electron microprobe and FI microthermometry supports a multistage origin of authigenic quartz. The diagenetic sequence reveals four cogenetic processes leading to different phases of quartz cementation. Of these four sources, pressure-solution at detrital grain boundaries is responsible for most of the observed quartz cement. (From authors' abstract by E.R.)

RANTITSCH, Gerd, 1997a, Thermal history of the Carnic Alps (Southern Alps, Austria) and its palaeogeographic implications: Tectonophysics, v. 272, no. 2-4, p. 213-232.

The thermal history of the Carnic Alps (Southern Alps, Austria) has been investigated by means of organic petrology, clay mineralogy and microthermometry. All obtained data, a methodical correlation and a numeric 1D simulation of the burial history result in the model of a multistage thermal history. The last stage consists of high-T FI phases related to Oligocene plutonic activity. (From author's abstract by E.R.)

RANTITSCH, Gerd, 1997b, Hydrocarbon-bearing fluid inclusions in Drauzug (Ostal Alps, Austria) and its significance for the genesis of the Pb-Zn deposits, Bleiberg: Austrian Fluid Info Workshop, extended abstracts, Mitt. Osterr. Miner. Ges., v. 142, p. 18 (in German).

RANTITSCH, Gerd, RUSSEGGER, Barbara, SACHSENHOFER, R.F., JOCHUM, Johannes and **SCHROLL, Erich,** 1997, Hydrocarbon-bearing fluid inclusions in the Drau Range (Eastern Alps, Austria): Implications for the genesis of the Bleiberg Pb-Zn deposit: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where Do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 567-xxx. First author at Institut für Geowissenschaften, Montanuniversität Leoben, Austria.

Hydrocarbons in ore minerals of the Bleiberg Pb-Zn deposit and in authigenic quartzes of the Lienzer Dolomiten (Drau Range, Eastern Alps) were characterized by their organic-chemical composition. Microthermometric data and the molecular composition of the hydrocarbons indicate a hyperthermal event of migrating condensate-like hydrocarbons in the Middle Cretaceous to Early Tertiary. The hydrocarbons possibly played an important role as reducing agents in second stage sulfide precipitation. (Authors' abstract)

RAO, D.R., SHARMA, Rajesh and **GURURAJAN, N.S.,** 1997, Mafic granulites of the Schirmacher region, East Antarctica: Fluid inclusion and geothermobarometric studies focusing on the Proterozoic evolution of the crust: Trans. of the Royal Society of Edinburgh: Earth Sci., v. 88, p. 1-17.

In the Proterozoic complex of the Schirmacher region of East Antarctica, a retrograde P-T history has been inferred through quantitative geothermobarometry and FI studies of the mafic granulites. Microthermometric investigations of the F phases trapped in quartz and garnet identified three types of I, namely, earliest pure CO_2 I (0.987-1.057 g/cm^{-3}), CO_2-H_2O I and aq I.

The T and P of metamorphism have been estimated through different calibrations of geothermometers and geobarometers. The estimated P-T conditions of the region suggest that the rocks were metamorphosed at a depth of 19-24 km, with a geothermal gradient of c. 35°C km^{-1}. The estimated P-T conditions of the rocks imply a clockwise P-T-t path with a gradual decrease in T of around 250°C and a decrease in P of around 1700 bar. They have a dP/dT gradient of $\approx 7 \pm 1$ bar °C^{-1}, arguing for an isobaric cooling history of the terrane under normal thickened crust after the underplating of mantle-derived material. (From authors' abstract by E.R.)

RAO, Xuefeng, 1997, Genesis of strata-bound ore deposits in central Guangxi, South China; fluid inclusion and isotope constraints: Doctoral thesis, Yale Univ., New Haven, CT, U.S., 241 pp.

RAPIEN, M.H., BODNAR, R.J., CZABO, Csaba, SIMMONS, Stuart and **WOOD, C.P.,** 1997, Magma evolution at White Island, New Zealand: Evidence from melt inclusions: Eos Trans. AGU v. 78 (17), Spring Meet. Suppl., p. S330-S331. First author at Dept. of Geological Sci., Virginia Tech, 4044 Derring Hall, Blacksburg, VA 24061-0420.

White Island is an active andesitic-dacitic volcano located off the north coast of the North Island of New Zealand. The volcano has been active for 10,000 years with recent alternating phreatic and phreatomagmatic eruptions. Much is known about the composition of the G emitted from the volcano. The purpose of this study is to better characterize the geochemistry of the magma by studying MI trapped in phenocrysts in ejecta from eruptions. The MI provide a sample of the magma from which the host phenocryst crystallized.

Samples from recent eruptions (1977-1992) are vesicular porphyritic andesitic-dacites containing subhedral and anhedral phenocrysts of plagioclase, orthopyroxene and clinopyroxene. A glassy matrix containing crystallites surrounds the phenocrysts. MI occur in all three phenocrysts. Solid I in the phenocrysts are optically distinct from the host phase, but not from the MI that occur in that same host. MI are randomly distributed in the phenocrysts or occur along growth zones in the phenocrysts. The crystalline I occur within the same growth rings as the MI and also as isolated I. Plagioclase contains both orthopyroxene and clinopyroxene I and both pyroxenes contain plagioclase I.

Microprobe and ion probe analyses were performed on the phenocrysts, I and matrix glass. Plagioclase phenocrysts and plagioclase I have similar compositions ranging from An 62-78. Orthopyroxene phenocrysts and I have the same composition, and plot in the enstatite field ranging in composition from mg#72-77 (Total Fe). Similarly, clinopyroxene phenocrysts and crystalline I have the same composition, and plot in the augite field ranging in composition from mg#72-77 (Total Fe). Major and trace element compositions of MI in all three phenocrysts are the same. Analyses of the glass in the matrix yields the same composition as the MI.

Each type of phenocryst can contain solid I of the other phenocrysts, indicating that all three phenocrysts were crystallizing at the same time. There is no control as to where or when in the magma chamber history these phenocrysts formed, therefore the phenocrysts and the MI must be thought of as a random sampling. However, because the MI show no chemical variation, the chemistry of the magma chamber was not changing during the unknown time interval during which the I were trapped. It is known, however, that the matrix glass formed by cooling during eruption. Because there is no difference between the I and matrix glass chemistry, this further indicates the magma composition remains constant, even though minerals have been crystallized out of the magma. (Authors' abstract)

REBBERT, C.R. and **RICE, J.M.**, 1997, Scapolite-plagioclase exchange: Cl-CO$_3$ scapolite solution chemistry and implications for peristerite plagioclase: Geochim. Cosmo. Acta, v. 61, no. 3, p. 555-567.

RECIO, C., FALLICK, A.E., UGIDOS, J.M. and **STEPHENS, W.E.**, 1997, Characterization of multiple fluid-granite interaction processes in the episyenites of Avila-Béjar, Central Iberian massif, Spain: Chem. Geol., v. 143, p. 127-144. First author at Dept. de Geología, Facultad de Ciencias, 37008 Salamanca, Spain.

Episyenitization leads to reduction of quartz content, albitized plagioclases and chloritized ferromagnesian phases, and the process results in increasingly ordered alkali feldspars. Whole rocks and mineral separates were studied for O and H isotopes. The data rule out meteoric F as the cause of syenitization (and the later resilicification of some) and suggest that at least two different F were involved in generating the syenites. The first is interpreted to be a high-T (300-450°C) late-magmatic deuteric F, as recorded by feldspar-O isotope data. Later, a different F with $\delta^{18}O \approx -1.4‰$ and $\delta D \approx -13‰$, isotopically indistinguishable from seawater on a deglaciated Earth, produced the chlorite, S quartz and minor epidote. Such a F was only available for a short period, since feldspars did not re-equilibrate. (From authors' abstract by E.R.)

REHKÄMPER, Mark, HALLIDAY, A.N., BARFOD, Dan, FITTON, J.G. and **DAWSON, J.B.**, 1997, Platinum-group element abundance patterns in different mantle environments: Science, v. 278, p. 1595-1598. First author at Dept. of Geological Sci., Univ. of Michigan, Ann Arbor, MI, USA.

Mantle-derived xenoliths from the Cameroon Line and northern Tanzania display differences in their platinum-group element (PGE) abundance patterns. The differences can be explained if the northern Tanzanian lithosphere developed in a F-rich suprasubduction zone environment, whereas the Cameroon Line lithosphere only experienced M extraction from anhydrous peridotites. (From authors' abstract by E.R.)

REN, Zhanli and **ZHAO, Zhongyuan**, 1997, Late Mesozoic comparative research on the geothermal field of the Ordos Basin and Qinshui Basin, north China: Acta Sedimentologica Sinica, v. 15, no. 2, p. 134-137.

The Ordos basin and Qinshui basin, separated by the Luliang uplift, are all large sedimentary basins. It was determined by vitrinite reflectance, apatite fission tracks and FI that paleogeothermal gradient and heat flow are 3.3-4.3°C/100 m and 81-95 m water/m^2 in the Ordox basin, 5.8°C/100 m and 106 m water/m^2 in the Qinshui basin. The Qinshui basin is higher than the Ordos basin. Those facts showed that there was a tectonic-thermal event in the Late Jurassic to Early Cretaceous. This tectonic-thermal event increased the thermometamorphic degree of Paleozoic gas source rocks and accelerated gas generation. (Authors' abstract)

RENARD, Francois and **ORTOLEVA, Peter**, 1997, Water films at grain-grain contacts: Debye-Hückel, osmotic model of stress, salinity, and mineralogy dependence: Geochim. Cosmo. Acta, v. 61, no. 10, p. 1963-1970. First author at LGIT, CNRS-observatoire, Univ. Jos. Fourier, BP 53, 38041 Grenoble, France.

Water film diffusion is one of the mechanisms proposed to explain the deformation of rocks by P-solution during geological processes in the upper crust. This mechanism assumes that matter is dissolved inside the contact between two grains. The resulting solutes are transported in the pore F through diffusion in an adsorbed water film.

The main problem of this theory is that it requires the presence of a water film that is believed to be stable under large deviatoric stresses inside the contact between two grains. In this paper, we show that the electrically charged surface of a mineral can attract counter-ions from the pore and, by the related change of osmotic P, keep water within the contact. This is due to the counter ions in the water film that increase the sal in the film relative to that in the pore. This lowers the free energy of water in the contact zone to a degree that balances the increase in free energy of water due to the elevated P in the film. These notions are made more precise by combining the theory of the Debye-Hückle double layer with equations of osmotic P. The resulting D-H/O theory predicts the dependence of the water film thickness on stress across the contact, composition of the pore F, and the identity of the minerals involved. (Authors' abstract)

RENÉ, Milos, 1997, Fluid system of the Vitkov II uranium deposit (Bor pluton, western part of Bohemian massif, Czech Republic): Austrian Fluid Info Workshop, extended abstracts, Mitt. Osterr. Miner. Ges., v. 142, p. 19-20. Author at Inst. of Rock Structure and Mechanics, Acad. of Sci. of Czech Republic V Holesovickách 41, 182 09 Prague 8, Czech Republic.

The Bor pluton forms part of Variscan granitoid magmatism of the Moldanubian zone of the Bohemian massif. It forms a N-S elongated body that was emplaced along the western Bohemian shear zone during the Lower Carboniferous. Uranium deposits of zoned or metasomatic type are developed along its western, mostly tectonic, contact with the Moldanubian metamorphics. The Vitkov II deposit is the representative of the metasomatic type associated with hydrothermally altered monzogranites (episyenites).

Hydrothermal alterations of the granites started with removal of the original magmatic quartz and with the transformation of biotite into chlorite I. The oldest ore bearing phase was marked by an intense influx of Mg, Fe and Na-rich F and by the genesis of chlorite II, hematite and by a large-scale albitization of the original feldspars (orthoclase and plagioclase).

The accompanying sericitization led to the development of S muscovite or phengite. Thicker parts of the shear zone 0-30 show a characteristic zoning of the hydrothermal alterations. The external belt comprises the chlorite-muscovite and chlorite-muscovite-zeolite zones, the middle belt comprises the chlorite-muscovite-albite zone and the internal belt is formed by the chlorite-quartz-leucoxene and by the chlorite zones. The authigenic quartz II is cogenetic with chlorite II, and veinlets of quartz III developed during younger mineralization stages.

Measurement of decrepitation of quartz II by the low frequency acoustic emission method yielded values between 250 and 500°C, the most frequent value being 420°C. Th of quartz III (Topp, 1993) give values of 66-210°C. Higher content of salts (21-28 wt.% eq. NaCl-$CaCl_2$) are characteristic for these I. The f_{O_2} value is controlled by the magnetite-hematite buffer and according to the composition of chlorite, it corresponds to -33 to -39 log f_{O_2}. The transfer of uranium took place in HPO_4^{-2} rich solutions in the pre-ore and in the ore bearing phases, the post-ore stages were dominated by a greater role of CO_3^{-2} rich solutions.

Occurrence of fossil solutions belonging to the system of deep, slow F circulation has been identified at the Vítkov II deposit in the course of exploration drilling (Markovic, 1977). These considerably mineralized saline F of Ca-Na-Cl-SO_4 type have been found in underground boreholes reaching down to depths of 1300-1400 m below today's surface. The saline F correspond in their composition both to the F found in the KTB-VB1 borehole at a depth of 3500-4000 m (Fritz et al., 1991) and to the F occurring in the I of uranium deposits of the western part of the Bohemian massif (Gerler, 1990). (From author's abstract by H.E.B.)

REYES, A.G., 1997, Magmatic-hydrothermal contributions to the 1991 Pinatubo eruption (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 5, p. 59. Author at Inst. of Geological and Nuclear Sci., P.O. Box 31312, Lower Hutt, New Zealand; email (a.reyes@gns.cri.nz).

During the exploration of the now defunct Pinatubo geothermal system in 1988-1989, the chemical and stable isotope compositions of gases and waters indicated that the well discharges contained as much as 75% of arc-type magmatic water. Gas geothermometers, such as H_2-Ar, indicated T as high as 365°C. Maximum well T of 330-336°C were measured at 1678-2190 m in the well nearest the summit, while FI Th in quartz at the same depths, ranged from 390-485°C. The FI homogenized at the critical point, or at the V-or L-phase. Generally, equivalent sal were 1.9 to 10%, but reached >40% NaCl b.w. Some contained both isotropic and anisotropic translucent dm. Due to the virulent acidity of the discharges, the wells were shut in 1990. Active magmatic input into the system was confirmed when the volcano started to erupt in April, 1991. During this time, ashes were emitted by the volcano, and Marunot River waters, which spring from near the summit, turned acid with pH of 1.95 (25°C). Sodium increased from 7 to 810 mg/kg, K from 3 to 140, Mg from 0.3 to 370, Ca from 7 to 260, B from 0.4 to 52, Cl from 8 to 2400, and SO_4 from 7 to 5330 mg/kg. The exhumation of the hydrothermal system thus was preceded by the expulsion of part of the acid waters. Ash samples at this time consisted mainly of dacite from the Pinatubo Volcanic Formation, soil fragments and up to 12% of hydrothermal alteration products. From April to the major eruption on 12 Jun 1991, the hydrothermal fraction in the ash and pumice decreased to <1%, reflecting the small size of the hydrothermal, in comparison to the magmatic system, and its depletion as the eruption went on. Ash leachates reflect interaction with the acid solutions of the hydrothermal system. (Author's abstract)

REYF, F.G., 1997, Direct evolution of W-rich brines from crystallizing melt within the Mariktikan granite pluton, west Transbaikalia: Mineralium Deposita, v. 32, p. 475-490. Author at Buryat Geological Inst. of the Acad. of Sci., Sakhyanova 6a, Ulan-Ude, 670047 Russia; email (burgin@eastsib.ru)

Uneconomic tungsten mineralization is associated with the Mariktikan granite pluton. The crystallization history of the pluton is subdivided into three stages of unequal duration. M and FI related to each of them have been studied using microthermometric and microanalytical procedures, including a technique for atomic emission spectroscopy of individual F opened by a laser microprobe. The main crystallization stage ranged from 1045 to 917°C. In spite of the low water content of the M (about 1 wt.%), F separation took place from the onset of crystallization. During the main crystallization stage, the exsolved F divided into two immiscible phases, CO_2-rich gas and salt-rich L (brine). However, it was homogeneous thereafter. Major ore components of the brine (Mn, Fe, W) displayed different behaviour as crystallization progressed. W concentration was below 0.1 wt.% at the main stage, attained 1 wt.% during the late stage and increased to 1.8 wt.% at the final stage. Such concentration was possible due to the high liquidus T, high Cl content, low water content (0.1%) and elevated W content (0.001%). (From author's abstract by E.R.)

AES-LM (atomic emission spectroscopy based on laser decrepitation of I into a spark discharge) was used to detect W, Fe, Mn, Cu and Al in 16 brine I (Table 3). Th NaCl and KCl are given for 72 I. Other dm include various chlorides of Fe, Mn, etc. (From author's text by E.R.)

REZAEE, M.R., LEMON, N.M. and SEGGIE, R.J., 1997, Tectonic fingerprints in siderite cement, Tirrawarra sandstone, southern Cooper basin, Australia: Geological Magazine, v. 134, no. 1, p. 99-112.
Indexed under FI (E.R.)

RHODES, A.L., ORESKES, N. and SHEETS, S., 1997, Recognition of a Paleo-hydrothermal system responsible for magnetite formation at El Laco, Chile: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F748-F749. First author at Dept. of Geol., Smith College, Northampton, MA 01063; email (arhodes@science.smith.edu))

The El Laco magnetite (±apatite) deposits of northern Chile are hosted within Plio-Pleistocene andesitic volcanic rocks. The magnetite deposits have been interpreted as having formed by crystallization from an immiscible iron oxide-phosphate M. This study presents textural and geochemical evidence that shows magnetite deposition was largely the result of metasomatic replacement of andesite and hydrothermal precipitation.

FI in diopside alteration are extremely saline, containing multiple, discrete crystal phases that distort the V bubble. Th are bimodal (710-750°C and 830-840°C), possibly reflecting two stages of metasomatic alteration by hydrosaline F. P FI in apatite intergrown with magnetite yield much lower Th (250-350°C) with varying sal (0.2-59 wt.% eq. NaCl). The measured T in apatite are inconsistent with the plausible T range from an iron oxide-phosphate M and suggest that apatite-magnetite formation was associated with a hydrothermal stage dominated by complex-solute bearing aq F that boiled.

$\delta^{18}O$ values in magnetite show no significant variability throughout the complex (mean=4.1±0.49 per mil), indicating that the bulk of the ore formed at similar T as magnetite in hydrothermal veins. $\delta^{18}O$ values of wall rock andesite show a distinct increase from 7.2 to 24.2 per mil with increasing degrees of hydrothermal alteration. Diopside alteration, apatite, and quartz all yield heavy $\delta^{18}O$ values (7.1-8.9, 7.8-8.0, and 7.1-27.9 per mil respectively) relative to values of typical igneous rocks. These data strongly suggest oxygen exchange with an isotopically heavy F distinct from P magmatic F. Ore may have been deposited by a mixture of magmatic-hydrothermal F, generated from a calc-alkali magma at depth, with evaporite-derived F or evaporitic rocks. Such a mixture would produce a saline, moderate-high T, and isotopically heavy F capable of mobilizing large amounts of iron. (From authors' abstract by H.E.B.)

RICHARDS, J.P., 1997, Controls on scale of Porgera-type porphyry/epithermal gold deposits associated with mafic, alkalic magmatism: Trans. Instn. Min. Metall. (Sect. B: Appl. Earth Sci.), v. 106, Jan-Apr 1997, p. 81-88.

The Porgera gold deposit in Papua New Guinea is one of the world's so-called 'giant' ore deposits, containing more than 600 t gold and locally exceeding 1 kg/t in grade. Several factors have acted in unison or sequentially to result in the spectacular concentration of metals. The absence of any one of these factors or the intervention of ore-destructive processes would have precluded the formation or preservation of a giant deposit.

Factors include: an extensional or trans-tensional tectonic setting within an arc or collisional environment, conducive to the generation and near-surface emplacement of hydrous, mafic, alkalic magmas; the exsolution of a magmatic hydrothermal F prior to sulphur saturation in the M, which would enable partitioning of precious metals in the hydrothermal regime; the development of the hydrothermal system into one favourable for the transport of gold (the chemistry of the country rocks and local groundwaters may have an important role to play in this regard); the action of late-stage faulting in the focusing of epithermal F flow; and the role of dissolved gases in promoting F phase separation and high-grade ore deposition. (From author's abstract by E.R.)

RICHARDS, J.P., BRAY, C.L., CHANNER, D.M. DeR. and SPOONER, E.T.C., 1995, Fluid processes at the Porgera gold deposit, Papua New Guinea: New evidence from gas and ion chromatographic analyses of fluid inclusions (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). First author at Dept. of Geol., Univ. of Leicester, University Rd., Leicester, LE1 7RH, U.K.,
See FIR, v. 28, p. 138 (E.R.).

RICHARDS, J.P., BRAY, C.J., CHANNER, D.M. DeR. and SPOONER, E.T.C., 1997, Fluid chemistry and processes at the Porgera gold deposit, Papua New Guinea: Mineralium Deposita, v. 32, p. 119-132. First author at Dept. of Geol., Univ. of Leicester, University Rd., Leicester, LE1 7RH, U.K.

The Porgera gold deposit in Papua New Guinea is a world-class example of an alkalic-type epithermal gold system (stage II), which overprints a precursor stage of magmatic-hydrothermal gold mineralization (stage I). Gas and ion chromatographic analyses of FI contained in vein minerals from both mineralization stages have been carried out, in order to constrain the compositions of the F involved in, and the processes attending, ore deposition. These data indicate the presence of three end-member L, the most dilute of which was present throughout the mineralization history and is interpreted to represent evolved groundwater of meteoric origin. Its composition is estimated to have been approximately 500 mM Na^+, 10 mM K^+, 5 mM Li^+, 250 mM Cl^-, 0.15 mM Br^-, and 0.01 mM I^-, plus significant concentrations of dissolved gases. More saline L were also present during the two main stages of ore formation, and although their compositions differ, both are interpreted to have been derived at least in part from magmatic F, and to have been the media by which gold was introduced into the system. Stage I minerals contain FI which decrease in sal toward this dilute end-member composition through the vein paragenesis, reflecting progressive dilution at depth of the magmatic F source by groundwaters. Ore deposition is thought to have been caused largely by simple cooling and/or wallrock reactions, although limited in situ F mixing may also have occurred. The most saline F, present in early quartz and pyrite, contain at least 810 mM Na^+, 530 mM Ca^{2+}, 130 mM K^+, 12 mM Li^+, 87 mM SO_4^{2-}, 960 mM Cl^-, 1.1 mM Br^-, and 0.05 mM I^-, plus significant but variable concentrations of dissolved gases. FI from stage II hydraulic breccia veins reveal the presence of two distinct L with contrasting sal, which were present at different times during vein formation. A higher sal L appears to have predominated during mineralization, whereas lower sal groundwaters filled the structures during intervening periods. The ore-forming F may have been forcibly injected into the veins from depth during fracturing and depressuration events, displacing the resident groundwaters in the process. The original composition of this F is estimated to have been at least 1770 mM Na^+, 59 mm K^+, 180 mM Li^+, 210 mM SO_4^{2-}, 680 mM Cl^-, 1.4 mM Br^-, and

0.09 mM I^-, plus 1.5 mol.% CO_2, 0.19 mol.% CH_4, and 0.04 nol.% N_2. Gas chromatographic analyses of FI from stage II samples show a decrease in total gas content between early unmineralized veins and post-mineralization vuggy quartz (suitable samples could not be obtained from the ore stage itself). Post-mineralization samples plot along an experimental gas-saturation curve in the CO_2-CH_4-H_2O-NaCl system, obtained at conditions similar to those attending stage II ore deposition at Porgera (200-300 bar, ~165°C). These results are interpreted to indicate a period of depressurization-induced phase separation during hydraulic fracturing which resulted in rich ore deposition. Volatile gases such as CH_4 and N_2, in addition to CO_2 in solution, are shown to have a significant negative effect on the total gas solubility. This effect may be of critical importance in lowering the T and increasing the depth (P) at which phase separation can occur in epithermal systems. (Authors' abstract)

RIDLEY, J.R. and **OJALA, V.J.**, 1997, Fluid pH estimation from nahcolite-bearing aqueous-carbonic inclusions, the example of the Granny Smith gold deposits, western Australia: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 284-285. First author at Inst. für Isotopengeologie und Mineralische Rohstoffe, ETH-Zentrum, CH-8092, Zürich, Switzerland; email (ridley@erdw.ethz-ch).

The estimation of the pH of the aqueous-carbonic low sal CO_2-H_2O-NaCl$\pm CH_4$ hydrothermal F that are typical of mesothermal gold deposits has generally been based on silicate-F equlibria and sal derived from FI microthermometric data with the assumption that halite is the dominant solute from the Granny Smith gold deposits. FI in quartz veins have variable L/V ratios. Estimated conditions of mineralisation are 325°C at 2 kbar. Within the aq-carbonic I, nahcolite ($NaHCO_3$) is a variably common dm (~5 vol.%). The recognition of nahcolite is based on laser Raman spectroscopy and from its low relief and high birefringence. Even where nahcolite is not present as a dm, the frequency of Te between -40 and -35°C suggests that bicarbonate or carbonate species are present in solution. The solubility of nahcolite allows an estimate of the total composition of the F, from which the pH at the conditions of entrapment are calculated to be around 6, hence slightly more alkaline than the average estimated for mesothermal gold-bearing hydrothermal F, and at the upper end of the range indicated by mineral equlibria. A number of implications of these calculations to gold-bearing systems are detailed. (From authors' abstract by E.R.)

RIGALI, M.J. and **NAGY, Bartholomew**, 1997, Organic free radicals and micropores in solid graphitic carbonaceous matter at the Oklo natural fission reactors, Gabon: Geochim. Cosmo. Acta, v. 61, no. 2, p. 357-368.

RIMSTIDT, J.D., 1997, Quartz solubility at low temperatures: Geochim. Cosmo. Acta, v. 61, no. 13, p. 2553-2558.

RIZZI, Giancarlo and **BRAITHWAITE, C.J.R.**, 1997, Sedimentary cycles and selective dolomitization in limestones hosting the giant Navan zinc-lead ore deposit, Ireland: Explor. Mining Geol., v. 6, no. 1, p. 63-77. Authors at Dept. of Geol. and Applied Geol., Univ. of Glasgow, G12 8QQ, Scotland.

The Navan zinc-lead ore deposit (70 million t) is hosted principally (97%) by a lower, mainly carbonate mudstone unit and an upper grainstone-dominated unit. The linear dolomite body has a flattened, laterally limited, tabular geometry in cross-section, suggesting that dolomitizing F initially rose vertically, cross-cutting stratigraphic and sedimentological boundaries, although F flow was subsequently controlled by these features.

Three stages of dolomitization are indicated by textural relationships, CL, oxygen isotopes, and FI data. Stage 1 crystals, with generally dully luminescing cores and up to six overlying subsidiary zones, are the main replacive phase. Crystal surfaces are commonly corroded and overlain by bright stage 2 rhombs (which also form new nuclei lining molds and fractures). Three subsets of zones are present in stage 2 crystals: bright, non-luminescent, and dull; these are locally separated by additional corrosion surfaces. Stage 3 comprises relatively large baroque crystals, generally dully luminescent but with up to seven sub zones. Isotopic and FI data suggest growth of successive stages from waters which became progressively hotter (60-160°C).

The distribution of the ores follows the dolomite trend. Ores were precipitated between stages 1 and 2 of dolomite growth, following stage 2, and also during the nucleation and growth of stage 3 crystals. Dolomitization and mineralization appear to have been temporally and genetically related. The cyclic sedimentation of the host rocks, which accentuates lithological and petrographical contrasts between depositional units, controlled dolomitization. The relationship between dolomitization and mineralization, which is closely associated with faults, provides powerful exploration criteria. The recognition of these features in limestones elsewhere in the Irish ore field may point toward unrecognized zinc-lead prospects. (From authors' abstract by E.R.)

ROBERTS, S.M., **SPENCER, R.J.**, **YANG, Wenbo** and **KROUSE, H.R.**, 1997, Deciphering some unique paleotemperature indicators in halite-bearing saline lake deposits from Death Valley, CA, U.S.A.: J. of Paleolimnology, v. 17, no. 1, p. 101-130.

Indexed under FI (E.R.)

RODGER, V.J., **WHITE, C.** and **PATTRICK, R.A.D.**, 1997, The mineralogy, textures and orefluids of the South Pennine orefield: Evidence from Milldam Mine (Laporte Minerals) (abst.): Mineral Deposits Study Group Annual General Meeting, Glasgow Univ., 1997, Programme and Abstracts Volume, p. xxx. First author at Univ. of Manchester, Oxford Road, Manchester, M13 9PL.

At Milldam Mine, an east-west trending mineral vein occurs in the Carboniferous limestone of the South Pennine Orefield. The mineralogy is principally fluorite, galena, baryte and calcite, with smaller amounts of pyrite, nickel-rich pyrite, chalcopyrite and sphalerite. First, there was diagenetic dolomitisation and silicification, followed by extensive fluoritisation of the limestones and calcite-pyrite precipitation in the interbedded volcanic tuffs, then the main mineralisation, followed by calcite and vein reopening. Several generations of distinct types of fluorite, baryte, calcite and pyrite formed, with many different mineral textures. There was both co-precipitation and sequential rhythmic precipitation of the major ore minerals into dissolution cavities in the host rocks. Precipitation of baryte, in particular, around brecciation clasts and other substrates resulted in spheroidal and colloform mineral growth.

FI yielded Th between 98.1 and 234.1°C. Sal in the range 18.90 to 25.87 eq. wt.% $CaCl_2$ were measured and $NaCl:CaCl_2$ ratios were low at 0.10 to 0.64.

These observations are consistent with previous work in other veins in the orefield and a similar genetic model is invoked. This proposes that $CaCl_2$-rich brines were expelled from the shale basins to the east, and possibly from the more distal North Sea Basin. The brines were pumped into the structural high of the South Pennines during the Variscan Orogeny. Precipitation of both sulphates and sulphides was a result of mixing of metalliferous brines, with some hydrocarbon content, with a sulphate formational F in the host limestones. (From authors' abstract by E.R.)

ROEDDER, E. and **BODNAR, R.J.,** 1997, Fluid inclusion studies of hydrothermal ore deposits, Chapter 13 in Geochemistry of Hydrothermal Ore Deposits, 3rd Ed., H.L. Barnes, ed., J. Wiley, p. 657-697.

Analytical aproaches to FI studies are systematically reviewed by Roedder and Bodnar. After briefly introducing the underlying assumptions and opportunities from FI studies, they systematically review approaches to the bulk and in situ analysis of I F by destructive and nondestructive techniques. Their emphasis is on the general approaches, advantages, and disadvantages of various techniques, not on results. Thus, they do not discuss extensively the methodology of observation, the physical chemistry of I F, or attempt to synthesize the observations that have been developed in the last 20 years. Other sources (e.g., Roedder, 1984, Reviews in Mineralogy, v. 12) remain necessary for systematic treatments of these topics. A concluding section touches on applications to exploration with the implicit but central message that FI observations should be a routine petrographic tool for everyone. (From review of volume by M.D. Barton, Econ. Geol., v. 93, no. 1, p. 108-110, 1998)

ROGGENSACK, Kurt, HERVIG, R.L., McKNIGHT, S.B., WILLIAMS, S.N., 1997, Explosive basaltic volcanism from Cerro Negro volcano: Influence of volatiles on eruptive style: Science, v. 277, p. 1639-1642. First author at Dept. of Geol., Box 871404, Arizona State Univ., Tempe, AZ 85287-1404, USA.

The 1992 and 1995 basaltic eruptions of Cerro Negro volcano, Nicaragua, had contrasting eruptive styles. Although they were nearly identical in composition, the 1992 eruption was explosive, producing a 7-kilometer-high sustained ash column, whereas the 1995 eruption was essentially effusive. The differences in water and carbon dioxide contents of M I from the two eruptions define minimum saturation P and show how decompression of initially similar magmas influences eruptive style. Before eruption, the explosive 1992 magma retained water and carbon dioxide while ascending to a moderate crustal level (about 6 kilometers), whereas the nonexplosive 1995 magma lost all carbon dioxide by degassing during ascent to shallow crustal levels (about 1-2 kilometers). (Authors' abstract)

RONCHI, L.H. and **BENY, Claire,** 1997, Raman spectroscopy; applications in geology and limitations: Acta Geologica Leopoldensia, v. 44, p. 5-25 (in Portugese).

A review (E.R.)

ROSENBAUM, J.M., 1997, Gaseous, liquid, and supercritical fluid H_2O and CO_2: Oxygen isotope fractionation behavior: Geochim. Cosmo. Acta, v. 61, no. 23, p. 4993-5003.

ROTHERHAM, J.F., 1997, Fluid conditions of post-metamorphic ironstones and mineralisation at the Starra Au-Cu deposit, Cloncurry district: Geological Society of Australia, Abstracts No. 44, p. 62. Author at Nat'l. Key Centre for Economic Geol. and Dept. of Earth Sci., James Cook Univ., Townsville, Queensland, 4811.

The Proterozoic Starra ironstone-hosted Au-Cu deposit (7.4 Mt @ 3.8 g/t Au and 1.9% Cu) is located in the Cloncurry district, approximately 160 km southeast of Mount Isa. It is hosted within the amhibolite-grade Staveley Formation [ironstones] of the Mary Kathleen Group, which has undergone several intense alteration episodes.

Three paragenetic stages are recognised: 1) Na-Ca metasomatism (quartz-albite-actinolite-scapolite), 2) K-Fe metasomatism (biotite-quartz-magnetite-hematite) and 3) mineralisation (sulphates, calcite, hematite, gold, sulphides, chlorite, muscovite). Microthermometric analyses show four dominant types of I are present from stage 2 and stage 3 (Table 1). Type 1 are almost pure CO_2, V-rich I which have high densities (0.72-1.0 g/cm^{-3}) and represent separation of immiscible hypersaline brine and CO_2-rich components. Type 2 I are closely associated with type 1 and are multiphase [They show halite, magnetite, calcite, and other dms, Th 345-615°C, sal 34-52 wt.% NaCl]. (Table 1). Type 3 I are 2-phase, L-rich±solid. [They show a small halite dm and have sal 8-27% NaCl]. Type 4I are multiphase (up to 6 solids). [They have Th 225-360°C and sal 30-42 wt.% NaCl.] Type 1 and 2 I are hosted within stage 2 quartz associated with the ironstones and type 3 and 4 I are hosted within stage 3 quartz associated with the mineralisation. The calculated $\delta^{18}O$ F composition from magnetite-quartz isotope pairs representing stage 2 imply waters of 7.8‰ and from hematite-calcite isotope pairs representing stage 3 imply waters of 9.5‰. The data suggest the ironstones formed from a probably magmatic, saline (34-52 wt.% NaCl eq.) F that reached T of 600°C. The later mineralising F is also consistent with a dominantly magmatic, saline (30-42 wt.% NaCl eq.) character and reached T of 360°C. The variation (number and composition) of dm within the two types of multiphase I suggest stage 2 and 3 F were different. (From author's abstract by E.R.) *See figure on page 239.*

RUB, M.G. and **ASHIKHMINA, N.A.,** 1997, Silver-bearing volcanoplutonic associations of the southern Primorsk region: Compositional features: Dokl. Ross. Akad. Nauk, v. 355, no. 1, p. 97-100 (in Russian, translated in Trans. (Dokl.) of the RAS/Earth Sci. Sections, v. 355, no. 5, p. 769- xxx). Authors at Inst. of Geol., of Ore Deposits, Petrog., Mineral., and Geochem. (IGEM), RAS, Staromonetnyi per. 35, Moscow, 109017 Russia.

The volcanoplutonic association studied is a member of the Paleogene volcanotetonic structure imposed on Cretaceous mesozoides of the Pacific mobile belt. The silver mineralization is represented by quartz-adular veins with silver sulfosalts, Au-Sn-bearing quartz-base metal veins, and other mineral types.

MI in quartz and sanidine from the rhyolites and sanidine granite porphyries begin to melt at 680-700°C. At T of about 720-750 and 830°C, the crystalline phases of I begin to melt, while complete homogenization occurs at 910-980°C.

The melting T of the mineral phases from M I observed in the quartz phenocrysts in granite porphyries is 730°C. Full homogenization occurs at 780°C. A gas bubble from these I contains a condensate, which freezes at 58±5°C [sic]; it presumably is CO_2. (From authors' text by E.R.)

RUGGIERI, Giovanni and **GAROFALO, Paolo,** 1997, Thermal variations in the Tendaho geothermal field (Ethiopia): Evidences from fluid inclusion data: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 286-287. First author at Inst. Internazionale per le Ricerche Geotermiche, 2 Piazza Solferino, 56126, Pisa, Italy; email (ruggieri@iirg.pi.cnr.it).

Four geothermal wells have been drilled. The basaltic and part of the sedimentary rocks sampled in the wells are hydrothermally altered. The main mineralogy of the hydrothermal phase includes clay minerals (mainly chlorite and vermiculite), zeolites (laumontite, stilbite, wairakite and heulandite), quartz, calcite, epidote, garnet, prehnite and pyroxene. Calcite and chlorite are ubiquitous in most parts of the wells. FI in quartz, calcite and laumontite crystals are mostly two-phase L-rich aq I; V-rich I were observed very rarely. A table lists Tm ice, Th, and the present-day in-hole T (Tms). Assuming hydrostatic P, the applied P correction is modest (<7°C). Sal are considered apparent, as the possible presence of dissolved CO_2 in the F depresses Tm ice. From the comparison between FI mean Th and present-day Tms it was possible to obtain some information on the thermal evolution of the wells. In part there has been heating since FI formation, and in others, cooling. Some FI in calcite probably indicate that stretching phenomena affected most of these I. (From authors' abstract by E.R.)

RUGGIERI, Giovanni, LATTANZI, Pierfranco, LUXORO, S.S., DESSÌ, Roberto, BENVENUTI, Marco and **TANELLI, Giuseppe,** 1997, Geology, mineralogy, and fluid inclusion data of the Furtei high-sulfidation gold deposit, Sardinia, Italy: Econ. Geol., v. 92, no. 1, p. 1-19. First author at Inst. Internazionale per le Ricerche Geotermiche, CNR, Piazza Solferino 2, 56100 Pisa, Italy.

The epithermal high-sulfidation Au-Ag-Cu deposit at Furtei occurs where hydrothermal circulation affected most of a volcano-sedimentary sequence over an area of about 5 km^2. Early hydrothermal activity was responsible for the acid alteration typical of high-sulfidation deposits, with formation of four hypogene alteration types of decreasing intensity. The ore stage clearly postdates hydrothermal alteration. FI indicate that the F present at the time of alteration and epithermal mineralization had T generally between 190 and 280°C and relatively low sal (max 5.5 wt.% NaCl eq.). The local coexistence of L- and V-rich I suggests boiling conditions. The I were trapped at depths of between 60 and 680 m below the water table. The occurrence of high-sal (31.5-44.8 wt.% NaCl eq.), high-T (390-500°C) I on cataclastic hydrothermal quartz suggests that a dense brine of probable magmatic derivation circulated in the Furtei system. This is consistent with geophysical data suggesting the presence of an intrusion at approximately a 1- to 1.5-km depth. A few relatively high-sal (around 22 wt.% NaCl eq.), low-T (255-275°C) I may be the result of episodic mixing of deep-saline brines with low-sal meteoric F. Late-stage barite contains low-sal (<1.6 wt.% NaCl eq.), low-T (around 100°C) FI. (From authors' abstract by E.R.)

RUSSELL, D.W. and **van MOORT, J.C.,** 1997, EPR as an exploration tool to assess quartz reefs, Beaconsfield Gold Mine, Tasmania, Australia: Modern Applications of EPR/ESR, Proceedings of the First Asia-Pacific EPR/ESR Symposium, Hong Kong, 20-24 Jan, 1997, Rudowicz, C.A., editor. First author at Geol. Dept., Univ. of Tasmania, GPO Box 252-79, Hobart, Australia.

A study of 307 quartz samples from the Beaconsfield goldfield indicates that the intensity of the $[AlO_4]^-$ EPR centre, determined at room T, can be used to separate reef quartz from barren quartz. (Authors' abstract)

Of possible interest to correlate with FI populations (E.R.).

RYAN, C.G., KHIN Zaw, HEINRICH, C.A., JAMIESON, D.N. and **ACHTERBERGH, E. van,** 1997, Probing ore forming processes using the scanning proton microprobe, abst.: Geological Society of Australia, Abstracts No. 44, p. 63. First author at GEMOC and CSIRO Exploration and Mining, P.O. Box 136, North Ryde NSW 2113, Australia.

The large penetration depths and predictable nature of MeV proton trajectories has permitted the development of standardless quantitative methods for microanalysis of minerals at ppm levels, trace-element imaging and non-destructive analysis of individual FI, all of which offer particular benefits to ore-formation reserach. By modeling Proton Induced X-ray Emission (PIXE) yields from the complex 3D geometry of an I in its host mineral, and by using beam-scanning to control the proton dose distribution across an I, the CSIRO method enables quantitative analysis of FI of 5-20 µm in diameter with sensitivities for the ore elements down to 40 ppm in the F (Ryan et al., 1995).

Research at the CSIRO is focused on the analysis of ore elements in F and experimental studies. Much of the work is centred on the analysis of hydrothermal F associated with copper-gold deposits. A good example is the Kidston granite-related breccia gold-copper deposit in North Queensland, Australia. Brine and V I show strong partitioning of Cu into the V phase and the presence of S in the V (Fig 1). This, and other work, suggests that brine-V segregation of trace metals, and transport in the V phase, plans an important role in Cu (and Au) deposit formation (Heinrich et al., 1993). (From authors' abstract by H.E.B.) *See figure on page 236.*

RYZHENKO, B.N., BARSUKOV, V.L. and **KNYAZEVA, S.N.,** 1997, Chemical characteristics (composition, pH, and eH) of the rock-water system: II. Diorite (andesite)–water and gabbro (basalt)–water systems: Geokhimiya, 1997, no. 12, p. 1227-1254 (in Russian; translated in Geochem. Internat'l., v. 35, no. 12, p. 1089-1115). Authors at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, ul. Kosygina 19, Moscow, 117975 Russia.

Computer simulation of the interaction (at T of 25-800°C and P of 0.001-5 kbar) between water and rocks of intermediate and basic composition (diorite and gabbro) without Cl, S, and C or with their contents at the background level demonstrates that the water phase in non-variant equilibria in these systems is alkaline (with a minimum in the pH value occurring at ~400°C). The total sal of the solutions increases with increasing T. In systems with carbon, the F is enriched in CO_2 at high T and possibly separates into immiscible CO_2-rich and H_2O-rich phases. In addition to the seven redox buffers described in the system granitoids–water, a series of potential-controlling buffer reactions is considered in the diorite-water and gabbro-water systems. Unlike the situation with acid rocks, these reactions in the latter systems are controlled only by the Fe(II)-Fe(III) equilibrium. A characteristic feature of these reactions, which is important for the Earth crust as a whole, is that they necessarily involve solid phases without elements of varying valence (a condition required by mass balance in the systems). (Authors' abstract)

RYZHENKO, B.N., SHVAROV, Yu.V. and **KOVALENKO, N.I.**, 1997, The Sn-Cl-F-C-S-H-O-Na system: Thermodynamic properties of components within the conditions of the Earth's crust: Geokhimiya, 1997, no. 11, p. 1149-1153 (in Russian; translated in Geochem. Internat'l., v. 35, no. 11, p. 1016-1020). First author at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, ul. Kosygina 19, Moscow, 117975 Russia.

SAAL, A.E., HART, S.R., SHIMIZU, N. and **HAURI, H.**, 1997, Carbonate-bearing melt inclusions from Mangaia lavas (Austral Islands): 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F838. First author at Dept. of Geol., Woods Hole Oceanographic Inst., Woods Hole, MA 02543; email (saal@mit.edu)

The existence of carbonate-rich M in the source of the Austral Islands magmas has been suggested largely based on indirect evidence. Direct evidence for P carbonate M in peridotite xenoliths or in basaltic rocks has never been reported. Preliminary petrographic and geochemical data of MI in olivine and clinopyroxene from two lavas from Mangaia show evidence for quenched carbonate M considered to be of P origin. The MI are partially crystallized and ellipsoidal in shape, 30 to 300 m [µm?] in the longest dimension, indicative of the P nature of the I. Post-entrapment crystallization produced Ti-augite (surrounded by kaersutite), sphene, ilmenite, high-Cr spinel, apatite and biotite, associated with silica-alumina-alkali-rich glasses, hydrous and/or carbonated magnesio-iron-rich silicate glasses, FeCuNi-sulfide globules and magnesio- and ferro-carbonate M. REEs in the MI show $(La/Yb)_{CN}$ ranging from 6 to 40 (compared to whole rocks usually having ratios of ≈10), with concentrations of La and Yb ranging from 90 to 1000 and 10 to 30 times chondrite, respectively. Partially resorbed clinopyroxene I in the olivine also occur, and their LREE concentrations are indicative of crystallization from LREE-enriched M. The observed mineral associations, mineral and M compositions, and textures in the MI are essentially the same as those described for carbonate-silicate M pockets in carbonated peridotitic xenoliths, and provide direct evidence for a carbonated mantle source for the Austral Island basalts. (From authors' abstract by E.R.)

SACHAN, H.K., BODNAR, R.J., SZABO, Cs, ISLAM, R. and **LAW, R.D.**, 1997, Low temperature high pressure eclogites from eastern Ladakh Himalayas (India): Evidence from mineral chemistry and fluid inclusions: Eos Trans. AGU v. 78 (17), Spring Meet. Suppl., p. S328. First author at Wadia Inst. of Himalayan Geol., Dehra Dun 248001 India and Dept. of Geological Sci., Viginia Tech, Blacksburg, VA 24061; email (geomail1@vt.edu)

A new discovery of eclogites in the Ladakh region (India) provides exceptional insights into the metamorphic evolution of the continental-type tectonic units in the eastern Himalayas.

Garnet-clinopyroxene and garnet-phengite thermometers indicate T of eclogitization in the range 420 to 590°C for garnet cores and 500 to 610°C for garnet mantles. Based on the jadeite content of omphacite, the minimum P is estimated to be 12-15 kbars. Two-phase P aq FI occur in clinopyroxenes and amphiboles. The I in clinopyroxenes homogenize to the L phase at 310 to 370°C, while those in amphibole homogenize at 260 to 280°C. I in both phases show initial melting T of -23 to -21°C. Ice melting T for I in clinopyroxene range from -10 to -7°C, while I in amphibole melt at -8 to -5°C. Average sal for clinopyroxene and amphibole are 13 and 10 wt.% eq. NaCl, respectively.

Based on mineral chemistry, textural evidence and FI data, three sequential metamorphic stages in formation of Himalayan subduction complex can be distinguished: 1) eclogitization of the protolith during subduction of the northeastern Indian continental margin); 2) blueschist retrograde metamorphism with simultaneous F invasion; and 3) greenschist retrograde metamorphism. We relate the blueschist and greenschist metamorphic events to uplift of the Himalayas. (From authors' abstract by E.R.)

SACHAN, H.K., BODNAR, R.J., SZABO, Cs., LAW, R.D. and **ISLAM, R.**, 1997, Fluid-assisted formation of eclogites from the western Himalaya (India): Exhumation history of subducted continental crust (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-398. Authors at Fluids Research Laboratory, Dept. of Geological Sci., Virginia Tech, Blacksburg, VA 24061.

The eclogites consist mostly of almandine-rich garnets, omphacite clinopyroxene, amphibole, phengite, rutile±zoisite±quartz.

Application of garnet-clinopyroxene thermometry indicates T of eclogitization in the range 530 to 580°C. Minimum P, estimated on the jadeite content of omphacite, ranges from 12 to 15 kbars. Two-phase P aq FI in clinopyroxenes and apatites homogenize in the range 266 to 367°C. The I contain no detectable gases and have sal of about 10 wt.% eq. NaCl.

Based on mineral chemistry, textural evidence and FI, data, the exhumation history of subducted continental crust occurred in two phases. The first isothermal phase exhumed the eclogites from a depth of 60 to 10 km, and was accompanied by the development of symplectite and zoned amphiboles of variable composition. The second phase of exhumation was along a more normal geothermal gradient which uplifted the eclogites to the near-surface environment. The occurrence of P aq I in the peak metamorphic minerals documents the presence of water-rich F associated with eclogitization. The FI also served as an internal source of F that promoted the formation of symplectites and lower-grade amphiboles during exhumation. (From authors' abstract by E.R.)

SACKETT, W.M. and **CONKRIGHT, M.E.**, 1997, Summary and re-evaluation of the high-temperature isotope geochemistry of methane: Geochim. Cosmo. Acta, v. 61, no. 9, p. 1941-1952. First author at Dept. of Marine Sci., Univ. of South Florida, St. Petersburg, FL, U.S.A.

Data are also summarized for the thermal destruction of methane and carbon isotope exchange between methane and amorphous carbon and carbon dioxide. The latter results are important when determining the source of methane in hydrothermal F. (From authors' abstract by E.R.)

SAKAGUCHI, A., 1997a, Water-rich and methene-rich fluid [sic] circulation and P-T history in the Shimanto accretionary complex, SW Japan (abst.): Geol. Soc. Japan Annual Meeting, Fukuoka, Oct. 10-12, Program, p. 49 (in Japanese).

SAKAGUCHI, A., 1997b, Deformation and diagenesis in the Yokonami melange, Shimanto accretionary complex, Shikoku, Japan: (abst.): Geol. Soc. Japan Annual Meeting, Fukuoka, Oct. 10-12, Program, p. 122 (in Japanese).

SALVI, Stefano and WILLIAMS-JONES, A.E., 1997a, Fluid-inclusion volatile analysis by gas chromatography: Application of a wide-bore porous-polymer capillary column to the separation of organic and inorganic compounds: The Canadian Mineralogist, v. 35, p. 1391-1414. First author at Laboratoire de Minéralogie, Univ. Paul-Sabatier, 39, allées Jules-Guesde, F-31000 Toulouse, France.

Gas chromatographic analyses of the volatile content of FI were carried out using a recently developed PoraPLOT® Q mega-bore capillary column (25 m X 0.53 mm, 20 µm film thickness, fused silica) and on-line crushing techniques during heating. For comparison, analyses were also conducted with a HayeSep® R packed column (10' X 1/8" 120 mesh, Ni alloy tubing), which is the column most widely used for the analysis of I gases. The wide-bore PoraPLOT® Q capillary column is ideally suited for analyses at relatively high flow-rates needed in processing FI gases released into the gas chromatograph by on-line crushing. This column proved superior to the packed column in that it reduced retention times by at least half, allowed clean separation of N_2, CO_2, CH_4, and higher hydrocarbons up to at lest C_6 paraffins, and greatly improved detection and accuracy of analyses for H_2O. Furthermore, using N_2 as a carrier gas, it is possible to analyze for Ar and H_2 to ~10^{-4} µmoles and ~10^{-5} µmoles, respectively. The latter gas could not be analyzed with the packed column. Optimum conditions were found to be a carrier-gas flow of 20 mL/min, and an oven T programmed to start at -20°C, subsequently raised (10°C/min) to 35°C and held for 10 min, then again raised (5°C/min) to 115°C. Runs lasted ~80 min. The PoraPLOT® Q capillary column was used to measure the composition of carbonic FI in the peralkaline granite at Strange Lake, Quebec-Labrador. These I were shown to contain heavy aliphatic hydrocarbons in proportions consistent with their production via a Fischer-Tropisch reaction involving Fe-oxide-catalyzed hydrogenation of magmatic CO_2 and CO. (Authors' abstract)

SALVI, Stefano and WILLIAMS-JONES, A.E., 1997b, Fischer-Tropsch synthesis of hydrocarbons during sub-solidus alteration of the Strange Lake peralkaline granite, Quebec/Labrador, Canada: Geochim. Cosmo. Acta, v. 61, no. 1, p. 83-99. First author at Dept. of Earth and Planet. Sci., McGill Univ., Montreal, Quebec H3A 1A7, Canada.

The composition of the carbonic phase(s) of FI in pegmatite quartz from the Strange Lake peralkaline complex has been analysed by gas chromatography using on-line extraction of I contents and a PoraPLOT® Q capillary column. The measured gas species are, in order of abundance, CH_4, H_2, C_2H_6, CO_2, N_2, C_3H_8, n-C_4H_{10}, n-C_5H_{12}, C_2H_2, i-C_4H_{10}, and C_2H_4. Minor amounts of i-C_5H_{12}, n-C_6H_{14}, i-C_6H_{14}, and neo-C_6H_{14} were also detected (but not quantified) in some samples. A suite of quartz samples from Ca-metasomatised pegmatites contains FI with a similar distribution of hydrocarbons but much higher proportions of CO_2.

The carbonic F coexisted immiscibly with a brine (Salvi and Williams-Jones, 1992), which on the basis of field and petrographic evidence, was interpreted to have originated from the magma. However, thermodynamic calculations indicate that the above gas species, specifically the hydrocarbons, could not have coexisted at equilibrium in the proportions measured, at any geologically reasonable conditions either prior to or post entrapment. We propose, instead that the gas compositions measured in the Strange Lake I, and in I from other alkalic complexes, resulted from the production of H_2 during the alteration of arfvedsonite to aegirine, and the subsequent reaction of this H_2 with orthomagmatic CO_2 and CO to form hydrocarbons in a magnetite-catalysed Fischer-Tropsch synthesis. Locally, influx of an oxidised calcic brine, derived externally from the pluton, altered the original composition of the F by converting hydrocarbons to CO_2. (Authors' abstract)

SALVI, Stefano and WILLIAMS-JONES, A.E., 1997c, Analyses of volatiles in fluid inclusions by gas chromatography: Applications to the origin of reduced gases in alkaline rocks: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 288-289. First author at Laboratoire de Minéralogie, 39 allès Jules-Guesde, F-31000 Toulouse, France; email (salvi@lucid.ups-tsle.fr).

A gas chromatographic system for on-line analysis of FI, based on the design developed by Bray and Spooner is described. The optimal conditions for analyses were established. We were also successful in analyzing H_2 and Ar, using N_2 as the carrier gas. Detection limits are ~10^{-5} µmoles for H_2, and ~10^{-4} µmoles for Ar. Reduced carbonic species are commonly reported from IF in silica-undersaturated alkaline rocks and in peralkaline granites. These F are rich in CH_4 and H_2, contain heavier alkanes, and may contain significant N_2, CO_2, CO, and aromatic hydrocarbons. The origin of these F is a matter of considerable debate.

In the Strange Lake peralkaline granite. Quebec/Labrador, pegmatites and adjacent altered granites contain immiscible aq and carbonic FI. Analysis showed methane, hydrogen, and heavier hydrocarbons (in decreasing order of abundance, C_2H_6 to C_6H_{14}). Thermodynamic calculations in the system C-O-H show that the hydrocarbons could not have co-existed at equilibrium in the proportions measured, either prior to or after entrapment. We propose that these reflect the reaction of H_2 with orthomagmatic CO_2 and CO to form hydrocarbons by disequilibrium reactions. We propose that the H_2 was produced during subsolidus alteration of arfvedsonite to aegirine, magnetite and quartz, and that magnetite produced by this alteration catalyzed the hydrocarbon synthesis. (From authors' abstract by E.R.)

SAMSON, I.M., BAS, Bulent and HOLM, P.E., 1997, Hydrothermal evolution of auriferous shear zones, Wawa, Ontario, 1997: Econ. Geol., v. 92, p. 325-342. Authors at Dept. of Earth Sci., Univ. of Windsor, Windsor, Ontario, Canada N9B 3P4.

Deformation zones in the southwestern portion of the Archean Michipicoten greenstone belt host a large number of quartz vein systems, some of which contain small gold deposits. A wide variety of FI types is present within the quartz veins. Aq and aq-carbonic I occur in all vein sets. The former have sal ranging from 0 to 23 wt.% NaCl eq. and the later have XCO_2 values values ranging from 0.05 to 0.26 (mode ~0.1) and CO_2/CH_4 ratios of between 0.68 and 1. Nahcolite-bearing aq and aq-carbonic I with high CO_2/CH_4 ratios and moderate sal (5-18 wt.%) are only present in vein sets 1 and 2, as are carbonic I (with little or no H_2O) with CO_2/CO_2+CH_4 ratios ranging from 0 to 1.

Data from FI distributions, microthermometry, Raman spectroscopy, and quadrupole mass spectrometry indicate that F sal decreased and that the CO_2/CH_4 ratios of the F increased with time. Of the F identified, the earliest were high-sal (>18 wt.%) aq F and CH_4-rich aq-carbonic and carbonic F. These F are restricted to vein set 1 in the best mineralized system studied, the Surluga deposit, and are the most likely candidate for the mineralizing F. Local water-rock interaction cannot explain the presence of CH_4 and requires initially low fO_2 or water-carbon reactions at some depth below the deposit. Methane-rich F appear to be absent from poorly mineralized or barren veins. Moderate sal (avg ~11 wt.%) HCO_3^--rich, CH_4-poor aq and aq-carbonic F infiltrated the deformation zones after the formation of vein set 2 and are probably related to Proterozoic carbonatitic-lamprophyric magmatism. Stage 3 veins were formed from low-sal aq-carbonic F. There is evidence of F immiscibility in all stages except the last stage of hydrothermal activity. (From authors' abstract by E.R.)

SAMSON, I.M. and **WILLIAMS-JONES, A.E., OLIVO, G.R.**, 1997, Genesis of the Gallinas Mountains REE-fluorite deposits, New Mexico: Evidence from mineral paragenesis and fluid inclusions (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A130. First author at Dept. of Earth Sci., Univ. of Windsor, Windsor, ON N9B 3P4.

The Gallinas Mountains deposits represent a rare example of breccia-hosted, hydrothermal, REE-fluorite mineralization. The deposits are closely associated with hypabyssal, Oligocene, trachytic intrusions which have been emplaced into a sequence of Permian siliciclastic rocks. Bastnaesite is the principal REE mineral and is disseminated through the matrix of fluorite-cemented intrusive breccia pipes and sandstone-hosted fault breccias. Other minerals in the breccia matrices include quartz, barite, celestite and hematite-goethite (after pyrite). Textural relationships indicate a paragenetic sequence in which quartz was the first mineral to precipitate, followed sequentially by the deposition of bastnaesite, fluorite, Ca-bastnaesite, and barite. Up to three types of fluorite are present. The earliest fluorite in the breccia pipe deposits comprises euhedra up to 1 cm in diameter. These are overgrown and replaced by a FI-rich fluorite, which in turn is cemented by fine-grained, purple fluorite.

Primary FI in quartz and bastnaesite consist dominantly of aq L, along with a V phase and one to three small solids (LVS). Similar P LVS I occur in early fluorite, but are accompanied by P LVS I in which solids occupy most of the I volume. In a significant proportion of the latter I, gypsum is the largest solid. Later fluorite and barite only contain aq, L-V I (LV). Quartz-hosted I homogenize at the highest T, mainly between 300 and 400°C, followed by bastnaesite (250-350°C), early fluorite (120-300°C) and later phases (80-150°C). LVS I in quartz display a narrow range of sal (14-16 eq. wt.% NaCl), whereas sal of both LVS and LV I in later minerals (bastnaesite and all fluorites) range to slightly higher values (14-19.5 eq. wt.% NaCl).

A model is proposed in which the trachytic magmas exsolved an aq phase, rich in F and REE and essentially Ca-free, which precipitated quartz and bastnaesite in response to cooling. Mixing with Ca and sulphate-bearing formational waters is thought to have caused the precipitation of fluorite and barite, respectively, along with the observed sal increase. (Authors' abstract)

SAMUELSSON, Jorgen, 1997, Petroleum potential and thermal history of the Caledonian foreland basin, Sweden: Master's degree, Dept. of Geol., Chalmers Univ. of Tech., Goteborg, Sweden, 61 pp.

Indexed under FI (E.R.)

SASADA, T., HIYAGON, H., BELL, K., EBIHARA, M., 1997, Mantle-derived noble gases in carbonatites: Geochim. Cosmo. Acta, v. 61, no. 19, p. 4219-4228. First author at Earthquake Research Inst., Univ. of Tokyo, Bunkyo-ku, Tokyo, 113, Japan.

Isotopic compositions of the noble gases (He, Ne, Ar, Kr, Xe) were obtained by stepwise heating of separated mineral phases from carbonatites. Mineral phases used were apatite, forsterite, diopside, calcite, monticellite, and perovskite. Large amount of in situ produced ^{238}U-fissiogenic $^{131-136}Xe$, along with lesser amounts of ^{238}U-fissiogenic $^{83-86}Kr$ and in situ ^{4}He were found in most samples. Some samples, mostly apatites, showed excess ^{129}Xe relative to air, considered to be primordial and attributed to now extinct nuclide ^{129}I once present in the early history of the Earth.

Neon isotopic compositions were also anomalous and are attributed to Wetherill reactions, such as $^{18}O(\alpha,n)^{21}Ne$, $^{19}F(\alpha,n)^{22}Na(\beta+)^{22}Ne$, and so on. The measured $^{40}Ar/^{36}Ar$ ratios are extremely variable and range from values that are close to atmospheric to values as high as 42400. The presence of excess ^{129}Xe in carbonatites suggests that carbon in carbonatites is unlikely to be recycled C related to subduction processes. (From authors' abstract by E.R.)

SASAKI, K. and **NAKAJIMA, K.**, 1997, Gas composition of fluid inclusions in the Tono and Kurihashi granitic rocks and their contact metamorphic zones, Kitakami mountains (abst.): Abstracts of 1997 Japan Earth and Planetary Sci. Joint Meeting, March 25-28, 1997 at Nagoya Univ., (in Japanese, translated by T. Sawaki).

The authors chemically analyzed FI from the Tono granite, and from quartz veins and aplites in marginal parts of the Kurihashi granite and surrounding sedimentary rocks (hornfels), in order to establish the change of chemical composition of F during magmatic differentiation and the role of F in contact metamorphism. Quartz crystals of 0.05-0.1 mm in size were separated from the samples, and they were crushed by piston cylinders for extraction of G in FI. The extracted G were analyzed by a G chromatography, and H_2, CH_4, CO_2 and CO were detected. The central part of the Tono granite is more felsic than the marginal part. CO_2 contents and CO_2/CH_4 ratios of FI increase from the marginal part to the central part although CH_4 contents do not change. CO_2/CH_4 ratios from southern and western marginal parts are 20-180 and 290, respectively. Rock facies of the south marginal part is different from that of the western part, and the difference of the rock facies may reflect the difference of chemical composition of FI. In the Kurihashi granite, CO_2/CH_4 ratios of I from granite, aplites and quartz veins are 20-80, 50-110 and 10-20, respectively. CO_2 contents of I from the granite increase with elevation of sampling points. (Authors' abstract)

SASAKI, K., NAKAJIMA, K. and **KANISAWA, S.**, 1997, Contact metamorphism and metamorphic fluids in the Kurihashi contact metamorphic zone, Kitakami Mountains (abst.): Program, 1997 Ann. Meeting Min. Soc., Japan/Jap.Assoc., Min., Pet., and Econ. Geol., p. 224 (in Japanese, translated courtesy of T. Sawaki).

In general, F infiltration is thought to influence metamorphism. The authors studied relations between chemical compositions of F and metamorphism by gas analyses of intergranular and I F of hornfelses.

In the Kitakami Mountains, Tohoku district, Japan, there are many Cretaceous granitic bodies of magnetite-series, with accompanying contact aureoles. Psammitic, pelitic, tuffaceous, basaltic, andesitic, siliceous and calcareous rocks are thermally metamorphosed around the Kurihashi granite, one of the granitic bodies. The maximum metamorphic T at the immediate contact between the granite and the hornfelses are estimated at 740-770°C.

The hornfelses crushed to 0.5-1.0 mm size was used for gas analyses. Gases extracted by crushing the samples at 80°C were introduced into a gas chromatograph, and CH_4 and CO_2 contents were determined. As the results, CO_2 contents of calcareous rocks and pelitic rocks bearing calcite veins were much higher than those of other pelitic rocks. This indicates that F from which calcite precipitated during metamorphism were enriched in CO_2. On the other hand, CH_4 contents of pelitic rocks with neither calcite nor quartz veins were higher than CO_2. These rocks contain graphite, and metamorphic F were probably under reduced conditions. CO_2/CH_4 ratios of F in pelitic rocks increased toward the granitic body. This may be attributed to oxidization of metamorphic F:F of fO_2 lower than the QFM-buffer system were oxidized by the Kurihashi granite of magnetite-series. (Authors' abstract)

SASAKI, M., FUJIMOTO, K., TAKAHASHI, M., HARAYAMA, S., SATO, T. and **MAEKAWA, T.**, 1997, A report on hydrothermal alteration at Iwozawa, Ohmachi, Nagano Prefecture: (abst.): Geothermal Research Soc. Japan Ann. Meeting, Oct. 6-8, 1997, Sapporo Program, unpaginated, No.P18 (in Japanese).

SATO, Hisao, YAMAGUCHI, Yoshiaki and **MAKINO, Kuniaki**, 1997, Cl incorporation into successively zoned amphiboles from the Ramnes cauldron, Norway: American Mineralogist, v. 82, p. 316-324. Authors at Dept. of Geol., Faculty of Sci., Shinshu Univ., Asahi, Matsumoto 390, Japan.

Amphibole from alkali granites in the Ramnes cauldron in the Oslo rift was altered hydrothermally by corrosion and growth through multiple events of F circulation. The alteration developed successive zones of amphibole at the crystal margins, with Cl contents ranging up to 2.96%, and suggesting different F conditions in chemistry and T for the three zones. The zoning was developed through two stages of hydrothermal alteration. In the early hydrothermal event, a saline and high-T F altered the original hornblende to the Cl-rich zone. Late stage alteration by a high Fe/Cl and relatively low-T F partially overprinted the zone at the crystal margin. (From authors' abstract by E.R.)

SAUSSE, Judith, JACQUOT, Emmanuel, FRITZ, Bertrand, LEROY, J.L. and **LESPINASSE, Marc**, 1997, Evolution of the fissural permeability during fluid-rock interactions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 290-291. First author at Univ. Henri Poincaré-Nancy 1, UMR EP 578, BP 239, 54506 Vandœuvre-lès-Nancy cedex, France; email (sausse@lpesh.u-nancy.fr).

The FIP are the witnesses of fossil F flows and their study can lead to the quantification of a fossil permeability. Thereby it is important to know what can be the influence of water-rock exchanges on this parameter. A simulation of the percolation of a meteoric F through cracks in a granitic rock is thus performed using computer codes. The evolution of the rock mineralogy and permeability is characterized with time. This simulation indicates that under meteoric conditions, an alteration paragenesis in a granite can develop in 23 years, and during this alteration, the fissural permeability is increased +40 % in the most altered blocks. (From authors' abstract by E.R.)

SAVARY, V., DUBOIS, M., LEDÉSERT, B, YARDLEY, B.W.D. and **ROYER, J.-J.**, 1997, History of fluid circulation in an alteration zone of the Soultz-sous-Forêts granite (Alsace, France): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 292-293. First author at CRPG/CNRS, 15 rue N-D des Pauvres, BP 20, 54501 Vandœuvre-lès-Nancy, France; email (vsavary@crpg.cnrs-nancy.fr).

The Soultz-sous-Forêts area (Alsace, France), a pilot site for geothermal "Hot Dry Rock" exploitation, is characterized by a high surface heat flow induced by circulations of hot F percolating through the thick (1 to 3 km) sedimentary cover and monzo granitic basement (Soultz granite).

FI in two generations of quartz in a highly altered core (3469 m) showed Tt of ~154±3°C, in agreement with present borehole T, for one generation and not for another. This latter difference could be from deep penetration of surface waters. (From authors' abstract by E.R.)

SAVARY, Véronique and **PAGEL, Maurice**, 1997, The effects of water radiolysis on local redox conditions in the Oklo, Gabon, natural fission reactors 10 and 16: Geochim. Cosmo. Acta, v. 61, no. 21, p. 4479-4494. Authors at CREGU and G.R. CNRS-CREGU, B.P. 23, 54501 Vandœuvre-lès-Nancy Cédex, France.

In an area where the fission zone 10 is in contact with sandstones devoid of organic matter, H_2O-H_2-O_2 and H_2O-H_2±CH_4 I were observed in healed microcracks in the detrital quartz grains. Based on microthermometric mesurements, the sal of the aq solution ranges from 0.2 to 18 wt.% eq. NaCl. Raman analysis of the gas phase indicates that the hydrogen to oxygen ratio differs from an I to the other.

The presence of H_2- and O_2- bearing FI confirms the existence of water radiolysis in the reactor zone. In zones rich in organic matter, oxygen was preferentially consumed in reactions with organic matter and its radiolytic products. In the absence of organic matter and its radiolytic products, oxidizing conditions prevailed and hematite and minium have formed. (From authors' abstract by E.R.)

SAVOYE, S., ARANYOSSY, J.-F., BEAUCAIRE, C., LOUVAT, D. and **MICHELOT, J.-L.**, 1997, The influence of fluid inclusions on the groundwater chemistry in granitic environment: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 294-295. First author at CEA-FAR, DCC/DESD/SESD.LIRE, BP6, 92265 Fontenay-aux-Roses Cedex, France; email (savoye@azurite.cea.fr).

Geochemistry of deep groundwaters in granitic rocks has been extensively studied because these rocks are one of the geological formations considered for the isolation of radioactive wastes. Dynamics and sal of these groundwaters must be fully understood as they could mobilize radionuclides from the repository toward the biosphere. A part of this study is related to FI of granitic rocks as a potential source of dissolved chlorine (Nordstrom et al., 1987): is the quantity of salt liberated through FI leakage sufficient to account for the groundwater sal?; and, if it is sufficient, do we have the possibility to trace FI salts into groundwaters? We used crush-leach procedures on samples from 8 granites; Cl^-, Br^-, F^- and SO_4^{2-} were analyzed by ion chromatography and ICP-MS. It results that the total chlorine content of rocks varies from 60 to 370 ppm, 40 to 80% of this chlorine comes from the chlorine-bearing minerals, 0.5 to 10% from intergranular solutions, and 10 to 50% is from FI. Under static flow conditions, in only one granite can FI be the major source of dissolved chlorine.

In conclusion, from the study on eight granitic rocks, the FI leakage cannot be considered as a general process responsible for the high sal of deep groundwaters in crystalline rocks. (From authors' abstract by E.R.)

SAWAKI, Takayuki and **SASADA, Masakatsu**, 1997, Thermal history of the Onikobe geothermal system, based on microthermometry of fluid inclusions: J. of the Geothermal Research Soc. of Japan, v. 19., no. 3, p. 165-183.

The thermal history of the Onikobe geothermal system, northeast Japan, was studied, based on microthermometry of FI in quartz, anhydrite, calcite and wairakite in hydrothermal veins from wells. FI of hydrothermal quartz and anhydrite in granitic rocks around the bottom of well KR-1, were formed by trapping boiling F. Their final melting points of ice (Tm) and Th range from -0.3 to -3.0°C and from 270 to 320°C, respectively. The Th are plotted on the boiling point curve of water adjusted to the present water table (BPC). On the other hand, Th of FI in volcanic rocks shallower than 1200 m in the borehole are plotted between the BPC and the present well T profile (WT). FI from well KR-2 are divided into two groups, based on their Th's; one's Th's plot on or above the BPC, and the other's on the WT. Th of FI from well KR-3 deeper than 2300 m plot near the BPC, where the WT is also drawn near the BPC. Th of FI from well KR-4 have ranges of 40-80°C at each level, and the highest Th correspond to the WT. FI from well KR-5 are divided into three groups, based on their Th's. Th's of group 1 are plotted above the BPC at very shallow levels, and their host rock are remarkably silicified. Those of group 2 are on the BPC, those of group 3 are between the BPC and the WT, or on the WT.

The microthermometrical data of FI and petrography of hydrothermal veins suggest that geothermal activity is still vigorous at deeper levels of the wells KR-1 and KR-3. FI whose Th are different occur in the wells KR-2 and KR-5. These variations are probably reflected by a cooling process around the wells, and suggest that the geothermal activity around the wells KR-2 and KR-5 has declined. The higher WT than Th around the well KR-4 suggests that FI of lower Th than the WT were formed in a past stage of lower T, and that geothermal activity around the well is possibly high. (From authors' abstract by E.R.)

SAWAKI, Takayuki, SASADA, Masakatsu and **SASAKI, Munetake**, 1997a, Gas analyses of fluid inclusions in quartz from pegmatites in Japan: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 296-297. Authors at Geological Survey of Japan, Higashi 1-1-3, Tsukuba, Ibaraki 305, Japan; email (sawaki@gsj.go.jp).

We have studied the gases in FI in quartz from granites, pegmatites and metamorphic rocks, and gases of the I were analyzed by quadrupole mass spectrometer and capacitance manometer. We think that the studies of FI from pegmatites give us clues to study of evolution of thermal F and/or origin of ore deposits related to granitic intrusions. A diagram of logCO_2 vs logCH_4 (mol.%) shows most samples falling in the brackets 0.1-10 CO_2 and 0.001-1.0 CH_4. On a plot of CH_4-N_2-CO_2, most are within 20% of the CO_2 corner. The values are interpreted in terms of the origins of the granite types sampled (E.R.). (From authors' abstract by E.R.)

SAWAKI, T., SASADA, M. and **SASAKI, M.**, 1997b, Geochemistry of fluid inclusions in granites and pegmatites from Japan (II): (abst.): Geol. Soc. Japan Annual Meeting, Fukuoka, Oct. 10-12, Program, p. 402 (in Japanese).

SAWAKI, Takayuki, SASADA, Masakatsu, SASAKI, Munetake and **GOKO, Kazunori**, 1997, Fluid inclusion study of the Kirishima geothermal system, Japan: Geothermics, v. 26, no. 3, p. 305-327. First author at Geological Survey of Japan, Higashi 1-1-3, Tsukuba, Ibaraki 305, Japan.

Gases from FI in quartz and anhydrite were analyzed with a quadrupole mass spectrometer and a capacitance manometer. The quartz and anhydrite occur in hydrothermal veins in volcanic and pelitic rocks collected from geothermal wells in the Kirishima area, southwest Japan. The geothermal wells are located in a graben made up of Quaternary volcanic rocks underlain by sedimentary rocks of the Shimanto Group.

Results of individual FI analyses show that the FI comprise mainly H_2O and a variable but small amount of CO_2. CH_4 and other hydrocarbons are also detected in I in a hydrothermal sample from the pelitic Shimanto Group. Peak ratios of CO_2/H_2O in individual FI are variable in some samples. This indicates that there is a difference in gas compositions of the FI, and suggests that the I were formed in multistages or trapped heterogeneous boiling F.

Results of bulk analyses show that the I are mainly composed of H_2O (98-99 mol%) with small amounts of non-condensable gases, mainly CO_2 and N_2, CH_4 and Ar. The proportion of N_2 is about one order of magnitude lower than CO_2, CH_4 is generally two orders of magnitude lower than CO_2 and Ar is just above the detection limit of the mass spectrometer. The gas concentration in the FI is much higher than that in the present-day discharge F. CO_2/N_2 and CO_2/CH_4 ratios of the FI from the volcanic rocks are lower than those of the present-day discharge F. CO_2/N_2 and CO_2/CH_4 ratios in residual F increase with progressive degassing, because N_2 and CH_4 are released from the residual F more easily than CO_2. Thus, the difference in the CO_2/N_2 and CO_2/CH_4 ratios between the FI and the present-day discharge F in the Kirishima area may be ascribed to the degree of degassing, and the FI in the area were probably formed by trapping F that were weakly influenced by degassing. PCO_2 values calculated from the gas compositions of the FI are higher than that of buffer systems involving alteration minerals in the area. This suggests that the FI might be trapped F which were not in equilibrium with the alteration mineral assemblages, that is, F prior to considerable degassing and alteration. (Authors' abstract)

SAWAKI, Takayuki, SASADA, Masakatsu, SASAKI, Munetake, TSUKIMURA, Katsuhiro, HYODO, Masami, OKABE, Takashi, UCHIDA, Toshihiro and YAGI, Masahiko, 1997, Synthetic fluid inclusion logging to measure temperatures and sample fluids in the Kakkonda geothermal field, Japan: Geothermics, v. 26, no. 3, p. 281-303. First author at Geological Survey of Japan, Higashi 1-1-3, Tsukuba, Ibaraki 305, Japan.

Synthetic FI logging is a new tool to measure T and sample F in high-T geothermal wells. F in the microcracks of a crystal can be trapped in I through healing. FI in quartz, for example, can be synthesized easily in geothermal boreholes and can be used as long as the host crystal is stable (e.g. α-quartz is stable up to 573°C). This technique can be applied to high-T geothermal wells where conventional T measurement methods are not feasible. Cracked crystals of quartz, soaked in silica-saturated solutions in gold or platinum capsules mounted on containers, are placed in a geothermal borehole. Geothermal F enters the microcracks in the crystals at the selected sampling depths, and I containing ambient F are formed through crack healing. Tt of FI in quartz are determined by microthermometry using a heating stage with P corrections. Other cracked crystals mounted in containers with rupture disks are used for F sampling. The first borehole experiment was conducted at WD-1, a deep research hole drilled in the Kakkonda geothermal field, northeast Japan, from September to October 1994 (24 days). Results from the experiment confirmed that T measured from FI are consistent with borehole T measured by conventional logging tools. (Authors' abstract)

SAWAKI, T., SASADA, M., SASAKI, M., UCHIDA, T. and HYODO, M., 1997, Temperature logging of WD-1a by synthetic fluid inclusions - Results of a medium-term experiment in 1996 (abst.): Geothermal Research Soc. Japan Ann. Meeting, Oct. 6-8, 1997, Sapporo Program, unpaginated, No. P10 (in Japanese).

SCAMBELLURI, Marco, PICCARDO, G.B., PHILIPPOT, Pascal, ROBBIANO, Andrea and NEGRETTI, Laura, 1997, High salinity fluid inclusions formed from recycled seawater in deeply subducted alpine serpentinite: Earth and Planetary Sci. Letters, v. 148, p. 485-499. First author at Dipartimento di Scienze della Terra, Univ. of Genova, C.so Europa 26, 16132, Genova, Italy.

The origin of high-P brines has been investigated in the Erro-Tobbio peridotite (Western Alps), a mantle slice that was exposed to the seafloor of the Mesozoic Ligurian-Piedmontese Tethys and was later involved in Alpine subduction. Hydrothermal alteration by seawater-derived F led to replacement of the mantle assemblage by Cl-bearing serpentine (0.35 wt.% Cl), brucite (0.2 wt.%), Cl^- and alkali-bearing phyllosilicates (0.2 wt.% Cl; 0.2-0.55 wt.% Na_2O; 1-5 wt.% K_2O). Relics of these hydrous phases occur in olivine + titanian clinohumite + antigorite assemblages formed at 2.5 GPa and 550-600°C during partial devolatilization and veining of the hydrothermally altered peridotite. The high-P phases lack chlorine and alkalis and are coeval with FI trapped in the syn-eclogitic veins. The I are salt-saturated and contain up to 50 wt.% Cl, Na, K, Mg and Fe. High F chlorinity was probably achieved during rehydration of relict mantle minerals and deposition of hydrous phases in the veins. The data presented suggest that the seafloor hydrothermal signature was inherited by the eclogitic F due to partitioning of chlorine and alkalis into the F phase. The presence of salty brines in eclogitized hydrous peridotites can indicate deep recycling of seawater-derived F. Hydrous ultramafic systems can therefore act as large-scale carriers of seawater into the mantle. (Authors' abstract)

SCHAFER, B., GUNTHER, D. and DINGWELL, D.B., 1997, LA-ICP-MS analysis of individual synthetic FI in doped haplogranitic glass: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F738. First author at Bayerisches Geoinstitut, Univ. Bayreuth, D-95440, Bayreuth, Germany; email (beate.schaefer@unibayreuth.de)

The degassing of magma during ascent within the Earth is a fundamental control on the physics and chemistry of magmatic processes. To enhance our knowledge of element partitioning behavior during magmatic degassing, we have initiated an investigation of the partitioning of trace elements between co-existing F and M phases using direct microanalysis of synthetic FI in glass. The I were produced experimentally using a haplogranitic glass powder doped with selected elements (e.g., Nb, Cs, W) at 1000 ppm level and a 2.5 wt.% NaCl solution as starting materials, loaded together in Pt-capsules. Experiments were performed in hydrothermal rapid-quench cold-seal vessels at 2 kbar and 850°C and last up to a maximum of 25 days to ensure chemical equilibration between F phase and silicate M. The synthetic I are of ellipsoidal shape and up to 200 µm in diameter.

I (60 µm minimum size) were analyzed by LA-ICP-MS. External standardization with NIST 610 for the doped glass matrix and standard solutions for the FI were used. Cl serves as internal standard for the FI from bulk sal via FI microthermometry. I signal evaluation includes a correction for the matrix based on a highly compatible matrix element. Results show a RSD near 10% for the doped elements and down to 5% for the major elements Na and K. Limiting factors are internal standardization with Cl and the theoretical matrix influence correction on the FI signal. (Authors' abstract)

SCHALAMUK, I.B., ZUBIA, M., GENINI, A. and FERNANDEZ, R.R., 1997, Jurassic epithermal

Au-Ag deposits of Patagonia, Argentina: Ore Geol. Reviews, v. 12, p. 173-186. First author at Inst. de Recursos Minerales, Univ. Nacional de la Plata, Calle 47 # 522, 1900 La Plata, Argentina.

Important precious metal deposits have been discovered during the last 10 years in the Deseado massif region of Patagonia, Argentina. This region is a plateau consisting of Middle to Upper Jurassic volcanic rocks that host fracture-controlled epithermal Au-Ag mineralization. These mineral deposits represent low sulfidation type hydrothermal systems and formed following the main period of volcanism, probably during the Late Jurassic period. The presence of silica sinters and veins interpreted to be feeder structures indicates that the tops of some deposits have been preserved, with erosion of younger sedimentary and volcanic rocks now exposing these systems. These deposits represent diverse erosional levels ranging from sinter formed at the paleosurface, to intermediate Au-Ag rich quartz veins, to base metal-bearing Au-Ag veins that represent deeper levels of the epithermal systems. The best known deposits are in the Cerro Vanguardia district where vein systems occur over a 350 km^2 area and veins can be traced for more than 14 km. Geological mapping of the district has resulted in the definition of over 140 km of veins. Current reserves are over 3.2 million ounces Au equivalent with grades of 10 g/t Au and 120 g/t Ag. The geologic characteristics of the region and the presence of major Au-Ag deposits provide targets for continuing exploration in the Deseado massif. (Authors' abstract)

P I occur along growth zones in quartz and barite. Single-phase, two-phase and rare three-phase P I have been recognized. Freezing studies suggest that the trapped F belong to the H_2O-NaCl-KCl system. FI Th are generally <100°C in sinter and >100°C in feeder veins. Th of P FI in gold-bearing quartz from the Atila Vein (Cerro Vanguardia) vary from 200 to 240°C, with a minor population showing T between 250 and 310°C (Schalamuk et al., 1995b). Sal data from lower T I range from 1.6 to 4.8 wt.% eq. NaCl with an average of 3.8 wt.% eq. NaCl.

Quartz from the vein structures in the Manantial Espejo district, similar to those at Cerro Vanguardia, contain L- and V-rich P I characterized by low sal solutions (1 to 4 wt.% eq. NaCl) and Th between 164 and 240°C. Quartz-hosted FI from a siliceous breccia have Th from 165 to 232°C and sal of 5 to 6.6 wt.% eq. NaCl (Rios et al., 1994).

Th of FI in late barite from El Dorado Monserrat vary from 150 to 180°C and sal ranges from 1 to 1.7 wt.% eq. NaCl. In mineralized quartz, sal are similar to barite and Th of 190 to 280°C were obtained.

P FI are abundant along the growth zones in quartz crystals from the Bajo Pobre occurrence. Single-phase I dominate over the two-phase ones, suggesting Tt<100°C. The aq F indicated is almost pure water (≤ 0.3 wt.% eq. NaCl) with maximum Th V values of 230°C.

The few I detected in the El Macanudo siliceous vents are P, small and single phase, suggesting trapping at T<70°C (Schalamuk et al., 1995b). (From authors' text by E.R.)

SCHANDL, E.S. and **BLEEKER, Wouter**, 1997, Hydrothermal and metamorphic fluids of the Kidd Creek volcanogenic massif sulfide deposit: Preliminary evidence from fluid inclusions (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A132. First author at Dept. of Geol., Univ. of Toronto, 22 Russell St., Toronto, ON M5S 3B1.

Primary FI in what is thought to be syngenetic siderite preserve a record of the hydrothermal evolution of the Kidd Creek volcanogenic massive sulfide deposit. The banded and zoned siderite is intergrown with sphalerite, chalcopyrite and pyrite and occurs in irregular masses or in vein-like segregations. Microthermometric measurements suggest that the early, syngenetic carbonates in the ore zone crystallized from a predominantly aq F at a T of ca. 250-297°C and mean sal of 5.7±0.5 eq. wt.% NaCl.

Two distinct metamorphic F were identified at Kidd Creek, suggesting two distinct metamorphic events: (1) Albite porphyroblasts in the bornite zone, which contain numerous xenotime and monazite I, crystallized from aq F at about 450°C during peak metamorphic conditions. Their crystallization was probably contemporaneous with emplacement of the nearby Prosser Porphyry, ca 55 m.y. after ore deposition. (2) Late subhorizontal quartz veins which cross-cut the entire Kidd Creek deposit crystallized from F which had a similar composition and T to the F which crystallized the "flat veins" at gold deposits in the Timmins area. FI data indicates that some of the quartz veins at Kidd Creek formed at a T of 298±31°C from CO_2-rich F (with a minor CH_4 component) having a sal of 1.9±1.1 eq. wt.% NaCl. The close similarities in F composition, T and structural characteristics between "flat veins" and the subhorizontal quartz veins at Kidd Creek suggest that the emplacement of these veins represent a distinct event in the tectonic evolution of the Abitibi belt. (Authors' abstract)

SCHIANO, P. and **BOTTINGA, Y.**, 1997, Mantle flow and partial melting: Evidence from ultramafic nodules in alkali basalts from intraplate volcanos: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 185-186, Lunar and Planetary Inst., Houston. Authors at Laboratoire de Géochimie et Cosmochimie, Institut de Physique du Globe, 4, Place Jussieu, 75252 Paris, France.

The spinel-lherzolite and harzburgite nodules are from volcanos fed by five different hotspots. Except for neoblasts, all crystals in the nodules bear witness of different shear deformation events and contain F and glass I. All nodules show signs of partial melting and crystallization of new minerals from M.

The very numerous glass I, amounting to <0.1 vol.%, are predominantly associated with fractures. I have rounded shapes and may have been deformed viscously. They may contain one or more gas bubbles and S minerals belonging to either of two parageneses: (1) amphibole, rutile, clinopyroxene, Mg carbonate; (2) orthopyroxene, clinopyroxene, Mg carbonate. The minimum T of formation is ~1250°C. Gas bubbles in these glass I contain only measurable quantities of CO_2; the ratio CO_2/M can vary greatly for different I. Dissolved in the glass are Cl, H_2O, and CO_2. The densities of the CO_2 in the FI correspond to P between 0.7 and 1.4 GPa at 1250°C.

These I show polybaric partial melting: (1) a very fluid M associated with the P I, and (2) a very viscous M in the S I, in fractures, and as interstitial glass. Partial melting is not eutectic and may take place in the central regions of pyroxenes, where it is preceded by the exsolution of clinopyroxene lamellae. M is not concentrated in triple junctions. Porosity and permeability are due to fracturing and partial melting and are affected by recrystallization. Deformation is due to shearing; no signs of compression have been observed. Brittle failure occurs during time intervals of motion, which alternate with periods of rest, permitting annealing and recrystallization. The observed displacements are relatively small and strain does not amount to more than a few percent. (From authors' abstract by E.R.)

SCHIANO, Pierre, CLOCCHIATTI, Robert, LORAND, J.-P., MASSARE, Dominique, DELOULE, Etienne and CHAUSSIDON, Marc, 1997, Primitive basaltic melts included in podiform chromites from the Oman Ophiolite: Earth and Planet. Sci. Letters, v. 146, p. 489-497. First author at Labortoire de Géochimie-Cosmochimie (CNRS-URA 1758), IPG Paris and UFR Sciences de la Terre, Univ. Paris VII, 4 place Jussieu, 75252 Paris cedex 05, France.

In an attempt to characterize the composition of the parental M of ophiolitic chromatites and their tectonic setting, we have undertaken a study of polymineralic solid I trapped in chromites frm the Oman Ophiolite (Sumail nappe). High-T experiments performed on I show that they result from post-entrapment crystallization of homogeneous basaltic M with primitive compositions (Mg# = 63.5-66.8). The P nature of the I, demonstrated by their distribution outlining the crystallographic zones of mineral growth, indicates that the trapped M represent small amounts of the parental L of the host chromites. Homogenised M I show depleted trace element patterns, with significant Nb depletions, characteristic of a subduction-related origin. These observations indicate that chromite deposits from Oman harzburgitic ophiolites may have formed in a geodynamic setting akin to present-day back-arc basins. (Authors' abstract)

SCHMETZER, Karl, KIEFERT, Lore, BERNHARDT, H.-J. and BEILI, Zhang, 1997, Characterization of Chinese hydrothermal synthetic emerald: Gems & Gemology, v. 33, no. 4, p. 276-291. First author at Marbacher Strasse 22b, D-85238 Petershausen, Germany.

Synthetic emeralds grown hydrothermally in an alkali-free, chlorine-bearing solution have been manufactured in Guilin, China since 1987. Diagnositic microscopic features include growth and color zoning as well as oriented needle-like tubes and cone-shaped voids ("nailhead spicules") that are typically associated with small chrysoberyl crystals [tubes and voids are described and pictured to contain 2-phase fluids (H.E.B.)] Also distinctive is the presence of chlorine in this iron- and alkali-free hydrothermal synthetic emerald. In addition, spectroscopic properties in the mid- and near-infrared are useful to characterize this new Chinese product; features in the 2500-3100 cm^{-1} range (also found in other chlorine-bearing synthetic emeralds) help distinguish it from natural emeralds. (Authors' abstract)

SCHMETZER, Karl and BERNHARDT, H.-J., 1997, The identity of reddish-brown inclusions in a new type of Russian hydrothermal synthetic emerald: J. of Gemmology, v. 25, no. 6, p. 389-390. First author at Marbacher Strasse 22b, D-85238 Petershausen, Germany.

Transparent reddish-brown platelets in recently produced Russian hydrothermal synthetic emerald were determined as iron oxides with distinct contents of chromium, titanium and nickel. (Authors' abstract)

SCHMIDT, B.C., HOLTZ, François, SCAILLET, Bruno and PICHAVANT, Michel, 1997, The influence of H_2O-H_2 fluids and redox conditions on melting temperatures in the haplogranite system: Contrib. Mineral. Petrol., v. 126, p. 386-400.

SCHMIDT, C., CHOU, I.-M., BODNAR, R.J. and BASSETT, W.A., 1997, Applications of the hydrothermal diamond anvil cell in fluid inclusion research: *in* Proceedings of the Fifth Int'l. Symposium on Hydrothermal Reactions, Palmer, D.A. and Wesolowski, D.J., eds., 1997, Gatlinburg, TN USA, p. 235. First author at Fluids Research Laboratory, Dept. of Geological Sci., Virginia Tech, Blacksburg, VA 24061-0420.

Th measurements of volatile-rich FI, particularly at high sal and volatile densities, can be impossible or inaccurate if conventional heating stages are utilized, due to high internal P in the I causing decrepitation and stretching. As a result, the acquisition of isochores and high-T phase equilibria from synthethic FI has been limited to compositions having V P less than about 2 kbar. The hydrothermal diamond-anvil cell (HDAC) provides a means to exert an external hydrostatic P on the sample and thus to prevent decrepitation during the heating run. In this study, the HDAC was loaded with a polished 100 µm thick quartz chip containing FI, water as a P medium and an air bubble. The water/air bubble ratio was adjusted at room T in such a way that the corresponding isochore of the confining P medium had an about equal or higher P than the a priori estimated P at the phase transition T.

Using this technique, the liquid-vapor homogenization temperatures [Th(L-V)] and halite dissolution T [Tm(halite)] 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. Additionally, the approximate P-T locations of a part of the high-P portion of the L-V curve and lines of constant Th were calculated for H_2O+40 wt.% NaCl + 10 mol.% CO_2. For this composition, the P of the bubble-point curve is almost independent of the Th 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/°C at Th(L-V) = 500°C to 15 bar/°C for Th(L-V) = 650°C. The Tm(halite) average 342°C (range ±6°C) for samples of 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 CO_2 concentrations: Tm(halite) = 323°C for H_2O+40 wt.% NaCl and Tm(halite) = 332°C for H_2O+40 wt.% NaCl+5 mol.% CO_2.

In a related study, the liquidus was redetermined at high P for an aq solution containing 40 wt.% NaCl. These measurements confirm the data of Bodnar (1994) and indicate a curved liquidus shape. Compared to G-flow 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, the compression of the I host material, and the higher compressibility of the FI in comparison to the quartz host. (Authors' abstract)

SCHMIDT MUMM, Andreas, 1997a, Fluid systems in Archean tectogenesis: The southern Zimbabwe craton and northern marginal zone of the Limpopo Belt: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p.

298-299. Author at Inst. für Geologische Wissenschaften und Geiseltalmuseum, Domstr. 5, D-06108 Halle/Saale; email (Schmidt-Mumm@geologie.uni-halle.de).

The tectono-thermal evolution of the southern Zimbabwe craton and NMZ of the Limpopo Belt is well documented in FI assemblages. Determination of compositional and volumetric variation of the I in samples from the respective geological settings allows the reconstruction of three different regional scale F systems and the integration of the metallogenetic processes. A Palaeoproterozoic metamorphic overprint is demonstrated by the formation of the Au-mineralisation of the Renco deposit, which may in its initial stages have formed under partial interaction with hydrocarbon-bearing, diagenetic F. Interaction with diagenetic, highly saline, Ca-dominant, low T F is also evident from quartz veins in faults and associated alteration in granite in cratonic setting. (From author's abstract by E.R.)

SCHMIDT-MUMM, A., 1997b, Fluid inclusion studies–The link between petrogenesis and metallogenesis of gold deposits in the southern Zimbabwe craton and Limpopo Belt: Intraplate Magmatism and Tectonics of Southern Africa, Geol. Soc. Zimbabwe and Dept. of Geol., Univ. Zimbabwe, Harare, 3-17 Sept., 1997.

(No other data available)

SCHMIDT MUMM, A., OBERTHÜR, T., VETTER, U. and **BLENKINSOP, T.G.**, 1997, High CO_2 content of fluid inclusions in gold mineralisations in the Ashanti Belt, Ghana: A new category of ore forming fluids?: Mineralium Deposita, v. 32, p. 107-118. First author at Inst. für Geologische Wissenschaften und Geiseltalmuseum, Univ. Halle, Domstr. 5, D-06108 Halle/Saale, Germany; email (gfoj8@mlugeos1.geologie.uni-halle.de)

FI were studied in samples from the Ashanti, Konongo-Southern Cross, Prestea, Abosso/Damang and Ayanfuri gold deposits in the Ashanti Belt, Ghana. P FI in quartz from mineralised veins of the Ashanti, Prestea, Konongo-Southern Cross, and Abosso/Damang deposits contain almost exclusively volatile species. The P setting of the gaseous (i.e., the F components CO_2, CH_4 and N_2) FI in clusters and intragranular trails suggests they represent the mineralising F. Microthermometric and Raman spectroscopic analyses of the I revealed a CO_2 dominated F with variable contents of N_2 and traces of CH_4. Water content of most I is below the detection limits of the respective methods used. Aq I are rare in all samples with the exception of those from the granite-hosted Ayanfuri mineralisation. Here, I associated with the gold mineralisation contain a low sal (<6 eq. wt.% NaCl) aq solution with variable quantities of CO_2. Microthermometric investigations revealed densities of the gaseous I of 0.65 to 1.06 g/cm^3 at Ashanti, 0.85 to 0.98 g/cm^3 at Prestea, up to 1.02 g/cm^3 at Konongo-Southern Cross, and 0.8 to 1.0 g/cm^3 at Abosso/Damang. The FI data are used to outline the PT ranges of gold mineralisation of the respective gold deposits. The high density gaseous I found in the auriferous quartz at Ashanti and Prestea imply rather high P trapping conditions of up to 5.4 kbar. In contrast, mineralisation at Ayanfuri and Abosso/Damang is inferred to have occurred at lower P of only up to 2.2 kbar. Mesothermal gold mineralisation is generally regarded to have formed from F characterized by $H_2O>CO_2$ and low sal (± 6 eq. wt.% NaCl). However, FI in quartz from the gold mineralisations in the Ashanti belt point to distinctly different F compositions. Specifically, the predominance of CO_2 and $CO_2 >> H_2O$ have to be emphasized. F systems with this unique bulk composition were apparently active over more than 200 km along strike of the Ashanti belt. F rich in CO_2 may present a hitherto unrecognised new category of ore-forming F. (Authors' abstract)

SCHREYER, Werner and **STOECKHERT Bernhard,** 1997, High-pressure metamorphism in nature and experiment: Lithos, v. 41, no. 1-3, p. 1-4.

Indexed under FI (E.R.)

SCHREYER, W. and **WERDING, G.,** 1997, High-pressure behaviour of selected boron minerals and the question of boron distribution between fluids and rocks: Lithos, v. 41, no. 1-3, p. 251-266.

Indexed under FI (E.R.)

SCOTT, Steven and **YANG, Kaihui,** 1997, Metal-rich magmatic fluids in felsic volcanic rocks: An explanation for "giant" massive sulfide ore deposits?: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 300-301. First author at Scotiabank Marine Geol. Research Lab, Dept. of Geol., Univ. of Toronto, Toronto, Canada M5S 3B1; email (scottsd@ecf.utoronto.ca).

The source of hydrothermal F responsible for volcanogenic base and precious metal massive sulfide ores deposited on the sea floor has been debated for a long time. They may arise purely from the interaction of circulating sea water with the hot rocks ("hydrothermal leaching" model) or there may be an admixture of a F escaping from magma at depth ("magmatic F" model) as is seen in subaerial geothermal systems.

The magmatic volatile phase trapped in the volcanic rocks has a considerably higher concentration of metals (2.3 wt% Zn, 7.2 wt.% Cu, 2.7 wt.% Fe, 1.1 wt.% Ni, 2.7 wt.% S, 7.9 wt.% Cl, 2.5 wt.% Na, trace Ag and trace Au). This may be a natural example of a well known industrial process in which metals are volatilized by high T CO_2.

The leaching model is satisfactory for ordinary volcanogenic massive sulfide deposits, but not for the "giant" deposits (>100 mt of mineralization) such as the Brunswick #6 orebody, Bathurst, New Brunswick. An ore metal-rich magmatic F could easily be responsible for their formation. [The volume calculation are satisfactory, but] further studies are needed on F/M I from ancient ores and modern seafloor systems to determine whether or not magmatic F actually do mix with the hydrothermal circulation system. Some concerns with the magmatic F model are the unexplained absence of lead and presence of nickel in the MI, and the very high metal contents estimated for the magmatic F that must surely supersaturate a magmatic-seawater mixture. (From authors' abstract by E.R.)

SEITZ, J.C. and **BLENCOE, J.G.,** 1997, Experimental determination of the volumetric properties and solvus relations of H_2O-CO_2 mixtures at 300-400°C and 75-1000 bars: *in* Proceedings of the Fifth Int'l. Symposium on Hydrothermal Reactions, Palmer, D.A. and Wesolowski, D.J., eds., 1997, Gatlinburg, TN USA, p. 109-112. First author at Oak Ridge Nat'l. Laboratory, P.O. Box 2008, Bldg. 4500S, MS 6110, Oak Ridge, TN 37831.

SEITZ, J.C. and **BLENCOE, J.G.**, 1997, Experimentally determined volumetric properties and solvus relations for H_2O-CO_2-N_2 mixtures at 300°C and pressures < 1000 bars (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-209. First author at Dept. of Geological Sci., California State Univ., Hayward CA 94542; email (jseitz@csuhayward.edu).

Densities, excess molar volumes (V^{ex}) and solvus relations of H_2O-CO_2-N_2 mixtures were measured at 300°C and P up to 1000 bars using a custom-designed, high-T, high-P vibrating-tube densimeter. The exploded ternary diagram shows results for ternary mixtures and the binary subsystems. V^{ex} is indicated by the contours in the ternary system and the curves in the binary subsystems. The filled circles represent experimental data for the binary subsystems; >30 different mixtures were analyzed in the ternary system to determine the volumetric properties and the position of the solvus. The V^{ex} data for the H_2O-N_2 subsystem are discontinuous due to F immiscibility, which extends into the ternary system (stippled area). Our solvus data for H_2O-N_2 F are in good agreement with the data of Japas and Franck (1985) at 300°C. For H_2O-CO_2, our data indicate a smaller two-phase region at 300 and 350°C than previously determined by Tödheide and Franck (1963) and Takenouchi and Kennedy (1964). We are unaware of any previously published volumetric and solvus data for H_2O-CO_2-N_2 mixtures over a wide range of P, T, or composition. (Authors' abstract) *See figure on page 234.*

SELLECK, B.W., 1997, Fluid-basement interaction at the Proterozoic-Paleozoic unconformity, Adirondack periphery, New York State (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 29, no. 1, p. 78. Author at Dept. of Geol., Colgate Univ., 13 Oak Drive, Hamilton, NY 1346; email (bselleck@center.colgate.edu).

Widespread evidence for hydrothermal 'basinal' F flow (MVT-type) in basal sandstone aquifers (Potsdam Sandstone and equivalents) is found along the margins of the Adirondack Mountains of New York State. Such evidence includes dissolution and dolomitization of basement marbles, infiltration of basal Paleozoic sands into underlying solution pipes and tunnels, alteration of basement gneiss to illite-chlorite bearing 'pseudopaleosols' along the unconformity, and disseminated vein and fracture mineralization and alteration that extends well below the unconformity.

Mineral assemblages, FI data and isotopic data are all consistent with Na-Ca-Cl brines that resemble well-studied Paleozoic MVT-type F elsewhere in North America (Th of 120-200°C; sal 15-25 wt.% eq. NaCl). Variations in Th exhibit no obvious systematic regional trends. However, anomalously high T in some areas require further study. Oxygen isotope data on host minerals, combined with Th constrain the isotopic composition of the hydrothermal F, and suggest that relatively low water/rock ratios (highly 'evolved' brines) were present. Major and minor element trends suggest that the alteration of Proterozoic basement rocks served as a source of dissolved metals for the brine system.

Although a mid-Paleozoic (Devonian) age for one hydrothermal event is suggested by K-Ar ages along the northern Adirondack margin, earlier (Ordovician) or later (Carboniferous-Permian) events are also probable. Late Proterozoic vein/fracture mineralization may also be present throughout the Adirondack Mountains, but caused by F similar in character to those observed elsewhere. (Author's abstract)

SELTMANN, Reimar, 1997, Fluid-rock reactions and fluid saturation textures in rare-metal granites (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 67-68 (in English), ISBN 5-88918-002-9. Author at GeoForschungsZentrum Potsdam (GFX), Telegrafenberg A50, D-14473, Potsdam, Germany; email (seltm@gfz-potsdam.dc)

The instruction [intrusion?] and crystallization of the majority of highly fractionated Li-F granites into subvolcanic levels (1-4 km) is controlled in part by rapid uplift of the crust (2-7 mm/a) during extension. Rapid cooling due to steep geothermal gradients is characterized by magma quenching and intense fracturing of the carapace in many cases. Due to the so-called autoclave effect, a quenched glassy carapace (later recrystallized) is able to buffer overpressures (internal F P as much as 3-5 kbar) that greatly exceed local lithostatic P. Confined by the carapace, the M crystallizes inward and although initially undersaturated in water, it eventually becomes F saturated. This results in late-stage volatile separation beneath the carapace of the cupola. The passage of the granite system through the water-saturated liquidus boundary involves a change of volume and F composition.

Multiphase granitic subintrusions are characterized by a sequence of fine-grained, porphyritic to scriate to equigranular textures, often associated with pulses of explosive brecciation and greisen stockworks. Quench textures, such as embayment and skeletal of quartz (visible in SEM-CL images), characterize dikes and cupola parts of the intrusions. Occurring pegmatitic, miarolitic and rhythmical layered textures (comb quartzes, unidirectional solidification textures-USTs) may indicate stages of F saturation. Micrographic intergrowth of quartz and K-feldspar also reflect undercooled conditions that may have been related to rapid release of a F phase (i.e., P quenching). Nucleation-controlled phenomena, including variations in granite textures, however, can result from a multiplicity of causes.

Extensive fracture stockworks and breccia pipes around the tops of intrusions, which indicate the breakthrough of an impermeable barrier of the short-term self-healed igneous system, are common characteristics of F-saturated rare-metal granites. The closed system conditions in the M reservoir below the carapace enable effective fractionation (indicative are typical element ratios such as Y/Ho, Zr/Hf, Nb/Ta). The enrichment of magmatic volatile phases is reflected in F-, Cl-, B-, Li-, P-bearing minerals and C-H-O-enriched microinclusions and associated with the formation of ore-bearing M (salt M, pegmatitic residual M), whereas the subsequent brecciation due to degassing allows the channeling and accumulation of the mineralization. The higher the degree of fractionation, the greater the effects of circulating F derived from the magma and the higher the possible concentrations of ore. Hosting granitic rocks are characterized by REE patterns that show so-called tetrad effects. Granite-related hydrothermal systems at low latitude (especially such with porphyry-style mineralization) may have a significant component of meteoric water.

L-L immiscibility (i.e., F, Si-rich vs. P, Al-rich granitic M portions) and separation of a magmatic volatile phase due to rapid P release are typical phenomenon of mineralized shallow intrusions and related magmatic-hydrothermal transition processes. Laccolithic bodies formed through related dike-in-dike intrusions caused by sharp theological (density) contrasts, the existence of intra mineralization "vein dikes" (with magmatic topaz, Li-micas or muscovite), tourmaline orbicules snowball quartzes, etc. are typical signatures of late-magmatic stages. Subsolidus characteristics for crystal-F interactions in granites are microclinization, albitization, S muscovite, and other disequilibrium features. Accessories then often exhibit, due to interaction with a highly reactive F phase, metamictization, inhomogenity, hydration, fluorination.

Field evidence and textural, petrologic and geochemical data from mineralized systems such as subintrusions in Cornwall, Central Kazakhstan, Transbaikalia, the Mount Pleasant Sn-W-Mo deposits (New Brunswick) and the Erzgebirge Sn-W deposits (Germany) have been used to model the F and energy release from high-level to subvolcanic magmas. Textures such as rhythmic layered pegmatite-aplite zones, stockscheiders, USTs, and magmatic foliation are due to rhythmic alternations in magmatic-hydrothermal transition processes. Formation of USTs, for example, is due to rhythmic oversaturation of silica-rich hydrothermal F in the M. Other features related to F oversaturation include breccia textures (explosive devolatilization), ductile-brittle transition textures (fluidization), cupola collapse of the granitic system). The presence of many of these features associated with the same granite cupola indicates that considerable fluctuations in P and T occurred in the magmatic-hydrothermal system. These textural features thus help constrain P and T conditions used in modelling F-rock reactions and the genesis of granite-related ore deposits. (From author's abstract by E.R.)

SELTMANN, R., BREITER, K., FRYDA, J., THOMAS, R., DULSKI, P. and TAYLOR, R.P., 1997, Liquid-liquid immiscibility in the Podlesi stock (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 102. First author at GFZ Potsdam.

The Podlesi stock, a highly fractionated P-enriched Variscan rare metal granite from the Krusne hory Mts., is characterized by magmatic-hydrothermal transition processes. The upper part of the "stock granite" (albite-topaz-protolithionite granite, ca. 0.5% P_2O_5) is intercalated by ten subhorizontal 0.2-7.0 m thick layers of albite-topaz-zinnwaldite "dike granite" (up to 2% P_2O_5), and several thin dikes of zinnwaldite-topaz pegmatite. The fine-grained pericontact zone represents a rapidly crystallized carapace with chemistry roughly corresponding to the initial M, later acting as a barrier for uprising M and F. Under this barrier, in-situ fractionation with volatile enrichment operated. Residual M "intruded" into shrinkages resulting in flat layers of "dike granites" and pegmatites. Microthermometric data and microprobe analyses of MI confirmed the existence of at least two different M, which represent hints of L-L immiscibility. One of the M is rich in phosphorus (2.6 wt.% P_2O_5, $T_s = 587°C$, $C_w = 8.8$ eq. wt.% H_2O), the other is rich in fluorine (8.5 wt.% F, $T_s = 580°C$, 10.5 eq. wt.% H_2O). The high degree of fractionation is demonstrated by high content of rare alkalis (Li: 700-2,000 ppm, Rb: 1,500-3,000 ppm, Cs: 100-150 ppm), rare metals (Sn: up to 100 ppm, Nb: up to 95 ppm, Ta: up to 60 ppm) as well as high U/Th and Zr/Hf ratios. The REE contents are low and display flat patterns (Ce/Yb_{CN}: 4-12) with prominent negative Eu anomalies. (Authors' abstract)

SELVERSTONE, J., WAWRZYNIEC, T. and AXEN, G.J., 1997, Low-angle versus high-angle normal faulting associated with exhumation of deep-seated rocks: Geol. Soc. Amer. prog. abs. 29, p. A120.

SEWARD, T., 1997, Metal transport and deposition by hydrothermal ore fluids (abst.) in N.P. Laverov, ed. Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 (Betekhtin Symposium), p. 70 (in Russian). ISBN 5-88918-002-9.

SHAIDETSKA, V.S., 1997, Geochemistry of Neogene evaporites of the Transcarpathian Trough in Ukraine: Slovak Geol. Mag. 3, no. 3, p. 193-200. Author at Inst. of Geol. and Geochem. of Combustible Minerals, Nat'l. Acad. of Sci. of Ukraine, Naukova 3a, 290053 Lviv, Ukraine.

The initial brine during halite sedimentation in the Zaluzh salt-forming basin in the Chop-Mukacheve depression was of Na^+-Cl^--Mg^{2+}-K^+-SO_4^{2-} composition, and by ratio of K^+ and Mg^{2+} was close to the modern seawater saturated to the stage of halite precipitation. The progressive evaporation of the brine has led to a significant increase of the total concentration of solutions in the basin, but the halogenesis has not reached the high stages of its evolution and finished on the halite stage. During diagenesis the sediments were recrystallized under the impact of solutions, with the decreased concentration of the major compounds. (Author's abstract)

SHARYGIN, V.V., 1995, Melt inclusion study of some lamproite species from W. Kimberley, w. Australia and Leucite Hills, U.S.A.: Sixth Internat'l. Kimberlite Conference, Extended Abstracts, Russia, 1995, p. 509-511. Author at Inst. of Mineral. and Petrog., Universitetsky pr.3, 630090 Novosibirsk, Russia.

A review with 9 references and 15 analyses (14 constituents), of lamproites and I glasses from olivine, phlogopite, apatite, diopside, and leucite. (E.R.)

SHARYGIN, V.V., 1997a, Melt inclusion study of lamproites from Smoky Butte, Montana: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 302-303. Author at Inst. of Mineral. and Petrog., 630090 Novosibirsk, Russia; email (sharygin@uiggm.nsc.ru).

The two main rock varieties at Smoky Butte are olivine-bearing hyalolamproite and holocrystalline sanidine-bearing lamproite. P silicate-MI have been identified in minerals of both varieties.

These glasses differ drastically in composition from the host rocks. Raman spectroscopy of a bubble from a MI in olivine-2 show CO_2 (26.6 mol%) and N_2 (73.4 mol%). Using these values and P-V-T equations of FLINCOR program (version 1.2.3., Ph.Brown, 1989), the minimum trapping P for this I can roughly be estimated as 1.7 kb at 1250°C. On the basis of petrological evidence, the Smoky Butte lamproites are interpreted to represent rocks formed from primitive relatively SiO_2-rich mantle-derived magma. This magma ascended rapidly and crystallized at high T. (From author's abstract by E.R.)

SHARYGIN, V.V., 1997b, Evolution of lamproites suggested by melt inclusions in minerals: Geol. and Geophys., v. 38, no. 1, p. 136-147 (in Russian; Engl. abst.; also in Russian Geol. and Geophys., v. 38, no. 1, p. 142-153, in English).

Diverse lamproites have been investigated by thermobarogeochemical methods. Study of I glasses in minerals has shown that there is a common compositional trend in olivine and leucite lamproites from different occurrences (W. Kimberley, Leucite Hills, etc.): initial M evolution during crystallization had an agpaitic trend and was toward gradual depletion in Al_2O_3, CaO, MgO, P_2O_5 and enrichment in SiO_2, FeO*, BaO, TiO_2, ZrO_2, alkalies. This resulted in the formation of K-rich Al-undersaturated or Al-free silicates and K-Ba-titanates during the late stages of rock crystallization. According to cryometric and Raman studies, volatile components such as F (or HF), CO_2, N_2, and H_2O played a significant role in the evolution of P lamproitic magmas. In some cases, aq-saline F (or M) may have separated from silicate L during the latest stages of lamproite magma evolution. Only lamproitic rocks from SE Spain (verite, fortunite) contain I glasses different in composition to those in lamproites from other localities. They are not agpaitic and have shoshonitic affinity.

In general, the evolution of lamproitic magma during crystallization differs greatly from that of other potassic L (in particular, shoshonite and K-basaltoid) in its peralkaline trend. M evolution during crystallization in these other rock types has a strong miaskitic trend and is directed toward a gradual increase in SiO_2, Al_2O_3, alkalis and depletion in FeO*, MgO, CaO, TiO_2 and P_2O_5. (Author's abstract)

SHARYGIN, V.V., 1997c, Evolution of lamproites suggested by melt inclusions in minerals: Russian Geol. and Geophys., v. 38, Proceedings of the Sixth Int'l. Kimberlite Conference, v. 1: Kimberlites, Related Rocks and Mantle Xenoliths, p. 142-153 (in Engl.). Author at Inst. of Mineral. and Petrog., Siberian Div. of the RAS, Univ. pr., 630090, Novosibirsk, Russia.

Diverse lamproites have been investigated by thermobarogeochemical methods. Study of I glasses in minerals has shown that there is a common compositional trend in olivine and leucite lamproites from different occurrences (W. Kimberley, Leucite Hills, etc.): initial M evolution during crystallization had an agpaitic trend and was towards gradual depletion in Al_2O_3, CaO, MgO, P_2O_5 and enrichment in SiO_2, FeO_T, BaO, TiO_2, ZrO_2, alkalies. This resulted in the formation of K-rich Al-undersaturated or Al-free silicates and K-Ba-titanates during the late stages of rock crystallization. According to cryometric and Raman studies, volatile components such as F (or HF), CO_2, N_2, and H_2O played a significant role in the evolution of P lamproitic magmas. In some cases, aq-saline F (or M) may separate from silicate L during the latest stages of lamproite magma evolution. Only lamproitic rocks from SE Spain (verite, fortunite) contain I glasses different in composition from those in lamproites from other localities. They are not agpaitic and have shoshonitic affinity.

In general, the evolution of lamproitic magma during crystallization differs greatly from that of other potassic L (in particular, shoshonite and K-basaltoid) in its peralkaline trend. M evolution during crystallization in these other rock types has a strong miaskitic trend and is directed toward a gradual increase in SiO_2, Al_2O_3, alkalies and depletion in FeO_T, MgO, CaO, TiO_2 and P_2O_5. (Author's abstract)

SHEETS, S.A., ORESKES, N., RHODES, A.L., BODNAR, R.J. and SZABO, Csaba, 1997, Fluid inclusion evidence for hydrothermal origin for magnetite-apatite mineralization at El Laco Chile (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-50. First author at Dept. of Earth Sci., Dartmouth College, Hanover, NH 03755.

The El Laco magnetite (±apatite) deposits of northern Chile are hosted within Plio-Pleistocene andesitic volcanic rocks. Conflicting hypotheses for the magnetite mineralization credit either metasomatism and precipitation. A detailed FI study of clinopyroxene and apatite in the deposits supports the latter interpretation.

We examined FI associated with two distinct phases of activity at El Laco: 1) diopsidic clinopyroxene in metasomatically altered wall-rock andesite, formed prior to major magnetite deposition and 2) apatite in magnetite ore. Clinopyroxene I are extremely saline, containing multiple discrete crystal phases which distort the V bubble, and little detectable L. Anhydrite and hematite were positively identified by SEM/EDS techniques; other phases likely include water soluble chlorides. Th for these I are bimodal, with one group between 710 and 750°C and another between 830 and 840°C, possibly reflecting two stages of metasomatic alteration of andesite. We interpret these data to indicate that metasomatic alteration was produced by hot, hydrosaline F, most likely of magmatic derivation.

P FI within apatite associated with ore-magnetite are very different. They exhibit very variable phase ratios, and measurements of freezing point depression and halite dissolution indicate a complex solute assemblage with highly varying sal, ranging from about 0.2 to 59 wt.% eq. NaCl. Th range from 250 to 350°C. We interpret the variable phase ratios and sal to indicate boiling hydrothermal F. The measured T are inconsistent with the plausible T range for an immiscible iron oxide-phosphate M--indeed, for a M of any kind--and suggest that apatite-magnetite formation at El Laco was associated with a stage in the hydrothermal regime dominated by complex-solute bearing aq F boiling near 250-350°C. (Authors' abstract)

SHEN, Anjiang, CHEN, Ziliao and LU, Junming, 1997, Diagenesis, porosity evolution and hydrocarbon evaluation of Permian reef complexes in the middle and lower Yangtze area: AAPG Bull., v. 81, no. 10, p. 1781-1782.

Data analysis from varieties of test of O-C stable isotope, trace elements, I T and CL of thin sections suggested that the Permian reef complexes had undergone marine, evaporative marine, mixture of meteoric water and seawater, meteoric water and burial diagenetic environments. (From authors' abstract by E.R.)

SHEN, A.H. and KEPPLER, Hans, 1997, Direct observation of complete miscibility in the albite-H_2O system: Nature, v. 385, p. 710-712. First author at Dept. of Earth Sci., Univ. of Cambridge, Downing Street, Cambridge CB2 3EQ, U.K.

There are essentially two main types of mobile phases in the Earth's crust and mantle: silicate M and hydrous F. Near the surface of the Earth, the physical and chemical properties of these phases are fundamentally different. But with increasing P, the solubility of water in silicate M and the solubility of silicate materials in hydrous F increase. This has led to the suggestion that, above a certain critical P, the compositions of the two phases in mutual equilibrium become indistinguishable. Here we report the direct visual observation of this phenomenon in the albite-H_2O system using an externally heated diamond anvil cell. Our results suggest both that there should be complete miscibility between silicate M and hydrous F in the deeper parts of the upper mantle and that, in the presence of a hydrous F, a melting T for this part of the mantle can no longer be defined. (Authors' abstract)

SHEN, Kun, NI, Pei and **LIU, Bin,** 1997, Research progress of fluid inclusion in metamorphite abroad: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 2 (in English). First author at Shandong Inst. of Experimental Research in Geosci., Jinan, 250013.

The research progress of FI in granulites, charnockites and migmatites is reviewed in this paper. (From authors' abstract by E.R.)

SHEPHERD, Thomas, AYORA, Carlos, CENDON, Dioni, CHENERY, Simon, MOISSETTE, Alain and **ZIMMERMANN, Heide,** 1997, Interlaboratory evaluation of techniques for the chemical analysis of single fluid inclusions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 304-305. First author at British Geological Survey, Keyworth, Nottingham, NG12 5GG , U.K.

Three techniques and three laboratories were involved: laser ablation ICP mass spectrometry (BGS), cryogenic-SEM-EDS (Inst. de Ciencies de la Terra), microextraction chemical analysis (Univ. Gottingen). Brine I in halite from five different evaporite environments, both marine and continental, were selected for study. These provided a wide range of I sizes (5-500 μm) and F compositions. In addition, chemical analyses were available for the coexisting parent brines for the Recent halites.

Techniques evaluated were: laser ablation inductively coupled plasma mass spectrometry; cryogenic-SEM energy dispersive analysis; and microextraction chemical analysis (MECA). To facilitate comparison, ICP relative concentrations have been normalized to the chlorine concentrations obtained by EDS and MECA. For EDS, most trace elements are below the limit of detection. Likewise, trace element determination by MECA is only applicable to I>500μm in diameter. I of this size are rare and their genetic relationship to the majority of smaller I cannot be unequivocally established. ICP data for Na are not reported due to possible host matrix interference during ablation. As illustrated by the Dead Sea halite I, there is excellent agreement between the ICP and EDS results for Mg, K and Ca. (From authors' abstract by E.R.)

SHEPHERD, T.J. and **CHENERY, S.R.,** 1997, Spatial resolution and selective analysis of multiple populations of magmatic-hydrothermal fluid inclusions by laser ablation ICP-mass spectrometry (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). Authors at British Geol. Survey, Nicker Hill, Keyworth, Nottingham NG12 5GG, U.K.

Even though crush leach techniques are becoming ever more sophisticated and bulk sample analysis is now possible using <1 mg of host mineral, the scale of I variation makes it impossible to physically isolate individual types or generations of I for analysis. Realistically, the analytical information required to understand the temporal and spatial changes in hydrothermal F chemistry can only be acquired by application of microbeam technology. Laser ablation ICP-mass spectrometry (LA-ICP-MS) is one of several new techniques now available to unravel the evolution of magmatic hydrothermal ore deposits.

Data [are] presented to illustrate the high spatial resolution of the technique and the ability to chemically discriminate between different generations of I, using aq FI from the Bingham Canyon and Questa copper-molybdenum porphyry deposits of the western USA, and an unusual style of U-Th-REE mineralization in the Capitan Mts., New Mexico. In each case, ICP-MS analyses [are] compared with published synchrotron or crush leach data for the deposits. Because the halogens can also be detected and measured by LA-ICP-MS, trace metal signals were estimated using chlorine as the I internal standard. At Capitan Mts., the magmatic-hydrothermal aq I contain measurable levels of U in solution which can be distinguished from U-bearing dm by applying time resolved analysis to the analyte signals. 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 future instrumental developments for mineral deposit research. (From authors' abstract by E.R.)

SHEPHERD, T.J., SCRIVENER, R.C. and **CHENERY, S.R.,** 1997, Laser ablation IPC-MS analysis of magmatic fluid inclusions: Abstracts of other papers read at the Annual Conference, January, 1997, published in Proceedings of the Ussher Society, v. 9, pt. 2, p. 216. First author at British Geological Survey, Keyworth, Nottingham, NG12 5GG

Multiphase I (L + V + daughter salts) in quartz from a pegmatite lens in an aplite sill, represent the earliest magmatic-hydrothermal F at the Birch Tor tin deposit of central Dartmoor. A group of I were analysed by laser ablation, IPC-MS (LAMP-IPC-MS). The IPC mass spectrometer is interfaced to a pulsed UV laser operating at 266 nm. This configuration allows elemental analysis of individual FI in a wide range of mineral matrices, with a very high degree of spatial resolution (better than 2 microns). Detection limits are related to the volume of the I (i.e. the mass of F released). For a 20 micron diameter I, detection limits for Cu and Zn are estimated to be approximately 10-25 ppm. Reproducibility for the major and minor elements is generally better than 25%.

The results demonstrate the dilution of a parent F, without significant alteration of the elemental ratios, and also indicate the contribution of granite-derived F to the base metal mineralization of the country rocks. (Authors' abstract)

SHEPPARD, S.M.F., 1997, Vibrations under pressure: Science, v. 277, p. 775-776. Author at Laboratoire de Science de la Terre, Ecole Normale Supéieure de Lyon, 69364 Lyon Cedex 07, France; email (Simon.Sheppard@geologie.ens-lyon.fr)

Dreisner's contribution (Science, v. 277, p. 791) shows that for isotopic exchange reactions involving a F such as water, changes of P can measurably influence the fractionation factor. The vibrational frequences of gases, L and solids change with P and T. Unlike a solid, the density of a F varies more rapidly under certain P-T conditions than others. The region of strongest density variations is around the critical point of the F. (From author's text by E.R.)

SHI, Lida and **LI, Cunyou,** 1997, Testing study for seeking gold using the electric conductible degree of ore-forming solution: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 13 (in English). Authors at Shenyang Inst. of Geol. and Mineral Resources, MGMR, Shenyang, 110032.

A review of the basic principles for the electrical conductible degree method of ore-forming solution [sic], applied to the Zhangquan Zhuang gold deposit, Hebei and the Gaolong gold deposit, Guanxi. (From authors' abstract by E.R.)

SHIBETSKIY, Yu.A., FOMIN, Yu.A. and **DEMIKHOV, Yu.N.**, 1997, Isotope geochemical comparison of gold ore deposits in the Archean greenstone belts: Mineralogicheskiy Zhurnal, v. 19, no. 1, p. 38-50 (in Russian; Engl. abst.).

Isotopic-geochemical and physical-chemical characteristics of the Archaean gold ore deposits in Chertomlyk and Sura greenstone structures are compared with those of gold deposits in the south African and west Australian shields. It has been found: 1) similarity of sulphur isotopes distribution in sulphides, oxygen isotopes in quartz, carbonates and magnetite, carbon isotopes in carbonates, noncarbonate forms and CO_2 of I, hydrogen isotopes in water of FI; 2) likeness of physical (P.T) and chemical (composition, fO_2), pH) properties of ore systems; 3) difference in estimates of $\delta^{18}O$ in water of FI. The conclusion is made about identity of gold-deposition processes at the early Precambrian in the Ukrainian and other shields of the world. (Authors' abstract)

SHIBUE, Y., 1997a, Equation for densities of hydrothermal solution and their bearing on fluid inclusion study (abst.): Abstracts of 47th Annual Meeting of the Soc. of Resource Geol., June 4-6, 1997, Tokyo, Japan (in Japanese, trans. courtesy T. Sawaki).

FI of high sal often occur in quartz of granites. Such FI possibly have magmatic origin. In order to verify this, trapping P and T of the I should be determined. The author examined the relation between isochores of FI and an H_2O-saturated solidus of granite. Isochores for Th = 250, 300 and 350°C, and NaCl = 0.2 and 4 mol/kg H_2O were calculated based on Haar et al. (1984), Rogers and Pitzer (1982) and Anderko and Pitzer (1993). Volume change of host quartz was also considered for the calculation, based on Hosieni et al. (1985) and Sterner and Bodnar (1991).

The calculation shows that an isochore of a NaCl-free I crosses the solidus of granite under 5 kbars, even if its Th is 250°C. The isochores cross the solidus at lower P with increasing Th, and those for NaCl-free V I cross it below 500 bars. Isochores cross it at higher P with incrasing NaCl contents. If a FI of NaCl = 4 mol/kg and Th<300°C coexisted with magma, the P is estimated to be >5 kbars. (Author's abstract)

SHIBUE, Yasuhiro, 1997b, Equations for densities of H_2O and H_2O + NaCl hydrothermal solution at elevated pressures and temperatures: Resource Geol., v. 47, no. 3, p. 145-154 (in Japanese).

SHIKAZONO, Naotatsu, 1997, Recent genetic considerations relating to unconformity-related and sandstone-type uranium deposits: Resource Geol., v. 47, no. 4, p. 235-244.

Indexed under FI (E.R.)

SHIMIZU, K., MARUYAMA, S. and **KOMIYA, T., 1997,** Petrology of melt inclusions within chromites of 2.7 Ga komatite in Reliance Formation, Belingwe greenstone belt, Zimbabwe: (abst.): Geol. Soc. Japan Annual Meeting, Fukuoka, Oct. 10-12, Program, p. 399 (in Japanese).

SHIMIZU, Kenji, KOMIYA, Tsuyoshi, MARUYAMA, Shigenori, HIROSE, Kei, and **SHIMIZU, Nobumichi,** 1997, Water content of melt inclusion in Cr-Spinel of 2.7 Ga Komatiite from Belingwe greenstone belt, Zimbabwe: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F750. First author at Dept. of Earth and Planetary Sci., Tokyo Inst. of Tech., email (shimmy@geo.titech.ac.jp)

This study reports MI in chromian spinels in Al-undepleted komatites from the Reliance Formation in the Belingwe greenstone belt (2.7 Ga), Zimbabwe and the Secondary Ion mass spectrometry (SIMS) analysis for water in the MI.

Komatiites in which the MI in Cr-Spinels were found have not been metamorphosed under the higher grade than prehnite-pumpellyite facies condition. Cr-spinels are high magnesian; 0.68-0.78 in Mg/(Mg+Fe^{2+}) ratio, and chromian; 0.72-0.79 in Cr/(Cr+Al) ratio. The coexisting olivines are very high magnesian ($Fo_{90.7-92.4}$), and clinopyroxenes (cpx) are mostly augites ($Wo_{38-49}En_{30-51}Fs_{9-30}$) and few pigeonites ($Wo_{7-13}En_{63-69}Fs_{24}$). The Raman spectroscopic analyses detected the only [dm] cpx, within I, but back scatter images and mass balance calculations require other unknown phases within some I. X-ray image analyses show that the MI and host Cr-spinels share sharp compositional boundaries with no indications of diffusive "relaxation" during metamorphism. This line of evidence suggests the Cr-spinels appear to have the original igneous compositions and may not have reacted to the I and/or the matrix after entrapment. The size of MI are usually <5 µm, but those as large as 15 m across can be observed. Microprobe analyses with broad beam show MI range from 14.2-21.0 wt.% in MgO, 48-56 wt.% in SiO_2, 0.75-0.84 in Mg/(Mg+Fe) ratio.

Before analysis with SIMS, the standards and unknown sample were left in vacuum (1x10-6 torr) for more than 24 hours. And an area of 150x150 µm (with the I at its center) was raster-cleaned with a strong primary beam for about 15 minutes to remove surface contamination (including hydrogen). The SIMS analysis shows that the residual glass (10.5 wt% in MgO) within I contains 2.6 wt.% in H_2O. The correction for the crystallization of quench crystals of cpx within the I based on the back scatter image indicates the M of ca. 11.6 wt.% in MgO contains ca. 1.8 wt.% in H_2O. The present results differ significantly from those of McDonough and Danyushevsky (1995, AGU spring meeting), who reported a lower-limit value of 0.19 wt.%, but still agree with their contention that the komatiitic magmas were produced under hydrous conditions. It follows, therefore, that the T of the Archean mantle can be estimated lower. (Authors' abstract)

SHINOHARA, H. and **HEDENQUIST, J.W.,** 1997, Constraints on magma degassing beneath the Far Southeast porphyry Cu-Au deposit, Philippines: J. of Petrol., v. 38, no. 12, p. 1741-1752. First author at Mineral and Fuel Resources Dept., Geological Survey of Japan, 1-1-3 Higashi, Tsukuba 305, Japan.

K-silicate alteration in the Far Southeast (FSE) porphyry Cu-Au deposit formed at ~1.4 Ma, concentric to dikes of quartz diorite porphyry. At ~2 km paleodepth the hydrothermal system consisted of magmatic hypersaline L and V at 550°C and $\leq$ 50 MPa (lithostatic P). Advanced argilic alteration formed at the same time over the deposit at $\leq$1 km paleodepth from acidic condensates of the V. At $\geq$1.3 Ma, K-silicate alteration was overprinted by 350°C magmatic L (~5 wt.% NaCl eq.) at hydrostatic P. Sericite alteration and much of the Cu-Au mineralization formed at this later stage. Evolution of the magmatic F composition was simulated with a magma-chamber crystallization model. Homogeneous crystallization during early stage convection is assumed, whereas at 50 vol.% crystals the chamber becomes stagnant and crystallizes from rim to core over a narrow crystallization interval. The model calculation, based on a magma chamber with 2 km thickness at 6 km depth (150 MPa) and $\geq$800°C (saturated M composition at 30 vol.% crystals, 5 wt.% H_2O, 0-2 wt.% Cl and δD of -40‰), can reproduce the chemical and isotopic compositions of the early and late magmatic F. The most critical factor controlling the compositional evolution of the model hydrothermal system is the transition from convective to stagnant magma-chamber crystallization. There is also a sharp decrease in the rate of F exsolution associated with this transition, which can account for the thermal collapse of the FSE porphyry system from K-silicate to sericite alteration. (Authors' abstract)

SHMULOVICH, K.I., 1997, Supercritical aqueous solutions at low and high pressures: *in* Proceedings of the Fifth Int'l. Symposium on Hydrothermal Reactions, Palmer, D.A. and Wesolowski, D.J., eds., 1997, Gatlinburg, TN USA, p. 207-209. Author at Inst. of Experimental Mineral. RAS, 142432 Chernogolovka, Russia and GeoForschungsZentrum Potsdam, Germany.

SHNIP, O.A., 1997, Hydrocarbons of gaseous and fluid inclusions in minerals from granites of petroleum-bearing regions: Geologiya Nefti i Gaza, v. 2, p. 41-44 (in Russian).

Indexed under FI (E.R.)

SHOCK, E.L., SASSANI, D.C. and **BETZ, Heidi**, 1997, Uranium in geologic fluids: Estimates of standard partial molal properties, oxidation potentials, and hydrolysis constants at high temperatures and pressures: Geochim. Cosmo. Acta, v. 61, no. 20, p. 4245-4266.

SHOCK, E.L., SASSANI, D.C., WILLIS, Marc and **SVERJENSKY, D.A.**, 1997, Inorganic species in geologic fluids: Correlations among standard molal thermodynamic properties of aqueous ions and hydroxide complexes: Geochim. Cosmo. Acta, v. 61, no. 5, p. 907-950.

SIEMANN, M.G., 1997, 3-dimensional plots for the chemical composition of brine inclusions in evaporates: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 306-307. Author at Technische Univ. Clausthal, 38678 Clausthal-Zellerfeld, Germany; email (siemann@immr.tu-clausthal.de).

Plots of the system Na-K-Mg-Cl-SO_4-H_2O, originally developed by Jänecke (1923), were traditionally used to demonstrate the chemical composition of brines in evaporates. The common way of plotting is a 2-dimensional projection of the system in a Mg-SO_4-2K triangle. 2Na or H_2O can be used as additional dimension vertical to the triangle plane. Here, the chemical composition of a brine is plotted in the 3D trigonal prism of 2K-SO_4-Mg, with 2Na as the third dimension. Using 3D diagrams, the chemical composition of brines can be plotted in relation to the saturation planes of the important evaporate minerals. Such a plot can also permit detection of various errors in technique. A second possibility for a 3D plot is to use the T as third dimension. With this diagram, stability areas of different evaporate minerals can easily be defined. For FI research the 3D plot with T as the third dimension is important for investigations employing heating-cooling stage. Using this plot, the change of the chemical composition of a solution during heating or cooling can easily be determined. Thus, the formation or dissolution of crystals during the procedure can be predicted or interpreted. (From author's abstract by E.R.)

SIERRA, J., ORTEGA, L., OYARZUN, R. and **LUNAR, R.**, 1997, The Veintiuno strata-bound copper deposit, Northern Chile: Contribution of fluid inclusion data: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 881-884. Authors at Departamento de Cristalografía, Facultad de Geología, Universidad Complutense de Madrid, Spain.

The Veintiuno copper deposit consists of economic manto- and vein-type mineralizations hosted by andesitic volcanic and volcaniclastic rocks. Mineralogy is simple and includes bornite, chalcopyrite and galena, in a gangue of calcite and barite. FI studies [calcite and barite] show that the ore F were high sal brines which circulated at T between 70 and 145°C. Boiling was the main mineralizing mechanism although some F mixing may have occurred. (Authors' abstract)

SILLITOE, R.H., 1997, Characteristics and controls of the largest porphyry copper-gold and epithermal gold deposits in the circum-Pacific region: Australian J. of Earth Sci., v. 44, no. 3, p. 373.

Indexed under FI (E.R.)

SILVA, G.deL.P. and **XAVIER, R.P.**, 1997, The gold-carbonaceous matter association in lode deposits of the Rio Itapicuru greenstone belt, northeastern Brazil: Internat'l. Geol. Review, v. 39, p. 688-702. Authors at Dept. de Metalogênese e Geoquímica, Inst. de Geosciências, Univ. Nacional de Campinas (UNICAMP), P.O. Box 6152, 13.081-970, Campinas SP, Brazil.

Carbonaceous units commonly host or are closely related to lode-gold mineralization in the mesothermal Fazenda Maria Preta (FMP) and Fazenda Canto (FC) deposits of the Paleoproterozoic Rio Itapicuru greenstone belt of northeastern Brazil. The Raman spectral parameters indicate that the carbonaceous matter in both deposits corresponds to some form of microcrystalline disordered graphitic material and defines a graphitization trend from the FMP to the FC deposit.

The carbonaceous matter of the FMP deposit is isotopically lighter (δ^{13}C = -23.3‰ to -30.8‰; x = -27.4±1.8‰ relative to PDB) than the carbonaceous material of the FC (δ^{13}C = -18.5‰ to -21.0‰, x = -19.7±0.9‰). These δ^{13}C values, together with the geologic evidence, point toward a primarily biogenic organic origin.

The δ^{13}C compositions of CO_2 resulting from the oxidation or hydrolysis of the carbonaceous matter, calculated by applying the equilibrium CO_2-graphite or fractionation, fall within the range -9.7 to -18.8‰ at 360 to

420°C (FMP deposit and -6.0 to -10.0‰ at 390 to 455°C (FC deposit). These calculated $\delta^{13}C$ values are lower than those obtained from P FI CO_2 in gold-bearing veins (-6.0 to -10.2‰ for the FMP deposit; -2.8 to -4.9‰ for the FC deposit) and imply that the thermal maturation process of the carbonaceous matter contributed little to changes in the chemistry and isotopic composition of the ore F. The presence of the carbonaceous matter may have been an important factor in gold deposition during F-carbon interaction, acting: (1) as a chemical trap, by reducing the $f(O_2)$ of the ore F or enhancing F immiscibility by adding small quantities of CH_4 and N_2 to the F phase; and/or (2) as a physical barrier, by adsorbing gold on its surface as activated carbon. (From authors' abstract by E.R.)

SIMAKOV, S.K. and **IVANOV, M.V.**, 1997, Specific features of the fluid regime of eclogite-type diamond formation in subduction-related processes within the upper mantle: Dokl. Akad. Nauk, v. 354, no. 5, p. 669-671 (in Russian, translated in Trans. (Dokl.) of the Russian Acad. Sci./Earth Sci. Sections, v. 355, no. 5, p. 702-704). First author at All-Russia Research Inst. of Geol., (VSEGEI), St. Petersburg, Russia.

Calculations confirm the petrological model proposed by Shrauder and Navon, according to which crustal carbonates submerged into the mantle could be decomposed at certain T and P, with subsequent evolution of CO_2, from which the eclogite-type diamonds could be formed. In addition, the results obtained partially confirm the model previously proposed by Haggerty and Tompkins, according to which the asthenosphere has higher fO_2 values as compared to the lithosphere. (From authors' text by E.R.)

SIMMONS, S.F. and **BROWNE, P.R.L.**, 1997, Saline fluid inclusions in sphalerite from the Broadlands-Ohaaki geothermal system: A coincidental trapping of fluids being boiled toward dryness: Econ. Geol., v. 92, p. 485-489. Authors at Geothermal Inst. and Geol. Dept., Univ. of Auckland, P/Bag 92019, Auckland, NZ.

FI measurements made on sphalerites from several low-sulfidation epithermal deposits suggest a genetic link between base metal mineralization and hydrothermal brines. We undertook a FI study of sphalerites from the Broadlands-Ohaaki geothermal system. Our findings indicate that brine-filled FI do exist in sphalerite from one location, but that their origin is a consequence of local boiling toward dryness rather than introduction of a deep brine. (From authors' text by E.R.) *See figure on page 236.*

SINGH, Keser and **SHARMA, Rajesh**, 1997, Magnesite mineralisation along the Chamba Thrust, Himachal Himalaya; structural control and depositional environment using fluid inclusions: J. Geological Soc. of India, v. 49, no. 3, p. 289-296.

The study reports magnesite mineralisation along the Chamba Thrust. The FI studies of magnesite and dolomite indicate that the F involved in the genesis of magnesite was hot saline in nature at about 200 to 275°C. The magnesite is formed from the reaction of this F with the limestone/dolomite during thrusting. (From authors' abstract by E.R.)

SIRBESCU, M.-L.C. and **NABELEK, P.I.**, 1997, Fluid evolution in a simple pegmatite from the Black Hills pegmatite field, South Dakota (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-457–A-458. Authors at Dept. of Geological Sci., Univ. of Missouri, Columbia, MO 65211.

A microthermometric study of FI in a compositionally simple pegmatitic dike from the 1.7 Gy Harney Peak Granite (HPG) pegmatitic aureole, was undertaken as part of a larger project to obtain direct evidence for the composition and evolution of magmatic F in a leucogranitic system. The study was carried out on quartz samples present in several mineral assemblages with perthitic feldspar, tourmaline, muscovite, biotite, apatite and/or garnet. Two distinct types of apparently S FI are found: 1) CO_2-rich I (XCH_4=0.02-0.07) that dominate quantitatively and have isochore T from 300 to 800°C (calculated at 3 kbar), and 2) complex saline aq I with freezing point depressions ranging from -45 to -15°C that show a relatively low and narrow range of isochore T from 200 to 350°C. Some of these bear NaCl and anisotropic dm. Although coexisting, the two types of FI have distinct trail distribution: CO_2 I are disposed along several hundreds of microns long, highly dense, healed cracks, while the aq I follow longer, continuous trails that eventually crosscut the host grain boundary. The P, unexsolved CO_2-H_2O bearing I documented in the HPG (Nabelek and Ternes, 1997, GCA) and some complex pegmatites are scarce in this relatively small pegmatite intrusion. The distribution and behavior of the two major FI populations suggest distinctive evolution paths followed by the carbonic and aq phases upon exsolution. Higher Tt and discontinuity of I trails for CO_2-rich F suggest a faster rate of crack healing compared to aq saline F, that continued to circulate and be expelled at lower T. The inferred lower mobility of the carbonic phase is in agreement with the experimentally determined wetting characteristics for supercritical CO_2 and H_2O F in quartz (Brenan, 1991, Rev. Mineral.). (Authors' abstract)

SLOBODNIK, M., **MUCHEZ, Ph.** and **VIAENE, W.**, 1997, Hydrothermal fluid flow in the Devonian and Carboniferous of the Rhenohercynicum of the Bohemian Massif: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 583-586. First author at Dept. of Geol. and Paleontol., Masaryk Univ., Brno, Czech Republic and Dept. Fysico-Chemical Gel., Catholic Univ., Leuven, Belgium.

Six generations of syntectonic and post-Variscan calcite veins have been distinguished in Palaeozoic rocks in the southern part of the Moravian Karst. The significant syntectonic veins precipitated from medium to highly saline F (9.1 to 19.5 eq. wt.% NaCl) at a minimum T (Th) of 82°-136°C. Small amounts of quartz, pyrite and galena are associated with post-Variscan calcite veins. The post-Variscan mineralizing F had a relatively low T (Th = 50°-88°) and high sal (15.5-22 eq. wt.% $CaCl_2$). This type of F is similar to the F from which Mississippi Valley-Type Pb-Zn deposits formed in other parts of the Rhenohercynian zone. (Authors' abstract)

SMELIK, E.A. and **KING, H.E., Jr.**, 1997, Crystal-growth studies of natural gas clathrate hydrates using a pressurized optical cell: American Mineralogist, v. 82, p. 88-98. First author at Exxon Research and Engineering Co., Rt. 22 E., Annandale, New Jersey 08801.

The crystal-growth behavior of structure I (sI), structure II (sII), and structure H (sH) clathrate hydrates has been studied using a specially designed, pressurized optical cell. Single crystals of each hydrate type, methane sI, methane-propane (95-5%) sII, and methane-methylcyclopentane sH, were grown in equilibrium with aq L+V±L hydrocarbon. Each structure type exhibits characteristic crystal morphology, which suggests that crystal habit in natural settings, such as sea-floor outcrops, may allow visual identification of hydrate types. In addition, the relative growth rates for different Miller planes for each crystal type were determined. The relative growth-rate schemes and resulting crystal morphology of each structure can be related to the unit-cell density distribution of the small cages in each structure. Four-phase P-T equilibrium data for methane-methylcyclopentane sH data were also measured using optical methods. Evaluation of these and previously published phase-equilibrium data for all three known hydrate structures strongly suggests that hydrate assemblages of coexisting sII and sH should be common in natural settings. (Authors' abstract)

SMIRNOV, S.Z., 1997, Inclusions of mineral-forming media in synthetic and natural gemstones (formation mechanisms and genetic application). PhD dissertation Novosibirsk (in Russian).

SMIRNOV, S.Z., BAKUMENKO, I.T., TOMILENKO, A.A. and **BUKIN, G.V.**, 1997, Inclusions of a mineral-forming medium as indicators of the origin of synthetic gemstones, exemplified by melt- and flux-grown crystals: Russian Geol. and Geophys., v. 38, no. 10, p. 1632-1641 (in Russian; Engl. abst.).

I of mineral forming medium give important information on mineral origin. Applying methods, which are commonly used in studying natural mineral formation conditions, authors attempted to determine specific features of MI in synthetic ruby, sapphire, emerald, alexandrite and spinel. Crystals grown from M and flux solutions were studied. The features of I morphology, phase and chemical composition, and conditions of phase transformations are discussed in this paper.

I in the synthetic crystals have a number of typomorphous features such as crystalline aggregate as [sic] vacuole filling, high T of the phase transformations and specific compositions. These features are not typical of I in natural minerals and permit us to distinguish between natural and synthetic gemstones. They also allow description of some characteristic conditions of gemstone synthesis method. (journal abstract)

We tried to characterize the I in synthetic gemstones, such as emerald, alexandrite, spinel, and corundum, with the methods which are routinely used while studying the F and MI in natural minerals. The shape and phase composition of I in flux-grown synthetic minerals are quite similar to the I in natural magmatic minerals, and their Th range is close to that for I in minerals formed in anhydrous granite magmas, but the chemical composition is absolutely different. Most of the I in M grown chrysoberyl and corundum crystals are gaseous. Some I in crystals grown by Czochralsky method contain a small amount of glass or an aggregate of crystalline phases along with low density gas. This study shows that the specific features of MI in synthetic gemstones manufactured by flux and M growth techniques helps distinguish between natural and synthetic gemstones and helps determine type of production process and, in some cases, the manufacturer. (Abstract provided courtesy Dr. S.Z. Smirnov)

SMIRNOV, Sergey, THOMAS, Victor, DEMIN, Sergey and **TKACHENKO, Anatoly**, 1997, Surface processes of crystal growth: Formation of primary fluid inclusions (on example of the synthetic crystals grown under different condition): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 308-309. First author at Inst. of Mineral. and Petrog., SB RAS, Univ. pr. 3, Novosibirsk 630090, Russia; email (smirnov@uiggm.nsc.ru).

Synthetic crystals of corundum, spinel, beryl and chrysoberyl grown from M, hydrothermal and flux solutions were used. The study involved spontaneously grown crystals and crystals grown on non-singular seed plates. The mechanisms of growth from hydrothermal solutions and from M yield very different I trapping phenomena. The obtained results can be applied for the modeling of the mechanisms of the formation of FI entrapment during the single crystal growth under natural conditions. (From authors' abstract by E.R.)

SMIT, C.A. and **van REENEN, D.D.**, 1997, Deep crustal shear zones, high-grade tectonites, and associated metasomatic alteration in the Limpopo Belt, South Africa; Implications for deep crustal processes: J. of Geol., v. 105, no. 1, p. 37-57.

Indexed under FI (E.R.).

SMITH, C.P., GÜBELIN, E.J., BASSETT, A.M. and **MANANDHAR, M.N.**, 1997, Rubies and fancy-color sapphires from Nepal: Gems & Gemology, v. 33, no. 1, p. 24-41. First author at Lucerne, Switzerland.

Gem-quality rubies and fancy-color sapphires have been recovered from dolomite marble lenses located high in the Himalayan mountains of east-central Nepal (Ganesh Himal). Discusses and illustrates solid and FI in these rubies. (H.E.B.).

SMITH, M.P., 1997a, Flud inclusions well logs: Petroleum migration, seals, and proximity to pay: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 310. Author at Advanced Hydrocarbon Stratigraphy, Inc., 3520 S. Rolling Oaks Dr., Tulsa, OK 74107-4515; email (AHStrat@aol.com).

FI Well Logging is a new technology for mapping petroleum migration, seals, and proximity to pay, even in a dry hole without shows. The data are FI volatile mass spectra of normal washed drill cuttings, taken at an interval of about 10 m from surface to TD. Various aspects of the FI compositions are plotted vs. depth. Multiple gas analyses of different FI populations are performed for each sample. The compositions of the various FI gas aliquots on a single sample can be quite different, and can provide insight into multiple migration episodes through the same strata. (From author's abstract by E.R.)

SMITH, M.P., 1997b, Fluid inclusion well logs; migration, seals and proximity to pay: AAPG Bull., v. 81, no. 8, p. 1354-1355 (also in AAPG Abstracts, v. 6, p. 109).

FI well logging is a new technology for mapping petroleum migration, seals, and proximity to pay. The data are FI volatile mass spectra of normal washed drill cuttings, taken at an interval of about 10 m from surface to TD. Various aspects of the FI compositions are plotted vs. depth. Multiple G analyses of different FI populations are performed for each sample. The compositions of the various FI G aliquots on a single sample can be quite different. All lithologies and geologic ages are analyzed. There is no difference in data based on age of the samples. The technique works equally well on samples from wells drilled with oil-based or water-based muds. Cores and outcrop samples can also be analyzed. Migration is documented as petroleum I bearing strata. Migration compartments can be either vertically extensive or focused. Insight is provided into product type, i.e. dry gas, wet gas, oil, or biodegraded oil. Seals are documented as boundaries of petroleum-I bearing strata with strata lacking petroleum I, or as boundaries between strata bearing markedly different types of included petroleum. Proximity to pay is sometimes inferred by I dominated by water soluble hydrocarbons, i.e., benzene, toluene, methane, and ethane, but lacking the less soluble petroleum constituents, i.e., paraffins and naphthenes. (Author's abstract)

SMITH, S.G., 1997, Controls on Zn grade at the Warrabarty carbonate-hosted Zn-Pb prospect, W.A., with some implications for the grade of MVT deposits: Geological Society of Australia, Abstracts No. 44, p. 66. Author at CODES Key Centre, Univ. of Tasmania, GPO Box 252-79, Hobart 7001.

Warrabarty is known only from drilling and occurs predominantly in breccias and veins with lesser disseminated to massive sulphide. The main generation of sphalerite is Fe-poor and typically occurs as thin (<5 mm) rims around breccia fragments or coating vein walls. Sphalerite rarely occludes porosity with several generations of dolomite and minor quartz gangue typically post-dating sphalerite. Both sphalerite and dolomite have complex internal paragenesis and detailed work has documented a series of precipitation-dissolution episodes in both minerals. Carbon and oxygen isotope data for gangue dolomites and original host rock dolomites show almost complete overlap on $\delta^{18}O$-$\delta^{13}C$ plots indicating that the mineralising F did not receive significant input from sources external to the host carbonate package. Furthermore, dolomite gangue compositions show no evidence for F mixing trends and it is concluded that a single F was responsible for carbonate transport and deposition.

T estimated from FI analyses indicate sphalerite and dolomite deposition occurred in the range 150-200°C from high saline (22-25.5 wt.% total salts), complex $NaCl$-$CaCl_2$ (± Mg-Fe-K) bearing brines. The textural and grade similarities between the low grade MVT class and typical Warrabarty mineralisation suggest that they formed from a similar, inefficient wall-rock reaction mechanism. The higher grade class of MVT deposits may have formed from fundamentally different processes, involving a more efficient depositional mechanism, such as F mixing. (From author's abstract by H.E.B.)

SMITHSON, S.B. and **GANCHIN. Y.V.**, 1997, Fluids, reflections and seismic velocity at the Kola Superdeep Borehole, Russia: Eos Trans. AGU v. 78 (17), Spring Meet. Suppl., p. S335. First author at Dept. of Geol. and Geophys. Univ. of Wyoming, P.O. Box 3006, Laramie, WY 82071-3006; email (smithson@moho.uwyo.edu)

The Kola Superdeep Borehole, drilled to a depth of 12.4 km, penetrates 8.6 km of dense higher velocity Proterozoic supracrustal rocks and 5.6 km of lower velocity Archean biotite gneisses, pelitic gneisses, migmatites, and amphibolites. Results of VSP and CDP profiling suggest the presence of F down to a depth of at least 12 km in the upper crust; the presence of these F lowering seismic velocity causes estimates of upper crustal composition to be too felsic. (From authors' abstract by E.R.)

SO, C.-S., CHOI, S.-H and **SHELTON, K.L.**, 1997, Geochemistry and genesis of hydrothermal Cu deposits in the Gyeongsang Basin (Andong area), Korea: A link between porphyry and epithermal systems: N.Jb. Miner. Abh., v. 171, no. 3, p. 281-307.

The Andong Cu ore mineralization occurred in three stages of quartz and calcite veins. The major ore minerals, pyrite and chalcopyrite, together with pyrrhotite, sphalerite, magnetite, hematite, galena and minor electrum and Pb-Bi and Ag-Sb sulphosalts, occur in fissure-filling quartz veins within sedimentary rocks.

Paragenesis of the main ore stage (I) can be divided into three substages: Ia, pyrite (+ chalcopyrite); Ib, chalcopyrite + magnetite; Ic, hematite + sulphosalts. Changes in mineralogy reflect decreases in T and fugacity of sulfur with a concomitant increase in fugacity of oxygen. FI data indicate progressive decreases in T and sal within each substage with increasing paragenetic time. During the early portion of stage I, high-T (≥ 320°C), high-sal F (up to ≈ 42 eq. wt.% NaCl) formed by condensation during decompression of a magmatic V phase at P ≈ 300 bars. During waning of substage Ia, high-T, high-sal F gave way to progressively cooler, more dilute F associated with main copper mineralization (substage Ib) and finally to ≈ 200°C and ≈ 1 eq. wt.% NaCl F associated with hematite±sulfosalt mineralization (substage Ic). These trends are interpreted to indicate progressive mixing of high-sal hydrothermal F with cooler, more dilute, oxidizing meteoric waters. The trend in δD and ^{18}O, coupled with FI data, are interpreted to indicate progressive meteoric water inundation of an early magmatic hydrothermal system. (From authors' abstract by E.R.)

SO, C.-S and **YUN, S.-T.**, 1997, Jurassic mesothermal gold mineralization of the Samhwanghak mine, Youngdong area, Republic of Korea: Constraints on hydrothermal fluid geochemistry: Econ. Geol., v. 92, p. 60-80. Authors at Dept. of Earth and Environmental Sci., Korea Univ., Seoul 136-701, Republic of Korea.

The mesothermal gold vein deposits of the Samhwanghak mine are gold-bearing but relatively sulfide-poor massive quartz veins which occupy shear zones in graphite-bearing paragneiss of Precambrian age.

Vein quartz was deposited mostly prior to deposition of sulfides and gold, and contains three main types of FI: (I) CO_2-CH_4 F, (II) low-sal (<9 wt.% NaCl eq.) H_2O-CO_2-CH_4 F with variable $CO_2 + CH_4$ contents, (III) dominantly aq (0-14 wt.% NaCl eq.) F with small amounts of CO_2. Type II inclusions are largely P in origin and represent early, immiscible F formed by extensive F unmixing CO_2-CH_4 effervescence) at T from 480 to 220°C and P up to >2 kbars. Initial hydrothermal F were near their critical states at T of 410 to 480°C and were homogeneous compositionally with $X_{CO_2 + CH_4}$ of 0.45 ($X_{CH_4} = 0.14$) and sal of ≈ 9 wt.% NaCl. Type III inclusions appear to be S and represent later F which formed through extensive F unmixing of type II F with progressive decreases in T (below 370°C) and P (down to ≈ 1 kbar), but may also include deep circulating meteoric waters.

Thermochemical calculations indicate the following evolution of hydrothermal F: fugacity of sulfur decreased progressively with decreasing T near the pyrite-pyrrhotite sulfidation curve; fugacity of oxygen was controlled largely through graphite-F interaction and evolved near the QFM buffer; pH was maintained near neutrality. T vs. fO_2 relationships indicate that hydrothermal F were derived originally from a nearby S-type magma, the Middle Jurassic Kimcheon Granite. Gold occurs as gold-rich (avg. 72 at % Au) electrum intimately associated with sulfide minerals, and precipitated from later aqueous (type III) F at T of 340-240°C as a combined result of cooling and decrease of sulfur activity (by sulfide precipitation and/or H_2S loss accompanying F unmixing). (From authors' abstract by E.R.)

SOBOLEV, N.V. and **EFIMOVA, E.S.**, 1997, Syngenetic mica inclusions in diamonds: Evidence for volatiles significance in deep lithospheric mantle (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-191. Authors at Inst. of Mineral. and Petrog., 630090, Novosibirsk, Russia; email (sobolev@uggim.nsc.ru).

Here we report on phlogopite and biotite I coexisting with minerals either of peridotitic paragenesis (U-type) or eclogitic ones (E-type) from a collection consisting of about 22 diamonds from Siberian and Arkhangelsk kimberlites. All analyzed micas contain up to 0.74 wt.% F and up to 0.49 wt.% Cl.

Hydrous phases such as biotite and phlogopite may play a significant role at "diamond" depth of the mantle. It is likely that an abundance of volatiles in a lithospheric mantle within the diamond stability field may vary locally as in the case of dominating Mir-Sputnik pair of pipes in a studied collection. (From authors' abstract by E.R.)

SOBOLEV, N.V., KAMINSKY, F.V., GRIFFIN, W.L., YEFIMOVA, E.S., WIN, T.T., RYAN, C.G. and **BOTKUNOV, A.I.**, 1997, Mineral inclusions in diamonds from the Sputnik kimberlite pipe, Yakutia: Lithos, v. 39, p. 135-157. First author at Inst. of Mineral. and Petrog., Russian Acad. Sci., Novosibirsk 630090, Russia.

Large compositional variations among I of one phase (olivine, garnet, chromite) within single diamonds indicate that the chemical environment of diamond crystallization changed rapidly relative to diamond growth rates in many cases. The minor differences between I in Mir and Sputnik may reflect lateral heterogeneity in the upper mantle. (From authors' abstract by E.R.)

SOBOLEV, R.N. and **ZHU, Yungfeng**, 1997, Temperature of magma crystallization in 5 km section of granitic body: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 311-312. First author at Geological Fac., Lomonosov Moscow State Univ., Russia, 119899 Moscow.

Determinations were made of Th for MI in alkali feldsapr and quartz phenocrysts from 4 depths (0-4067 m) and from center and rim of Eldjurtu granite (near volcano Elbrus). The differences are small (≤110°C) for alkali feldspar but ≤245°C for granite. The point is made that Tm for a given mineral is always less than T of magma intrusion (E.R.).

SOKOLOV, S.V. and **VEKSLER, Ilya**, 1997, Mineralogy of melt inclusions in niocalite from carbonatites of the Oka Complex, Canada (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A140. First author at All-Russia Inst.of Mineral Resources, Staromonetny per., 31, Moscow, 109017, Russia.

Niocalite is a rare F-bearing silicate of Ca and Nb first found in carbonatites of Oka (Canada) and known to be present also in rocks of Kaiserstuhl complex (Germany) and natrocarbonatite lavas of Oldoinyo Lengai volcano (Tanzania). The samples used in this study are from Oka carbonatites where niocalite is associated with Mn-monticellite, diopside, phlogopite, magnetite and apatite. P M I in niocalite are up to 60 microns across, and are composed by an aggregate of dm (90-95 vol.%) and heterogeneous (gas + liquid) F. Crystalline daughter phases were analysed by electron microprobe. The usual mineral association found in the I is: diopside + andradite + magnetite + calcite±phlogopite, in rare instances it may be: diopside + calcite±(melilite, phlogopite and monticellite). In one of the I a phase was detected which has 69.83 wt.% CaO and is presumably portlandite (though fluorite also could not be ruled out completely). In most cases the chemical composition of daughter phases of studied I is similar to that of the Oka rock-forming minerals. All silicate phases are characterized by high Mn content. It can be concluded that Oka niocalite crystallized from silicate-carbonate volatile-rich M. (Authors' abstract)

SOLOMON, Michael and **KHIN Zaw**, 1997, Formation on the seafloor of the Hellyer volcanogenic massive sulfide deposit: Econ. Geol., v. 92, p. 680-695. Authors at Centre for Ore Deposit and Exploration Studies, Univ. of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7001.

New FI data from the stockwork veins beneath the Hellyer orebody, a relatively undeformed, Late Cambrian polymetallic volcanogenic massive sulfide deposit, allow semiquantitative modeling of the behavior of the ore F on the sea floor and the manner of growth of the massive sulfide. The earliest cool F may have been denser than seawater and ponded in a basin identified by sedimentological and structural studies. Subsequent vent F mixed with the cooler brine. Estimates of likely T and sal in the brine pool for the first main mineralization stage (avg 200°C, 11 wt.% sal), assuming a steady or quasi-steady state, had been established, and using volume fluxes similar to those observed in modern oceans, indicate T <<100°C. Sulfides (mostly pyrite, sphalerite, and galena) precipitated from the vent F after mixing with cooler basin F settled from the gravity current to the basin floor, a pattern that would have continued whether or not a true steady state was reached. If the early F were buoyant in seawater they ponded after mixing, forming a hybrid brine pool that would have required longer periods to homogenize. At the peak T (≥ 300°C) and volume flux the sal of the vent F fell to <7.5 wt.%, but the flow paths would have been maintained unless the brine pool had been drained. The brine pool model explains several features of the Hellyer ore that differ from those of the ores of the Hokuroko basin, namely, the large metal content, high Zn/Cu ratio, low aspect ratio, absence of chimney fragments, presence of mineral banding, and high barite sulfur isotope values, features seen in many other massive sulfide orebodies. (From authors' abstract by E.R.)

SOLOVÓVA, I.P., RYÁBCHIKOV, I.D., BABÁNSKY, A.D. and **FAUZI, H.**, 1997, Mobilization of fluorine and conditions of formation of vein fluorite in rare-metal granites as exemplified in the Homrat Akarem deposit, Egypt: in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 75, ISBN 5-88918-002-9 (in Russian; English translation courtesy Dr. D. B. Brown). Authors at IGEM, RAS, Moskvá.

The Homrat Akarem deposit is located in the Eastern Desert of Egypt approximately 120 km east of the town of Aswan. Fluorite veins, up to 0.5 m wide and up to 80 m long, occur in a granite massif of the same name. In geochemical terms, the Homrat Akarem granites correspond to Li-F granites and possess increased amounts of such rare and disseminated elements as Be, Li, Rb, Sn, Mo, W, Pb, Zr, and Zn.

During a study of the M, solid and F microinclusions in quartz from the Homrat Akarem rare-metal granites, the P-T parameters of several key moments in the evolution of fluorine (containing up to 0.5 wt.% F) from a water-saturated (9-10 wt.% H_2O) granitic system, have been determined: 1. Crystallization of quartz-640°C, 8 kbar; 2. Complete solidification of melt-500-550°C; 3. Partial loss of F by MI-550°C, 6 kbar; 4. Isolation of late-magmatic F-500-550°C, 4-5 kbar; and 5. Crystallization of microschlieren in the granite-300°C, 0.1 kbar.

Proofs have been obtained of the magmatic origin of the topaz. Moreover, a study of the FI in the vein fluorite has shown that this fluorite deposit was formed at T of 320-95°C and P of 500-800 bars, with involvement of high- and low-mineralized F (0.1-4.3 and 13.5; 19.0 wt.% eq. NaCl respectively). The weakly-mineralized solutions could have developed as a result of cooling of F-containing, essentially chloride F which separated from the residual granitic M at a T of the order of 550°C. CO_2 F did not participate in the ore-deposition and appeared only during the late phase of carbonitization of the fluorite veins.

The behaviour of the fluorine during the magmatic and post-magmatic phases of evolution of these rare-metal granites, and also the possible genetic association between them and the fluorite mineralization, have been investigated through thermodynamic calculations using the TBG data obtained. It has been shown that topaz, which at a lower T is replaced by fluorite, is stable in association with quartz, muscovite, microcline, and low-Ca plagioclase, above 350°C. (Authors' abstract)

SONIN, V.M., ZHIMULEV, E.I., FEDOROV, I.I. and **OSORGIN, N.Yu.**, 1997, Etching of diamond crystals in silicate melt in the presence of aqueous fluid under high P-T parameters: Geokhimiya, 1997, no. 4, p. 451-455 (in Russian, translated in Geochem. Internat'l., v. 35 no. 4, p. 393-397).

SOTAK, Jan, KOTULOVA, Julia, PITONAK, Pavel, SPISIAK, Jan, MAGYAR, Julius and **RUDINEC, Rudolf**, 1997, Sedimentology and hydrocarbon habitat of the submarine-fan deposits of the Levoca Basin (Centrocarpathian Paleogene, Slovakia): AAPG Bull., v. 81, no. 8, p. 1413-1414.

Oil generation in the basinal deposits is noticeable from the presence of solid bitumens and HC-rich FI. Both of them point to overpressure conditions during HC generation and migration. Potential HC traps can be expected in porous sedimentary members. (From authors' abstract by E.R.)

SOUISSI, F., DANDURAND, J.L. and **FORTUNÉ, J.P.**, 1997, Thermal and chemical evolution of fluids during fluorite deposition in the Zaghouan province, north-eastern Tunisia: Mineralium Deposita, v. 32, p. 257-270. First author at Laboratoire de Géochimie, Inst. National de Recherche Scientifique et Technique, BP 95, 2050 Hammam-Lif, Tunisia.

Several F, Pb, Zn and Ba deposits occur in reef limestones, as stratiform replacement heaps and lenses, breccia fillings and dissolution void fillings and lodes. Microthermometric analyses of the IF observed in fluorite and quartz show that the economic concentrations of fluorite have deposited from moderate to highly sal (12-22.5 wt.% NaCl eq.) hydrothermal (110-160°C) mineralizing F. Late remobilizations, observed in the stratiform deposits, are related to the circulation of a warmer (up to 185°C) but less saline (10 wt.% NaCl eq.) F and more saline (12-22 wt.% NaCl eq.) F. The highest T (up to 250°C) and sal (32-34 wt.% NaCl eq.) are observed to the west of the province. Less saline (3-6 wt.% NaCl eq.) and moderately hot to hot F (up to 220±20°C) and rich in gaseous CO_2 invade most of the ore deposits in later stages and give rise to the massive quartz within fractures. Chemical analyses of the F extracted from the I occurring in fluorite show Na^+, Ca^{2+} and Cl^- and T of the F in the source reservoir to be estimated as 275±25°C. The mineralogical associations hosted within carbonate rocks, the T and the sal of the F, their composition and the molar ratios between the major ionic species, as well as the presence of L hydrocarbons in the mineralizing F, show that the ore deposits belong to the carbonate-hosted F, Pb, Zn, Ba Mississippi Valley-Type deposits. (From authors' abstract by E.R.)

SOUZA NETO, J.A., SONNET, Ph. and **LEGRAND, J.M.**, 1997, Nitrogen-rich fluid inclusions in the Itajubatiba gold skarn deposit, NE Brazil: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 313-314. First author at Univ. Catholique de Louvain, Louvain-la-Neuve, Belgium.

The Itajubatiba gold deposit occurs in metasomatized marble, schist, and orthoderived migmatite and alkaline rocks. Gold occurs within the calc-silicate rocks either disseminated or in tension gash fractures. It is associated with quartz, calcite, pyrrhotite, pyrite and chalcopyrite. FI were analyzed in quartz, calcite and garnet. They can be divided into four groups according to their order of abundance. (1) One- and two-phase carbonic FI. In the gold-bearing veins, Tm_{CO_2}=-57.4 to -56.8°C, and Th_{CO_2}=16 to 28°C (peak at 25°C). In the barren vein and in calc-silicate rocks, Tm_{CO_2}=-56.8 to -56.6°C and Th_{CO_2}=-26 to 30.4°C (peak at 13°C). FI from the gold-bearing veins show up to 4 mol% of N_2±traces of CH_4, with density=0.712 g/cm^3. (2) Nitrogen FI have Th_{N_2} from -157 to -133°C, and some down to -196°C. Te values >-146.9°C indicate up to 18 mol.% CH_4; density=0.005-0.152 g/cm^3. (3) Aq-saline FI from gold-bearing veins have Te between -43 and -31°C, sal of 7.8 wt.% NaCl, Th=140°C, and density=0.963 g/cm^3. In the barren veins and in the calc-silicate rocks, Te is above -67°C, sal is lower (4.8 wt.% NaCl), Th=340°C and density is lower (0.680 g/cm^3). (4) Aq-carbonic FI show either L or L+VCO_2. The degree of fill by the L carbonic phase is in the range 20-40%, but can reach 70% at places. Tm_{CO_2} has two peaks=-57.7 or -59.3°C. Gold-bearing veins have X_{H_2O}=0.86, X_{CO_2}=0.13, sal=4.8

wt.% NaCl and bulk density 0.967 g/cm^3, coresponding to Tm$_{Clath}$=7.5°C, Th$_{CO_2}$(l)=15°C and volumetric fraction CO$_2$=0.3 at 20°C. Barren veins have X$_{H_2O}$=0.68, X$_{CO_2}$=0.31, sal of 5.6 wt.% NaCl and bulk density of 0.959 g/cm^3, corresponding to Tm$_{Clath}$=7.5°C, Th$_{CO_2}$(l)=5°C and volumetric fraction CO$_2$=0.5 at 20°C. Th$_{tot}$ for both vein types varies from 240 to 400°C (peak at 300°C) and homogenization usually occurs to the CO$_2$ phase. These I can show up to 11 mol.% of N$_2$ in the gaseous carbonic phase.

An important characteristic of the observed F in these rocks is the presence of nitrogen, probably from the breakdown of organic matter, NH$_4$-bearing biotite, muscovite, or K-feldspar, or deep-seated (mantle). Nitrogen I contain from 14 to 18 mol.% of CH$_4$. Methane could originate by a reaction between hydrous F and graphite in the marble. F components at the Itajubatiba gold deposit such as N$_2$ and CH$_4$ could have played a significant role for gold deposition, possibly by causing instability of the gold complexes. (From authors' abstract by E.R.)

SPRY, P.G., FOSTER, F., TRUCKLE, J.S. and **CHADWICK, T.H.**, 1997, The mineralogy of the Golden Sunlight gold-silver telluride deposit, Whitehall, Montana, U.S.A.: Mineral. and Petrol., v. 59, p. 143-164. First author at Dept. of Geological and Atmospheric Sci., Iowa State Univ., Ames, Iowa, U.S.A.

The Golden Sunlight gold-silver telluride deposit, hosted primarily within the Mineral Hill breccia pipe (MHBP), is spatially related to a high-level, Late Cretaceous multiple intrusive, alkaline to subalkaline porphyry system. Base metal veins and manganese (rhodochrosite) mineralization occur up to 2 km from the MHBP and form part of a regional mineral zonation pattern genetically related to a low-grade porphyry molybdenum system. (From authors' abstract by E.R.)

SRIKANTAPPA, C. and **VENUGOPAL, L.**, 1997, Fluid inclusions in migmatites from Hunsur, Karnataka: J. Geological Soc. of India, v. 49, p. 503-511. Authors at Dept. of Geol., Manasagangotri, Univ. of Mysore, Mysore - 570-006.

FI studies in migmatites around Hunsur document the presence of a) CO$_2$-CH$_4$, CO$_2$ and CO$_2$-H$_2$O I in paleosome, b) predominantly CO$_2$ I in leucosome and c) CO$_2$ and low sal aq I in late pink granite. Chronological studies of CO$_2$ I in quartz grains from migmatites and their densities corresponding to Th maxima plus mineral P-T data for the regional metamorphism indicate that they are syn-migmatitic F. An internal origin of CO$_2$ I during the process of migmatization is envisaged. (Authors' abstract)

STACHEL, Thomas and **HARRIS, J.W.**, 1997, Diamond precipitation and mantle metasomatism–Evidence from the trace element chemistry of silicate inclusions in diamonds from Akwatia, Ghana: Contrib. Mineral. Petrol., v. 129, p. 143-154. First author at Inst. für Mineralogie, Univ. Frankfurt, Postfach 11 99 32, D-60054 Frankfurt, Germany.

Trace element concentrations in the four principal peridotitic silicate phases (garnet, olivine, orthopyroxene, clinopyroxene) included in diamonds from Akwatia (Birim Field, Ghana) were determined using SIMS. Equilibration T for harzburgitic I are generally below the C-H-O solidus of their paragenesis, those of lherzolitic I are above. Crystallization of harzburgitic diamonds from CO$_2$-bearing M or F may thus be excluded. Diamond I chemistry and mineralogy also is inconsistent with known examples of metasomatism by H$_2$O-rich M. We therefore favour diamond precipitation by oxidation of CH$_4$-rich F with highly fractionated trace element patterns which are possibly due to "chromatographic" fractionation processes. (From authors' abstract by E.R.)

STALDER, R., FOLEY, S.F., BREY, G.P., FORSYTHE, L.M. and **HORN, I.**, 1997, First results from a new experimental technique to determine fluid/solid trace element partition coefficients using diamond aggregate extraction traps: N.Jb. Miner. Abh., v. 172, no. 1, p. 117-132.

STASIUK, L.D. and **SNOWDON, L.R.**, 1997, Fluorescence microspectrometry of synthetic and natural hydrocarbon fluid inclusions: Crude oil chemistry, density and application to petroleum migration: Applied Geochem., v. 12, p. 229-241. Authors at Geological Survey of Canada, Calgary, 3303-33rd St., N.W., Calgary, Alberta, T2L 2A7, Canada.

The fluorescence spectra of crude oils, synthesized as hydrocarbon FI in NaCl crystals, have been recorded and correlated with crude oil chemical analysis. First order linear regression equations provide a method for constraining the chemical composition of natural hydrocarbon FI. (From authors' abstract by E.R.)

STEELE, G.B., RICE, C.M., BOYCE, Adrian and **FALLICK, Tony**, 1995, Hypogene and supergene silver mineralisation at Cerro Rico, Bolivia (abst.): Mineral Deposits Study Group, Univ. Southampton, UK (unpaginated). First author at Dept. of Geol. and Petrol. Geol., Univ. of Aberdeen, Aberdeen, AB9 2UE, Scotland.

Cerro Rico is the world's largest silver deposit. Since its discovery in 1545, it has produced an estimated 1-2 billion oz. of silver. Hypogene silver mineralisation is hosted by a sheeted, polymetallic vein system which cross-cuts a pervasively altered Miocene dacite dome. During a late oxidation event, hypogene silver was remobilised to form a disseminated supergene orebody.

Hydrothermal alteration shows features characteristic of both the porphyry and epithermal environment. Acid-sulphate alteration, consisting of advanced argillic alteration capped by residual vuggy silica, overlies deeper sericitisation and tourmalinisation. The advanced argillic assemblage (quartz, dickite, aluminum phosphate-sulphate (APS) minerals and pyrite), formed through the neutralisation of a supergene, acid-sulphate F at T between 120 and 280°C and a pH of <6.

Polymetallic vein mineralisation is vertically and laterally zoned from deep Sn-W-Bi-As-Cu assemblages to peripheral Pb-Zn-Sb-Ag. Silver occurs within complex Pb-Sb sulphosalts, tetrahedrite (freibergite) and pyrargyrite. The richest hypogene silver ores are coincident with the zone of advanced argillic alteration. Hydrothermal veins cutting the acid-sulphate alteration also contain banded cryptocrystalline quartz, APS minerals and barite.

Oxidation commenced during the closing stages of hypogene mineralisation in response to lowering of the palaeo-water table. Silver was remobilised laterally from veins to wall rock and may also have been transported upwards through the capillary movement of pore F. The lack of supergene enrichment at the base of oxidation indicates that there was no net downward movement of silver. Barite and iron hydroxides provided favourable substrates for the deposition of secondary silver sulphides and silver halides respectively. Native silver is reported from the worked-out oxidised veins.

FI within late-stage vein quartz yield uncorrected Th between 190 and 280°C and an average sal of 8 wt.% NaCl eq. Late-stage barite contains monophase aq I with an average sal of 5 wt.% NaCl eq. Stable isotope analyses ($\delta^{18}O$ and δD) of quartz and clay minerals are consistent with a magmatic source for the hypogene hydrothermal F $\delta^{34}S$ isotopes of all sulphide phases have a distinctly magmatic signature. A mixing model involving magmatic F and meteoric groundwater is proposed to explain the $\delta^{18}O_{SO_4}$ and $\delta^{34}S$ isotopes of late stage barites.

Hypogene 'bonanza' silver mineralisation was precipitated where reduced, hypogene, magmatic F entered the acid-sulphate zone, below the palaeo-water table. Oxidation resulted in residual enrichment of these vein ores and formation of the disseminated orebody. With an estimated current resource of 143 Mt @ 175 g/t Ag, this disseminated supergene mineralisation constitutes a world-class silver orebody. (Authors' abstract)

STEMPROK, Miroslav, 1997, Composition and nature of fluids forming mineral zones around ore-bearing granites (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 78-79 (in English), ISBN 5-88918-002-9. Author at Faculty of Sci., Charles Univ., Prague, Czech Republic.

[Various] data justify at least seven models for the origin of the metal-enriched F responsible for the granite-related mineralization which are as follows: a) emanation differentiation-migration of volatiles carrying ore metals to the tops of L or L-crystal granites. b) metasomatic differentiation-leaching of solid granites by postmagmatic hydrothermal F, c) crystallization differentiation-accumulation of some ore elements into residual M and F from fractional crystallization of granites, d) thermogravitational differentiation-gravitational enrichment of metallic ionic groups in L granitic M and their extraction by transmagmatic F, e) metamorphic differentiation-movement of metamorphic F enriched in metals by the heat of granitic intrusions, f) mantle F extraction-movement of transmagmatic and/or mantle F through the mantle, lithosphere and granites where the granites and their conduits serve as the channelways for their migration, g) meteoric water circulation-meteoric water set to movement by the heat of a cooling intrusion or by radioactive heat of the high-heat production granites.

Despite this variety of the models accepted in the literature, the composition of F precipitating the minerals in non-carbonate environment is strikingly similar, characterized by the predominance of Na, Ca, K among the cations and Cl among the anions and with variable representation of CO_2 and sulphur species.

The present knowledge gives little support to a single-stage model of T zoning around homogeneous granite bodies with hydrothermal F cooling gradually away from the parental intrusion. More plausible is the model of a complex granitoid batholith whose late stage igneous high silica members concentrated, channeled or set to movement hydrothermal F which in a sequential way formed the aureole of hydrothermal ore deposits, the idea which was accepted by Betekhtin (1955b) for F derived from crystallizing magmas. (From author's abstract by E.R.)

STENINA, N.G., 1997, Problems of ore formation in light of new data on the mechanism of mineral matter transformation (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 168-169 (In Russian; Engl. translation from: English Version of the Abstracts of the Oral Presentations of the Papers of the Russian Participants, p. 30-31). ISBN 5-88918-002-9. Author at Inst. of Geol., SB RAS, 630090, Universitetskii pr. 3, Novosibirsk, Russia.

Discusses the significance of "aqua-complex": [2 TO_3-OH_2-Me^{n+} $2M^{m+}$ $O_4{}^1$]

Five functions of aqua-complex were determined as follows: 1) it is responsible for variability of mineral matter, 2) it provides evolution of rocks and 3) formation of granitic M, 4) it appears to be a reason for the existence of geochemical associations, 5) it provides conversion of energy within the Earth's crust.

A concept of aqua-complex gives new insight into the process of ore formation as it [reveals] interrelation mechanism between such processes as rock deformations, mineral matter evolution (metamorphosis), formation of granitic magma and hydrothermal activity. These geological events take place within a continuum of rock matter which has a structure of aqua-complex. [sic] (From author's abstract by E.R.)

STEVENS, G., 1997, Melting, carbonic fluids and water recycling in the deep crust: An example from the Limpopo belt, South Africa: J. Metamorphic Geol., 1997, no. 15, p. 141-154. Author at Economic Geol. Research Unit, Univ. of the Witwatersrand, P/B 3, PO Wits 2050, Johannesburg, South Africa.

The proposed retrograde orthoamphibole isograd in the Southern Marginal Zone of the Limpopo Belt separates hydrated, amphibolite grade metapelites from their granulite grade precursors and provides an intriguing geological dilemma. Widespread rehydration of metapelitic granulites under conditions of 660-600°C and ≥0.6 GPa, and CO_2-dominated FI populations appear to suggest thorough flushing of the high-grade crust with an externally derived carbonic F. However, past studies of the carbon and oxygen isotope geochemistry of the hydrated rocks have not demonstrated the involvement of any voluminous 'out of equilibrium' F in the evolution of the rocks. This contribution proposes a model wherein the hydrating F are derived from crystallizing anatectic leucosomes, generated by in situ F-absent biotite melting along the prograde path. Model equilibrium F compositions suggest that reaction between this M-derived H_2O and biogenic graphite produced CO_2-rich F compositions and potentially high F:rock ratios at the wet granite solidus. This single process holds the potential for wide-spread retrogression of formerly high-grade assemblages, at a variety of aH_2O values, without external F input. (From author's abstract by E.R.)

STUDENT, J.J. and **BODNAR, R.J.,** 1997, Modeling the P-V-T-X properties of haplogranite melt inclusions during heating and cooling: Eos Trans. AGU v. 78 (17), Spring Meet. Suppl., p. S331. Authors at Dept. of Geological Sci., Virginia Tech, Blacksburg, VA 24061.

A model is presented which predicts the P-V-T-X evolution of crystalline MI during cooling and heating. In the model, hydrous haplogranite M (Ab-Or-Qtz-H_2O) are trapped in quartz at a selected P between 500-5000 bars, 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. 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.

As an example of the results predicted by the model, Figure A shows the calculated phase volume relationships for a H_2O-saturated minimum M trapped at 500 bars and 782°C in quartz. During heating from room T water phases in the bubble homogenize to the L phase at 365°C (Fig. A, II). With continued heating the internal P in the I follows the H_2O isochore to the haplogranite minimum M curve (solidus) where first melting begins (Fig. A, point III). With continued heating, the P-T path follows the H_2O-saturated solidus and the internal P decreases has H_2O, feldspar and quartz dissolve in the M (Fig. A, III, IV and V). Total homogenization occurs at the trapping conditions with the simultaneous consumption of H_2O (Th) and feldspar-quartz (T_{msil}) by the M (Fig. A. VI).

In the H_2O-saturated examples, total homogenization occurs with the simultaneous consumption of quartz, feldspar and V by the M. The entrapment T is determined by the T of complete melting of feldspar and quartz (T_{msil}) and the V-M Th which are both equal to Tt. In the mixed scenario, total homogenization occurs by V-M Th at an unreasonably high T that does not correspond to Tt. In the mixed trapping scenario, the T of complete melting for feldspar (T_{mfeld}) corresponds to Tt, at a T lower than V-M Th. The minimum entrapment T for H_2O-undersaturated M can be determined by the T of complete melting of feldspar and quartz (T_{msil}). In this case, Th occurs at a lower T than T_{msil}, and Th defines the water saturated liquidus T. Results from the modeling suggest that phase relationships observed during the heating of natural I can be used for petrologic interpretation to distinguish H_2O-saturated and H_2O-undersaturated M entrapment. (Authors' abstract) *See figure on page 235.*

STURCHIO, N.C., ANTONIO, M.R., SODERHOLM, L., SUTTON, S., BRANNON, J.C., and MISRA, K.C., 1997, Uranium in calcite: XAFS and X-ray microprobe data: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F762-F763. First author at Argonne Nat'l. Laboratory, Argonne, IL 60439.

Uranium is present at ppb to ppm concentrations in calcium carbonate minerals, but its valence and mechanism of incorporation in these minerals is largely a matter of speculation. Despite the fact that much of Quaternary geochronology is based on U-series dating of calcium carbonates, the processes controlling U distribution and transport in calcium carbonate-water systems remain poorly understood.

We collected XAFS and X-ray microprobe fluorescence data on samples of late-stage amber calcite from the Gordonsville Mine in the Central Tennessee Zinc District. This spar calcite (FI Th=60-100°C, sal=7-12 wt.% eq. NaCl) has unusually high U concentration (26.2-37.9 ppm). XAFS show an edge energy and shape consistent with tetravalent U. Best fits of the Fourier-transformed XAFS data yielded 5 shells. This result is consistent with the reducing nature of the calcite depositional environment, as evidenced by the presence of L hydrocarbon and bitumen I in the calcite. X-ray fluorescence maps (NSLS/X26A) show U distributed homogeneously at the 10 micrometer scale throughout the calcite. (From authors' abstract by E.R.)

SUCHY, Vaclav, ROZKOSNY, Ivan and DOBES, Petr, 1997, Organic maturity, conditions of veining and hydrocarbon migration in the Barrandian basin (lower Paleozoic), Czech Republic: AAPG Bull., v. 81, no. 8, p. 1414.

The Ordovician to Middle Devonian Barrandian basin of central Bohemia contains more than 6 km thick sequence of marine sediments that has never been investigated systematically for its hydrocarbon potential. Silurian sedimentary units appear to be especially rich in organic carbon and exhibit numerous small-scale accumulations of bitumens and oils. The level of diagenetic transformation of the Silurian strata was established throughout the basin by means of organic petrography, clay mineralogy and FI studies. Reflectance of vitrinoid macerals as the most significant maturity parameter varies between 0.93 to 1.38% Rm, which points to the maturation within the oil/gas window. Illite crystallinity (I.C.) data from adjacent clayey sediments range from 2.30 to 0.48 (delta degrees 2theta) and suggest that the rocks have undergone medium to high levels of diagenesis. Several generations of tectonic and hydraulic veins filled with semi-solid bitumen and oil-I-rich calcite and quartz are evidence that the hydrocarbons once migrated through the sediments. Vitrinite paleogeothermometry and FI data suggest diagenetic T between 90-160°C. Diagenetic modeling shows that approximately 3 km of presumably post-Givetian sediments, which have since been eroded, were responsible for these burial alterations. (Authors' abstract)

SUCHY, Vaclav, ZEMAN, Antonín, BOSAK, Pavel, DOBES, Petr, HLADIKOVA, Jana and JACKOVA, Ivana, 1997, Hydrothermal calcite veins and the origin of caves in the Lower Palaeozoic of the Barrandian basin, Czech Republic: Evidence of extensive (post?) Variscan fluid flow: GAEA 3, 18th IAS, Regional European Meeting of Sedimentology, Heidelberg, Sept. 2-4, 1997, Abstracts, p. 325. First author at Geological Inst. of the Acad. of Sci. of the Czech Republic, Rozvojová 135, 165 00 Praha 6 Suchdol, Czech Republic; email (sediment@gli.cas.cz)

Silurian and Devonian carbonate and shale sequences of the Barrandian basin contain abundant bed-normal, north-south trending calcite veins of syn- to post-tectonic origin. Petroleum I-rich quartz crystals occur as a light coating on the walls of some thin veins and subvertical joints. FI homogenization measurements on calcite samples indicate precipitation of the veins from NaCl-KCl-$CaCl_2$-$MgCl_2$ brines of variable sal (0.35 to 22.4 wt.% NaCl eq.), at 55-115°C. These T roughly correspond to burial depths of approximately 2 km or more, which were attained after the middle Devonian. On a standard plot $\delta^{13}C$ vs $\delta^{18}O$ with respect to PDB all investigated vein calcites plot within a region defined by the coordinates, +1.9 to -6.4‰ $\delta^{13}C$ and -11.3 to -7.4‰ $\delta^{18}O$. These stable isotope signatures indicate that the vein-forming F may have been either deep circulating meteoric waters or, more likely, basinal F ascending from deeper sections of the basin.

The process of veining was accompanied by an extensive dissolution of enclosing carbonate, yielding large dissolution cavities coated with black Mn-rich encrustations that place stratigraphic constraints on the age of hydrothermal alteration. [and suggest a) hydrothermal origin of at least some caves in the area. (From authors' abstract by E.R.)

SUK, N.I., 1997, Salt extraction of ore metals and the ore-bearing problem of alkaline magmatic complexes (abst.): in N.P. Laverov, ed. Principal Genetic Problems

Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 (Betekhtin Symposium), p. 80-81 (in Russian). ISBN 5-88918-002-9.

SULEIMENOV, O.M. and **SEWARD, T.M.**, 1997, A spectrophotometric study of hydrogen sulphide ionisation in aqueous solutions to 350°C: Geochim. Cosmo. Acta, v. 61, no. 24, p. 5187-5198.

SUN, Baozhong, XU, Guizhong and **BIAN, Qiantao,** 1997, Origin study of Langshan Huogeqi banded cupreous quartzite in Inner Mongolia: Acta Petrologica Sinica, v. 13, no. 2, p. 226-232 (in Chinese; Engl. abst.). Authors at Inst. of Geol., Chinese Acad. of Sci., Beijing 100029.

The study of texture, structure, CL, main and trace elements, REE, and of mineral composition of tourmaline and Th of I in quartz are made for Huogeqi banded cupreous [quartzite]. The quartzite possesses the characteristics of syngenetic sedimentary structure and geological occurrence, and of hydrothermal sedimentary geochemistry and mineral composition. These characteristics are similar to Chinese Dachang hydrothermal sedimentary rocks—banded silicalite and tourmaline rock. They demonstrate that Huogeqi ore deposit of banded cupreous quartzite is of hydrothermal sedimentary genesis. (Authors' abstract)

SUN, Baozhong, XU, Guizhong and **BIAN, Qiantao,** 1997, Origin study of Langshan Huogeqi banded cupreous quartzite in Inner Mongolia: Acta Petrologica Sinica, v. 13, no. 2, p. 226-232 (in Chinese; Engl. abst.). Authors at Inst. of Geol., Chinese Acad. of Sci., Beijing, 100029.

The study of texture, structure, CL, main and trace elements, REE, and of mineral composition of tourmaline and Th of I in quartz are made for Huogeqi banded cupreous [quartzite]. The quartzite possesses the characteristics of syngenetic sedimentary structure and geological occurrence, and of hydrothermal sedimentary geochemistry and mineral composition. These characteristics are similar to Chinese Dachang hydrothermal sedimentary rocks – banded silicalite and tourmaline rock. They demonstrate that Huogeqi ore deposit of banded cupreous quartzite is of hydrothermal sedimentary genesis. (Authors' abstract)

SUSHCHEVSKAYA, T.M., BARANOV, E.N. and **KARPUKHINA, V.S.**, 1997, Fluids of ascending and descending branches of convective hydrothermal paleosystems of massive sulfide deposits (Southern Urals, Russia): in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 383-386. Authors at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, Moscow, Russia.

FI in quartz phenocrysts from felsic volcanites, hosting massive sulfide deposits at Verkhneuralsky area, have been analyzed by G chromatographic and microthermometric methods. Interpretation of the obtained data along with the results of geochemical mapping allowed description of the chemical and physical characteristics of ascending and descending branches of convective hydrothermal systems, where the deposits were formed. (Authors' abstract)

Microthermometric experiments have been carried out for FI in quartz, barite, carbonates, sphalerite samples from ore bodies and in quartz phenocrysts (S I) from altered felsic rocks (Karpukhina & Baranov, Geokhimiya, p. 48-63, 1995). Th lies in the range of 370-130°C, the P reached 0.5-1.0 kbar, sal varied from 0.8 to 12 wt.% NaCl eq. Lateral paleotemperature zonality was typical for the altered wall rocks. Maximal Th values (370-250°C) were found in the narrow linear zones of ore transporting channels. Th decrease (190-150°C) is characteristic of the flanks. Evidence for boiling of mineral-forming solutions in the lower parts of the hydrothermal system was found in several cases. (From authors' text by E.R.)

SVERJENSKY, D.A., SHOCK, E.L. and **HELGESON, H.C.,** 1997, Prediction of the thermodynamic properties of aqueous metal complexes to 1000°C and 5 kb: Geochim. Cosmo. Acta, v. 61, no. 7, p. 1359-1412.

SYLVESTER, P.T., 1997, New technique using laser ablation blasts into geochemical labs: EOS, v. 78, p. 117-118, 120.

A review of various procedures for laser release of material for analysis by ICP/PMS. (E.R.)

TABERNER, Conxita, AYORA, Carlos, PUEYO, J.J., CENDÓN, D., and **GARCÍA-VEIGAS, J.,** 1997, The geochemical evolution of Tertiary marine evaporite basins: GAEA 3, 18th IAS, Regional European Meeting of Sedimentology, Heidelberg, Sept. 2-4, 1997, Abstracts, p. 332. First author at Institut de Ciències de la Terra (I.C.T.-C.S.I.C.), C/Lluis Solé i Sabarís s/n, 08028 Barcelona, Spain; email (ctaberner@ija.csic.es)

We have reconstructed the evolution of some marine Tertiary basins on the basis of the mineral paragenesis, FI, X-ray microanalysis, and the isotopic composition ($\delta^{34}S$ and $\delta^{18}O$) of sulphates present in the evaporitic sequences. Numerical modelling reproduces evaporation scenarios, enables the quantification of the degree of restriction of evaporite basins and can be used as a predictive tool for locating potash deposits. Geochemical modelling of FI trapped in halitic sequences identifies how close the original F was to the saturation stage for potash precipitation. The use of this approach is also shown to be a powerful tool in the reconstruction of the ocean chemistry and of the isotopic composition of the sulphate dissolved in the ocean during past geological times.

One essential key for the formation of sylvite deposits of economic significant is the depletion of SO_4^{2-} in the evaporite basin. FI from several Tertiary basins (either $MgSO_4$-rich or KCl-rich) have shown that the evolution of the brines, as sampled in the FI, is consistent with the evaporation path of seawater with a composition similar to that of present day seawater. The depletion of SO_4^{2-} takes place during evaporation and is completely explained by assuming the addition of variable amounts of Ca^{2+} in the basin. The origin of this Ca-excess is still unknown, although dolomitization of limestones might be a reasonable candidate, and thus it is the process most frequently employed to explain the Ca-excess.

The significance of the input of meteoric waters and recycling of older evaporites during the precipitation of marine evaporitic sequences is usually disregarded. The importance of this contribution can be proved by numerically modelling of FI in halite and isotope data through evaporitic sequences. Quantification of the proportions of the different water inputs reaching the evaporitic basin enables the interpretation of the hydrological evolution of the marine evaporitic basin and the stages of restriction to the open sea, as well as the detection of the complete isolation from the sea. The combined use of these geochemical markers is essential for the evalution of the recycling of older evaporites and "autocannibalism" in the evaporitic basin itself as main processes in the formation of evaporitic sequences, which might otherwise be misinterpreted as being deposited entirely under a main marine influence. (From authors' abstract by E.R.)

TAGIROV, B.R., ZOTOV, A.V. and AKINFIEV, N.N., 1997, Experimental study of dissociation of HCl from 350 to 500°C and from 500 to 2500 bars: Thermodynamic properties of $HCl^\circ_{(aq)}$: Geochim. Cosmo. Acta, v. 61, no. 20, p. 4267-4280.

TAKAGI, H., MAEDA, S., HAYASHI, M., TAGUCHI, S., SAWAKI, T. and UCHIDA, T., 1997, Application of fluid inclusion data for geothermal model construction - Results of the development of exploration technology for fractured type geothermal reservoir: (abst.): Geothermal Research Soc. Japan Ann. Meeting, Oct. 6-8, 1997, Sapporo Program, unpaginated, No. A30 (in Japanese).

TAKAGI, Tetsuichi and TSUKIMURA, Katsuhiro, 1997, Genesis of oxidized- and reduced-type granites: Econ. Geol., v. 92, p. 81-86. First author at Hokkaido Branch, Geological Survey of Japan, Kita-8, Nishi-2, Kita-ku, Sapporo 060, Japan.

If the fO_2 of the magmas is buffered by H_2O-H_2, CO_2-CO, or CH_4-CO_2 no magnetite will crystallize and reduced-type granites will be formed. As a result, the genesis of oxidized-type and reduced-type granites can be attributed to the difference in volatile components in magmas. (From authors' abstract by E.R.)

TATSUMI, Yoshikyuki and KOGISO, Tetsu, 1997, Trace element transport during dehydration processes in the subducted oceanic crust: 2. Origin of chemical and physical characteristics in arc magmatism: Earth and Planet. Sci. Letters, v. 148, p. 207-221. First author at School of Earth Sci., Fac. of Integrated Human Sci., Kyoto Univ., Yoshida-Nihon-Matsu, Kyoto 606-01, Japan.

Experimental data for element mobilization by aq F during the amphibolite/eclogite transition supports the suggestion that aq F derived from the subducting crust play an essential role in generating arc magmatism and in producing their distinctive chemistry. (From authors' abstract by E.R.)

TAUSON, V.L. and SMAGUNOV, N.V., 1997, Effect of gold-accompanying elements on gold behavior in the Fe-S-aqua-salt solution system at 4500°C [sic] and 100 MPa: Russian Geol. and Geophys., v. 38, no. 3, p. 706-xxx.

TAYLOR, Paul, LARTER, Steve, JONES, Martin, DALE, Jason and HORSTAD, Idar, 1997, The effect of oil-water-rock partitioning on the occurrence of alkylphenols in petroleum systems: Geochim. Cosmo. Acta, v. 61, no. 9, p. 1899-1910.

TAYLOR, R.P., JACKSON, S.E., LONGERICH, H.P. and WEBSTER, J.D., 1997, In situ trace-element analysis of individual silicate melt inclusions by laser ablation microprobe-inductively coupled plasma-mass spectrometry (LAM-ICP-MS): Geochim. Cosmo. Acta, v. 61, no. 13, p. 2559-2567. First author at Ottawa-Carleton Geosci. Centre, Dept. of Earth Sci., Carleton Univ., Ottawa, Ontario K1S 5B6, Canada.

This paper reports the successful application of laser ablation microprobe-inductively coupled plasma-mass spectrometry (LAM-ICP-MS) to the in situ analysis of a diverse suite of 20 trace elements including Zr, Hf, Nb, Ta, Y, and REEs, in individual silicate MI in phenocrysts from Fantale volcano, Ethiopia. The UV laser, a frequency quadrupled Nd:YAG operating at 266 nm, significantly improves the ablation characteristics of minerals that do not absorb strongly at near-IR wavelengths (e.g., quartz and feldspar). Furthermore, it allows for a significant reduction in ablation pit size to ca. 10 µm, thereby permitting numerous applications that require high-resolution sampling. Multiple ablations in individual MI in the size range 10-50 µm demonstrate both the effectiveness of the technique and the generally homogeneous character of the I. Comparison of the LAM-ICP-MS data for international reference material RGM-1 (a rhyolite), with recommended values, indicates an analytical precision of <10% for most of the trace elements determined in this study. The trace element abundances of the Fantale MI, determined by LAM-ICP-MS, are typical of those of pantellerites (i.e., peralkaline rhyolites), and are consistent with their origin as tiny volumes of M trapped in quartz and alkali-feldspar phenocrysts during the final stage of fractional crystallization of the host peralkaline magma. (Authors' abstract)

TAYLOR, W.E.G., 1997, A review of Egyptian gold deposits: Newsletter of the International Liason Group on Gold Mineralization, R.P. Foster, ed., no. xx, p. 60-62.

A summary of some of the papers presented in Egyptian Geological Survey and Mining Authority, 1996 Abstracts of the Geol. Survey of Egypt Centennial, Cairo, 19-22 November, 1996, 219 pp. Includes papers by El Kazzas and by Loizenbauer and Neumayr (see this volume; further details unavailable). (E.R.)

TECCE, F., BELKIN, H.E. and CAVARRETTA, G., 1997a, Fluid inclusions in sulphates from the Cesano 1 geothermal well (Latium, Italy): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 315. First author at CNR-Centro di Studio per il Quaternario e l'Evoluzione Ambientale, c/i Dip. Scienze della Terra, P.le Aldo Moro, 5-00185 Roma, Italy; email (ftecce@gea.geo.uniroma1.it).

Cesano 1 well is a productive well in the Sabatini volcanic district. It reached the depth of 1430 m and produced a very saline and peculiar brine (356,000 ppm of TDS) mainly consisting of Na and K, enriched also in Rb, Li, Cs, Ca, Mg and NH_4; prevailing anion is sulphate, followed by chloride, borate and carbonate, both groups here reported in order of abundance. Numerous FI are present both in gorgeyite [$Na_3Ca_2(SO_4)_3(OH)$] and in cesanite [$K_2Ca_5(SO_4)_6H_2O$] crystals, from 611 m and 1252 m. Three types of I have been observed: A) two-phase L+V, L-rich I are most common; B) two-phase L+V, V-rich I; C) three-phase L+V+S inclusions. FI in 1252 m cesanite samples are mostly A-type elongated tubular and rectangular I. Th values range between 190 and 200°C. Tm ice values range between -8.2 and -5.2°C. The fact that, on warming, new phases nucleate after the Tm ice and stay up to +155 to +180°C suggests that the F is a multicomponent solution. SEM-EDS analyses performed on broken I solids indicate they are mostly Na, K, Ca, and Sr sulphates. The narrow range of Th values obtained for 1252 m samples is consistent with present-day T. On the other hand, Th values for 611 m samples are spread, indicating post-trapping phenomena such as necking-down or fracture. Among the few values obtained for this depth, only the one at about 145°C would reflect the in-hole T measured for that depth. (From authors' abstract by E.R.)

TECCE, F., BELKIN, H.E. and CAVARRETTA, G., 1997b, Preliminary data on fluid inclusions in secondary minerals from Capodimonte 1D geothermal well, Vulsini volcanic district, Latium, Italy: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 316. First author at CNR-Centro di Studio per il Quaternario e l'Evoluzione Ambientale, c/i Dip. Scienze della Terra, P.le Aldo Moro, 5-00185 Roma, Italy; email (ftecce@gea.geo.uniromal.it).

Capodimonte 1D well, although unproductive, is made of multiple trachytic dykes which intruded into the sedimentary basement and older dykes resulting in a S thermo-metamorphic, high-T assemblage of corundum, andalusite, topaz, pyroxene, wollastonite, tourmaline, cancrinite, vesuvianite and garnet. A low-T group of minerals such as pectolite, chlorite, sericite, calcite, anhydrite and pyrite show four types of FI: A) aq two-phase L+V, both L-rich and V-rich (rarer I); B) two-phase CO_2L+V, V-rich I; C) triphase Lw+CO_2(g)+CO_2(l) inclusions; D) multiphase saline I L+V+S.

B-type and C-type I are present in anhydrite crystals from the deeper parts of the well. V-rich CO_2 I show the triple point at -56.4 to -56.6°C suggesting the presence of pure CO_2. Th[L?] for these I cluster around 28°C. At shallower depths the FI show no CO_2. Microthermometric data obtained on A- and D-types show Th from about 260°C at 2050 m to about 235°C at 1690 m. The very few Tm ice values obtained for the shallowest samples indicate sal values of about 7 wt.% eq. NaCl. After correction of Th values for hydrostatic P, the Tt closely match the in-hole measured T, thus indicating that anhydrite and calcite are in equlibrium with present thermal conditions. (From authors' abstract by E.R.)

TEDESCO, D., 1997, Systematic variations in the ^{3}He/^{4}He ratio and carbon of fumarolic fluids from active volcanic areas in Italy: Evidence for radiogenic ^{4}He and crustal carbon addition by the subducting African plate?: Earth and Planet. Sci. Letters, v. 151, no. 3-4, p. 255.

TENG, H., YAMASAKI, A., CHUN, M.-K. and LEE, H., 1997, Solubility of liquid CO_2 in water at temperatures from 278 to 293°C and pressures from 6.44 MPa to 29.49 MPa and densities of the corresponding solutions: J. Chemical Thermodynamics, 1997, no. 29, p. 1301-xxxx.

THALHAMMER, O.A.R., 1997, Metamorphogenic vein-type gold deposits: characteristics, classification, source of gold, new exploration targets (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 170-171 (in English), ISBN 5-88918-002-9. Author at Inst. of Geological Sci., Univ. of Leoben, Leoben, Austria.

Vein-type gold deposits share numerous common features: a) They are structurally controlled, i.e., associated with major faults, or shear zones, or they show relationship to a sedimentary fabric, or to deformational features such as folds or cleavage. b) They have a paragenesis dominated by quartz, albite, chlorite, and minor carbonate as gangue minerals, and pyrite, arsenopyrite,±charcopyrite±pyrrhotite as associated sulfides. c) Gold commonly occurs as native Au, but pyrite and arsenopyrite may show quite high gold concentrations as well. d) The veins almost lack zonation, and exhibit a weak alteration zone which is characterized by enrichment of chlorite and/or sericite, Au, Ag and As. e) FI studies reveal low sal (typically less than 5 wt.% eq.), and high CO_2±CH_4 contents; often F characteristics are consistent with a metamorphic F source. f) Deposits are closely related to metamorphism and/or an igneous activity such as a granitoid intrusion. (From author's abstract by E.R.)

THIERSCH, P.C., WILLIAMS-JONES, A.E. and CLARK, J.R., 1997, Epithermal mineralization and ore controls of the Shasta Au-Ag deposit, Toodoggone District, British Columbia, Canada: Mineralium Deposita, v. 32, p. 44-57. First author at Dept. of Earth and Planet. Sci., McGill Univ., 3450 Univ. St., Montreal, QC, Canada H3A 2A7.

The Shasta gold-silver deposit, British Columbia, Canada, is an adularia-sericite-type epithermal deposit in which deposition of precious metals coincided with the transition of quartz- to calcite-dominant gangue. FI microthermometry indicates that ore minerals were deposited between 280°C and 225°C, from a relatively dilute hydrothermal F (~1.5 wt.% NaCl eq.). Abundant V-rich I in ore-stage calcite are consistent with boiling. Oxygen and hydrogen isotopic data ($\delta^{18}O_{fluid}$ = -1.5 to -4.1‰; δD_{fluid} = -148 to -171‰) suggest that the F had a meteoric origin, but was ^{18}O-enriched by interaction with volcanic wallrocks. Initial (~280°C) F pH and log fO_2 conditions are estimated at 5.3 to 6.0, and -32.5 to -33 bar, respectively; during ore deposition, the F became more alkaline and oxidizing. Mineralization was controlled by boiling in response to hydraulic brecciation. Calcite and base metal sulfides precipitated due to the increase in pH that accompanied boiling, and the associated decrease in H_2S concentration led to precipitation of gold and silver. (From authors' abstract by E.R.)

THIERY, Régis and DUBESSY, Jean, 1997, Modelling of high-pressure vapour-liquid equilibria in the H_2O-NaCl system from 100°C to 700°C based on the ion-dipole MSA model: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 317-318. First author at CREGU, BP23, 54501 Vandœuvre-lès-Nancy, France; email (thiery@ensta.fr).

The H_2O-NaCl system is important in geological processes, but represents one of the most difficult systems to tackle, as it is characterized by complex intermolecular and interionic interactions. An equation state, based on the so-called Mean Spherical Approximation (MSA) of ion-dipole mixtures, is proposed here. It shows that it is possible to model L-V equilibria in the H_2O-NaCl system with only two empirical parameters, one of them having a physical meaning, the formation constant of the ion-pair NaCl°. It is worth noting that such study has revealed the following essential point for equations of state which have a strong physical basis: [they] must take into account the nature of the ion-bearing species, free ions or ion-pairs. Hopefully, the speciation of the salt must not be introduced in the model, but is considered as a fitting parameter like an empirical parameter constrained by the P-T-x-y experimental data of L-V equilibria. (From authors' abstract by E.R.)

THOMAS, Rainer, 1997, Determination of the water content in melt inclusions of granitic rocks: Comparison of results obtained from microthermometry and microprobe analyses: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 319-320. Author at GeoForschungsZentrum Potsdam, Telegrafenberg A50, D-14473 Potsdam, Germany; email (thomas@gfz-potsdam.de).

Using a simple kinetic technique based on the different homogenisation behaviour of the crystallised MI in dependence on volatile contents, T and heating duration, we can obtain values for volatile contents for I within the host mineral which are too deep in the sample or too small for ion probe or FTIR spectroscopy. Our method cannot separate or distinguish the effect of water from that of other volatile, semi-volatile or fluxing components. Therefore, we express the results as "equivalent water content" (C2), the amount of water which would produce the observed kinetic effect. The kinetic method is calibrated by determination of absolute concentrations, using the microthermometric "Naumov" method or microbeam techniques (ion and electron probe) as well as spectrometric procedures (FTIR). On sufficiently large I, the different methods complement each other, [and corroborate each other, as tabulated]. However, independent from the calibration, we can also easily determine relative changes in the volatile content by diffusion through the host during the homogenisation process. These data demonstrate that diffusive volatile loss (here a coupled diffusion of water and fluorine) can be significant during the 20 hours heating experiments which are necessary to obtain homogeneous glass for microprobe analysis. The distinction between diffusion and leakage is important. Leakage (opening the I) causes rapid and complete loss of water, and I which have leaked generally fail to homogenise under the experimental conditions (600-1000°C and 20 hours). (From author's abstract by E.R.)

THOMAS, R. and **KLEMM, W.,** 1997, Microthermometric study of silicate melt inclusions in Variscan granites from SE Germany: Volatile contents and entrapment conditions: J. of Petrol., v. 38, no. 12, p. 1753-1765: First author at Geoforschungszentrum Potsdam, Telegrafenberg A 50, D-14473 Potsdam, Germany.

MI in granitic rocks are generally crystalline and must be homogenized to glass before analysis. We employ a simple kinetic technique with microthermometry to estimate total volatile contents and P-T conditions of trapping of the M from their homogenization behaviour. This information complements chemical data from microprobe or ion probe analysis, and can be obtained from I too small for direct analysis. We present here values for volatile contents (as eq. wt.% H_2O), Tt and trapping P derived from studies of MI in some Variscan granites of the Erzgebirge, Fichtelgebirge and Oberpfalz, Germany. The volatile concentrations range from 3 to 10 eq. wt.% H_2O. Microprobe analysis shows that the most volatile-rich I contain up to 8 wt.% F. Estimates of trapping pressures and T suggest that crystallization began at an emplacement level of 3-6.5 km near 700°C with 'normal' biotite and two-mica granites, and ended with topaz-albite granite (~650°C) and pegmatitic phases down to 520°C. This wide range of Tt and volatile contents is a general feature of MI in granites. Many of the granites studied are highly evolved geochemically, but the extreme volatile enrichment typical for these also occurs locally in the 'unspecialized' granites. (Authors' abstract)

THOMAS, T. and **KULIS, J.,** 1997, Infrared microscopic analysis of New Mexico pyrite: New Mexico Geol., v. 19, no. 2, p. 52.

Indexed under FI (E.R.)

TITOV, A.V., KRUK, N.N., POSPELOVA, L.N., ZHURAVLEV, D.Z. and **PALESSKII, S.V.,** 1997, Crystallization conditions and origin of magmas of the Rybalka gabbrodiorite-tonalite intrusion (Gorny Altai): Russian Geol. and Geophys., v. 38, no. 12, p. 1921-1931 (in Russian; Engl. abstr.).

This paper presents results of complex geological, mineralogical, isotopic and MI studies of granitoid rocks from the Rybalka pluton (Gorny Altai). The geological study of the pluton gave numerous examples of viscous interaction of magmas, with abundant schlieren and I. The detailed mineralogical studies of the rocks showed a complex structure of plagioclase phenocrysts, often with resorbed cores of labradorite-bytownite. High T of crystallization (1030-1180°C) for basic rocks and rather low T for tonalites and granodiorites (680-720°C for middle and late stages) were distinguished in MI studies. Analysis of the data obtained suggests the melting events and magma-magma "mixing" and "mingling" interactions to be the main petrogenetic mechanisms; the crystal fractionation processes were suppressed. (From authors' abstract by E.R.)

TOBIN, K.J., ONSTOTT, T.C. and **COLWELL, Frederick,** 1997, Establishing background calcite mineralization as a prelude to an in situ bioremediation effort (INEL, Idaho) (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-461. First author at Dept. of Geosci., Princeton Univ., Princeton, NJ 08544.

Sparry calcite cement fills vesicles and fractures that cross cut Pleistocene age Snake Sparry River Plain basalts. Examination of core material from TAN-33 (70-144 m bsl) at INEL provides a basis for determining background mineralization on the periphery of an organic-rich plume (the main contaminant is TCE). Vadose calcite (indicated by preserved rhizoliths, massive micritic/microsparic crusts, micritic clasts with circumgranular cracking) occurs within sedimentary interbeds at 134 and 144 m bsl. Vadose calcite must have formed near the surface before burial as all samples examined from TAN-33 are below the modern water table. Some sparry calcite in vesicles and veins exhibits neomorphic conversion to microspar identical to that observed in some vadose calcite samples. Sparry calcite has highly variable crystal morphologies (equant to fibrous). Fibrous calcite cements resemble crystal morphologies of spelean deposits. Sparry calcite has $\delta^{18}O$=-17.62 to -12.01‰ PDB and $\delta^{13}C$=-6.89 to -3.83‰ (n=39) values, which overlap with values from vadose calcite ($\delta^{18}O$=-16.96 to -15.98‰ PDB; $\delta^{13}C$=-5.56 to -3.07‰; n=11).

Only the most negative sparry calcite $\delta^{18}O$ values could possibly be in equilibrium with modern groundwater $\delta^{18}O$ values (-18.8 to -16.3‰ SMOW) at current observed T (9.5 to 17.5°C). Additionally, all sparry calcite $\delta^{13}C$ values are too positive to be in equilibrium with modern DIC $\delta^{13}C$ values, which are quite negative (-7.4 to -13.4‰). Finally, several sparry calcite samples have P FI. FI are mainly all-L, one phase in composition but some two phase I are present. Most two phase I in sparry calcite are L dominated with a somewhat consistent V:L ratio. This observation suggests that some stretching of the all-L, one phase I occurred at elevated T (>50°C). Since sampled basalts are at their maximum burial depth, which is <144 m, we suggest that emplacement of overlying basaltic lava flows could provide the heat necessary to form these two phase I. Petrographic, stable isotopic, and FI data indicate an ancient origin for calcite cements at TAN-33. The occurrence of background (ancient) mineralization will be valuable for delineating any modern mineralization that may be associated with elevated subsurface activity within a contaminant plume at INEL. (Authors' abstract)

TOBIN, K.J., WALKER, K.R. and GOLDBERG, S.G., 1997, Burial diagenesis of Middle Ordovician carbonate buildups (Alabama, USA); documentation of the dominance of shallow burial conditions: Sedimentary Geol., v. 114, no. 1-4, p. 223-236.
Indexed under FI (E.R.)

TOLSTYKH, M.L., NAUMOV, V.B., KONONKOVA, N.N., 1997, Three types of melt in the basaltic andesite from the Medvezh'ya Caldera, Iturup, southern Kuril Islands: Geokhimiya, 1997, no. 4, p. 391-397 (in Russian; translated in Geochem. Internat'l., v. 35, no. 4, p. 339-345). Authors at Vernadsky Inst. of Geochem. and Analytical Chem., RAS, ul. Kosygina 19, Moscow, 117975 Russia.

M I were studied in olivine, plagioclase, and orthopyroxene from nine basaltic andesite samples collected on young cones of the Medvezh'ya caldera on Iturup Island, southern Kuril Archipelago. M of the I were classified into three types: (I) magnesian basalt (47-49% SiO_2, 10.4-5.0% MgO, 0.3% K_2O) was detected in I in olivine and anorthite; (II) highly potassic dacite (64-69% SiO_2, 0.7-1.4 MgO, 5.4-6.8% K_2O), in I in plagioclase (An 83-71) from the youngest lava flows of the Kudryavyi cone; and (III) the most abundant inclusions, which occur in medium-potassic dacite M (64-72% SiO_2, 0.7-1.4% MgO, 1.2-2.0% K_2O), in plagioclase (*An* 72-58) from all of the examined samples and in orthopyroxene. The M of type I is much higher in S (0.12 wt.%) than the other M (0.03-0.04 wt.%). The basalt M is also rich in Cl (0.12 wt.%), whereas the dacite M vary broadly in Cl contents: from 0.02 wt.% in type II to 0.16 wt.% in type III. The M are similar in low water contents (<1 wt.%). The Th of the M are as follows: 1200-1300°C for type I, 1160-1170°C for type II, and 1070-1170°C for type III. (Authors' abstract)

TOMILENKO, A.A., CHEPUROV, A.I., PAL'YANOV, Yu.N., POKHILENKO, L.N. and SHEBANIN, A.P., 1995, Volatile components in the upper mantle: Sixth Internat'l. Kimberlite Conference, Extended Abstracts, Russia, 1995, p. 628-630. Authors at United Inst. of Geol., Geophys. and Mineral., 630090, Novosibirsk-90, Universitetsky pr., 3 Russia.

Nowadays the composition of volatiles and their role in deep-seated processes are judged mainly from experimental studies in the region of high P (Kushiro et al., 1968; Boettcher et al., 1980; Ryabchikov et al., 1980, 1982; Falloon et al., 1989; Eggler, 1987; Fedorov et al., 1991), thermodynamic calculations (Taylor et al., 1989; Fedorov et al., 1991, 1992) and results of mass-spectrometer and chromatographic studies of natural diamonds and satellite-minerals (Melton, Giardini, 1974, 1981; Roedder, 1984; Bartoshinsky et al., 1987; Tal'nikova et al., 1991; Pokhilenko et al., 1994). The detection of FI in crystals of natural and synthetic diamond and satellite-minerals of diamond and their investigation by non-destructive methods of analysis allows direct information to be obtained on the composition of volatiles involved in mineral-forming processes under the upper mantle conditions (Tomilenko, Chupin, 1983; Bakumenko et al., 1992; Voznyak et al., 1992; Chepurov et al., 1994; Pal'yanov et al., 1994).

A series of monophase FI have been found during careful optical studies of flatly parallel plates made from diamond crystals from the placers of northeastern Siberian Platform. They are located in healed cracks which are not exposed on the crystal's surface. The I are flat and have a shape of isometric plates with facet elements, mainly (111). They are colorless, isotropic in polarized light and behave as a matrix, given birefringence exists in the crystal [sic]. Along with FI the cracks contain graphite. Cryometric and Raman-spectroscopic investigations showed that all I may be divided into three types: carbon dioxide-nitrogen-hydrocarbonic (?) (type I), carbon dioxide-nitrogen (type II) and hydrocarbonic (?) (type III). Precipitation of one or several solid phases occurs (metastable phase transition) in all I on cooling in freezing stage in the range of -50 to -120°C. In all I of type I commonly two solid phases successively freeze out, which differ in melting T and composition (phase A-solid hydrocarbons (?) with melting T about -42°C and phase B-solid carbon dioxide with melting T about -66°C). In all type II inclusions on cooling only phase B (solid carbon dioxide) freezes out, and in I of type III only one solid phase A (solid hydrocarbons (?) with melting T about -36°C). The volume of precipitated solid phases for I of type I is about 30% (phase A about 10% and phase B about 20%), for type II about 20% (only phase B), and for I of type III about 75-80% (only phase A). Further cooling up to -196°C of the residual L does not result in it heterogenization or other changes in every type I. The results of cryometric and Raman spectroscopic studies suggest that the composition of I of type I is represented by carbon dioxide, nitrogen, and hydrocarbons (?), while type II, mainly by carbon dioxide and nitrogen, and I of type III, basically by hydrocarbons (?). FI of types II and III are typically localized within one healed crack and were most likely formed as a result of necking down of the first type I. Although the detected FI are located in diamonds along cracks, healed I undoubtedly indicate that during preservation of I the conditions (T, P, composition of medium) necessary for crystallization of substance still existed. The later is confirmed also by the presence of negative diamond shape in the habit of I, necking down and recrystallization of sites around I in diamond.

P F and MI were found in pyropes typical of parageneses of websterite xenoliths from kimberlite pipe "Mir" (Yakutia). The IR-spectra of FI have a strong absorption band in the frequency region 3000-2800 cm^{-1}, which is typical of hydrocarbons. Data of thermo- and cryometric studies of F in garnets, favor the alkane nature of these hydrocarbons. Judging from Th these I may be represented by n-alkanes not less than C_5-C_{11} (with due regard for critical T of the latter). After freezing of the L phase of I, melting of crystals formed is observed at -20°C and the last solid phases disappear at -10°C. In case of n-alkanes this may correspond to mixtures of alkanes with chains of C_{11} type and higher-molecular compounds. In MI melting of solid phases and solution of F bubble is observed at about 965-980°C. However, we failed to homogenize I because at about 1100°C they usually explode, apparently, due to developing high F P in I at these T.

The Raman spectroscopy data on the composition of FI in synthetic diamond also suggest a principal possibility on the participation of hydrocarbons (alkanes) in crystallization processes of diamond in its stability field. In synthetic diamonds, obtained by the T gradient method in the system Fe-Ni-C at a high-P apparatus of "split sphere" type, monophase LI of disc-, pipe-like-lenticular shape or with a facet of negative diamond crystal were found. The Raman-spectra of I display bands in the subregions of spectra 3000-2700, 1475-1450, 1310-1175, 1150-950 cm^{-1}. The absence of a strong line in the frequency region 1600 cm^{-1} indicates the presence of saturated hydrocarbons (alkanes) in I. In the frequency region 3000-2700 cm^{-1}, C-H valency variations occur, which are more or less localized within CH_2 and CH_3 groups. The narrow region 1475-1450 cm^{-1} in Raman-spectrum exhibits a band favored by the position of antisymmetric deformation of CH_3 and scissors-like variations of CH_2. The CH_2- torsion modes occur in the region 1310-1175 cm^{-1}, too. The absence of lines in the region 888-837 cm^{-1}, peculiar to nonbranched alkanes, suggests that Raman-spectrum registered is most likely a mixture of branched and cyclic alkanes. The Raman-spectrum region in these alkanes is free of lines. As the P in FI is essentially higher than one atmosphere, the spectra obtained do not coincide with the Raman-spectra of hydrocarbons recorded under normal conditions.

In garnets of eclogites from the kimberlite pipes "Udachnaya" and "Obnazhenaya" (Yakutia) monophase LI were found whose composition, according to data of cryometry and Raman-spectroscopy, is represented mainly by liquefied nitrogen. On cooling to -196°C, the majority of the I display no visible phase I, which suggests lower than -196°C heterogenization T of preserved solutions and their high density (more than 0.806 g/cm^3). Only in separate I, which seem to undergo partial unsealing, heterogenization of I was observed at -196°C (T_{hom}=-188÷-196°C).

On the basis of data of chromatographic analysis of volatiles from garnets and olivines of harzburgites, spinel lherzolites, garnet pyroxenes, diamondiferous dunites, and eclogites from kimberlite pipes "Mir", "Udachnaya" (Yakutia) and "Roberts Victor" (South Africa) and thermodynamic modeling of component composition of F for PT-conditions of formation of the rocks considered, calculated using program TEMPACT, it was established that prevailing components for all samples is water, methane, and carbon dioxide. Some samples along with water, carbon dioxide, and methane also contained elevated content of nitrogen. The amount of other components is negligible. The oxygen fugacity at PT-parameters and H/(O+H) values, typical of each rock investigated, was calculated using the data obtained. It was shown that redox conditions of formation of these associations are similar to conditions of buffer reaction WM at 50 kbar. However, the redox conditions of formation of these rocks cannot be judged unambiguously. They might have been formed under more reducing conditions, but the composition of FI varied during post-crystallization period and, hence, the possibility that the results of analysis reflect averaged situation from the conditions of rocks prior to their removal to the surface is not ruled out. (From authors' abstract by E.R.)

Includes a brief review with 20 references. See also FIR 28, p. 171-172 (E.R.).

TOMILENKO, A.A., CHEPUROV, A.I., PAL'YANOV, Yu. N., POKHILENKO, L.N. and SHEBANIN, A.P., 1997, Volatile components in the upper mantle (from data on fluid inclusions): Russian Geol. and Geophys., v. 38, no. 1, p. 276 (in Russian; Engl. abst.).

Cryometry, thermometry, Raman and IR spectrometry, and G chromatographic analysis were used to determine the composition of FI in natural and synthetic diamonds as well as in garnets from mantle-derived xenoliths in kimberlite pipes of Yakutia. FI localized in healed cracks, which are not exposed on the surface, have been found in natural diamonds from the placers of Yakutia, using light microscopy and a freezing stage. Preservation of these I seems to have occurred after crystallization of diamond but still under the conditions of its thermodynamic stability. All the I are one phase and contain a high-density L. Based on the results of cryometric and Raman spectroscopic analyses, three types of FI were established: carbon dioxide-nitrogen-hydrocarbon, carbon dioxide-nitrogen, and essentially hydrocarbon.

By means of Raman spectroscopy, the composition of P FI in synthetic diamonds, produced in their stability field, was found to be represented mainly by hydrocarbons. The P I in garnets, typical of websterite xenoliths from the Mir kimberlite pipe (Yakutia), according to the results of cryometric and infrared spectroscopy, also consist of hydrocarbons.

On the basis of chromatographic analyses of volatiles from garnets of cataclastic lherzolites from the Udachnaya kimberlite, and thermodynamic modelling of the chemical composition, oxygen fugacity was calculated at *PT*-parameters and H/(O + H) values specific to these rocks. The value of oxygen fugacity of cataclastic lherzolites lies between the CCO and IW buffers at 50 kbar. (Authors' abstract)

TOMILENKO, A.A., CHEPUROV, A.I., PAL'YANOV, Yu.N., POKHILENKO, L.N. and SHEBANIN, A.P., 1997, Volatile components in the upper mantle (from data on fluid inclusions): Russian Geol. and Geophys., v. 38, Proceedings of the Sixth Int'l. Kimberlite Conference, v. 1: Kimberlites, Related Rocks and Mantle Xenoliths, p. 294-303 (in Engl.). Authors at United Inst. of Geol., Geophys. and Mineral., SD of the RAS, Univ. pr., Novosibirsk, 630090, Russia.

FI localized in healed cracks, which are not exposed on the surface, have been found in natural diamonds from placers of Yakutia, using light microscopy and a freezing stage. Preservation of these I seems to have occurred after crystallization of diamond but still under the conditions of its thermodynamic stability. All the I are single phase and contain a high-density L. Based on the results of cryometric and Raman spectroscopic analyses, three types of FI were established: carbon dioxide-nitrogen-hydrocarbon, carbon dioxide-nitrogen, and essentially hydrocarbon. By means of the freezing stage and Raman spectroscopy the composition of P FI in synthetic diamonds, produced in their stability field, was found to be represented mainly by hydrocarbons. The P I in garnets, typical of websterite xenoliths from the Mir kimberlite pipe (Yakutia), according to the results of cryometric and infrared spectroscopy, also consist of hydrocarbons. On the basis of chromatographic analyses of volatiles from garnets of cataclastic lherzolites from xenoliths of the Udachnaya kimberlite pipe and thermodynamic modelling of the chemical composition, oxygen fugacity was calculated at PT-parameters and H/(O+H) values specific to these rocks. The value of oxygen fugacity of cataclastic lherzolites lies between the CCO and IW buffers at 50 kbar. (Authors' abstract)

TOMILENKO, Anatoly, CHEPUROV, Anatoly and **SHEBANIN, Anatoly,** 1997, Hydrocarbon inclusions in synthetic diamonds: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 323-324. Authors at United Inst. of Geol., Geophys. and Mineral., SB RAS, Novosibirsk, 630090, Russia; email (tomilen@uiggm.nsc.ru).

Optical and Raman spectroscopic studies of single-phase FI (5 to 40 μm) have been conducted in synthetic diamonds obtained in the field of their thermodynamic stability but under somewhat different growth conditions. Some diamonds (group A) were produced at 1350°C and 50 kbar in experiments whose duration did not exceed 2 hours, while others (group B) were grown on a seed at 1520-1540°C and 55-60 kbar during longer experiments (12-30 hours). Line shifts due to high I P, and major overlaps from diamond lines complicated the analyses.

Two types of FI were found: (1) hydrocarbon I in which of considerable importance, along with methane, are other branched and cyclic n-alkanes (type A) and (2) essentially methane I with a graphite film on I walls (type B). (From authors' abstract by E.R.)

TOMILENKO, A.A., CHEPUROV, A.I., TURKIN, A.I., SHEBANIN, A.P. and **SOBOLEV, N.V.,** 1997, Fluid inclusions in synthetic diamond crystals: Dokl. Akad. Nauk, v. 353, no. 2, p. 237-240 (in Russian, translated in Trans. (Dokl.) of the Russian Acad. Sci./Earth Sci. Sections, v. 353, no. 2, p. 247-250). Authors at Joint Inst. of Geol., Geophys., and Mineral., Siberian Div., RAS, Novosibirsk, Russia.

We continued experiments on growing diamond crystals containing F-phase I (Osorgin et al, 1987, DAN v. 295, p. 1214-1217). The goal of this research was to study the phase and chemical compositions of the FI, to elucidate the possible mechanism of their conservation, and to establish criteria for searching for these I in natural diamonds.

Diamond crystals were grown in "split sphere"-type multianvil apparatus, which are known in the literature as pressless apparatus. Feed material was composed of carbon source (graphite), solvent (Ni-Fe alloy), and substrate with a synthethic diamond crystal seed. (From authors' text by E.R.)

Using Raman methane and saturated hydrocarbons (alkanes), both branched and cyclic, were found. There is ambiguity in assigning Raman lines, since the internal P is perhaps 10 kbar. Note that there is no mention of a source for the H in these runs. (E.R.)

TOMILENKO, Anatoly, and **SHATSKY, Vladislav,** 1997, N_2-rich and CO_2-rich inclusions in minerals of eclogites and host rocks from the northern Muya block, east Siberia: Fifth International Eclogite Conference, Abstract Supplement No. 1 to Terra Nova, v. 9, p. xx. Authors at Inst. of Mineral. and Petrog., Novosibirsk, Russia.

FI were studied in eclogites and host rocks of the Northern Muya Block (east Siberia). The data of absolute ages of the eclogites suggest Vendian high-P (>15 kbar) metamorphism at 640-740°C (Shatsky et al., DAN 350-5, 1996). Inclusions were subjected to Raman-spectroscopy and cryometric studies. Four major types of I were determined. (1) Single-phase I of L (supercritical) N_2 are typical for eclogites. They occur more seldomly in the host gneisses. Raman data confirm that early I contain typically pure nitrogen (100 mol%), sometimes mixed with minor quantities of methane (up to 4.9 mol%). The quantity of components other than N_2 is greater in SI in eclogites, with CO_2 occurring besides CH_4 (up to 8.6 mol% for CH_4, to 9.1 mol% for CO_2). Single-phase, N_2 rich I are also found in quartz from the host rock. According to the Raman data, they contain nearly pure N_2 or a mixture of CO_2-N_2-CH_4: N_2 (80.3 to 100.0 mol%), CO_2 (0.0 to 8.2 mol%), and CH_4 (0.0 to 19.7 mol%). (2) Single-phase I of L CO_2 are most typical of the quartz in the gneiss host rock; they are more rare in eclogites. Such I contain almost pure CO_2 (98.5 to 100 mol%), with eventually minor admixture of nitrogen (up to 1.5 mol%). For a reference T of 740°C, P deducted from isochores corresponding to maximum density N_2 isochores in the eclogites and CO_2 in the host gneiss are in fair agreement: 9.0-9.5 kbar for the eclogites, 8.0-8.5 kbar for the host rocks. (3) Single-phase I of L methane are extremely rare; they were found in quartz from only host samples, as late SI. Raman analyses indicate a mixture of CH_4 (58.3 to 100 mol%), N_2 (3.5 to 30.7 mol%) and CO_2 (6.2 to 24.2 mol%). (4) SI of water-salt solutions occur both in the eclogites and in the host rocks. The F of these I are very late and were entrapped at a T<about 300°C and a P<about 2 kbar. (Authors' abstract)

TOMILENKO, Anatoly, SHATSKY, Vladislav, TOURET, J.L.R. and **SHEBANIN, Anatoly,** 1997, Fluid inclusions in eclogites and host rocks from the northern Muya block, western Transbaikalia, Russia: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 325-326. First author at United Inst. of Geol., Geophys. and Mineral., SB RAS Novosibirsk, 630090, Russia; email (tomilen@uiggm.nsc.ru).

The Northern Muya block contains an eclogite-gneiss complex. Published estimates for the P-T conditions of eclogite metamorphism are controversial. Four major types of FI have been defined in quartz from eclogite and enclosing gneiss on the basis of optical observation, microthermometry and Raman analysis:

(1) Single-phase I of L (supercritical) nitrogen, occurring as the most early (P?) I in single or isolated groups of 3-5 I, randomly disposed within the host crystal. Th=-188 to -196°C (0.77 to 0.81 g/cm^3 equivalent N_2 density). Some N_2-rich I did not heterogenize even at the lowest T reached by our freezing stage (-196°C). This suggests a N_2 density higher than 0.81 g/cm3, probably the highest value ever observed in a FI. Raman data confirm that early I contain typically pure nitrogen (100 mol.%), sometimes mixed with minor quantities of methane (up to 4.9 mol.%)

(2) Single-phase I of L CO_2. These P I are typical for the gneiss host rock, and occur only seldomly in quartz from eclogites. Th range from -10 to -46°C (equivalent CO_2-densities: 0.98 to 1.14 g/cm3). Raman data indicate almost pure CO_2 (98.5 to 100 mol.%),±N_2. For a reference T of 800°C, P deduced from isochores corresponding to maximum density N_2 isochores in the eclogite (group 1) and CO_2 in the host gneiss (group 2) are in fair agreement: 9.0-9.5 kb for the eclogites, 8.0-8.5 kb for the gneiss. These are lower (by approximately a factor of 2) than the P deduced from the mineral assemblage.

(3) Single-phase I of L (supercritical) methane (rare). Th L=-85 to -101°C (equivalent-methane densities between 0.22 and 0.30 g/cm^3). Raman analysis indicates a mixture of CH_4 (58.3 to 100 mol.%), N_2 (3.5 to 30.7 g/cm^3). and CO_2 (6.2 to 24.2 mol.%).

(4) Low-sal one- or two-phase aq. They are typically S, and correspond to very late F.

In conclusion, these preliminary data suggest that high-density N_2 and high-density CO_2 I were equilibrated after the climax of the high-P metamorphism in the Muya block, but still in a high P setting. (From authors' abstract by E.R.)

TOMILENKO, Anatoly and SHEBANIN, Anatoly, 1997, Composition of fluid in Precambrian granulites: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 321-322. Authors at United Inst. of Geol., Geophys. and Mineral., SB RAS, Novosibirsk, 630090, Russia; email (tomilen@uiggm.nsc.ru).

FI in minerals from various high-, medium-, and low-pressure granulites (quartz, garnet, plagioclases, cordierite, and sillimanite) were studied by means of microthermometry, Raman spectroscopy, and gas chromatography. All minerals from all studied regions mainly contain single-phase L, essentially pure CO_2 I. Some contain invisible films of water, as determined by the appearance of clathrates of CO_2 upon freezing and some contain ≤6.5 mol.% N_2. No CH_4 was found. The lowest Th of CO_2 I (and, respectively, the highest densities) were from the Chogar complex of the Stanovoi Range (-27 to -42°C and 1.06 to 1.12 g/cm^3). Much higher CO_2 Th and lower densities are typical of the moderate and low P granulites of the Butiya Uplift in the southern part of the Canadian Shield. The F P during metamorphism ranged down from ≤11 kbar in Chogar. The low-P granulites never exceeded 6.0 kbar, in agreement with other methods.

Chromatographic data on FI in garnets and quartz, along with the data on channels in cordierites show H_2O (32.5 to 95.0 mol.%) and CO_2 (4.6 to 67.4 mol.%), ±≤7.57 CH_4 and ≤2.74 N_2. Appreciable quantities of N_2 and sometimes CH_4 are associated with ancient tectonic zonex through the granulites. (From authors' abstract by E.R.)

TORNOS, Fernando, SPIRO, B.F., SHEPHERD, T.J. and RIBERA, Fidel, 1997, Sandstone-hosted gold lodes of the southern West Asturian Leonese zone (NW Spain): The role of depth in the genesis of the mineralization: Chron. Rech. Min., 1997, no. 528, p. 71-86. First author at Inst. Tecnológico Geominerao de España, c/Azafranal 48-50, 37001 Salamanca, Spain; email (ftaitge@iponet.es).

The southern West Asturian Leonese Zone, NW Spain, hosts numerous structurally controlled sulphide-poor gold-bearing quartz veins affected by regional lower greenschist facies metamorphism. They show contrasting morphologies, mineral assemblages and hydrothermal alterations according to the structural level of formation. These ores show two superimposed hydrothermal stages, one synchronous with and the other postdating the peak Variscan deformation. The first event has mesothermal features; FI and stable-isotope data indicate that H_2O-CO_2-(NaCl) metamorphic F were involved in this deep and early hydrothermal system (c. 300-400°C; $p_f \approx 1.7$-3 kbar). The second stage is characterized by the circulation of low-sal F of meteoric origin at variable T (<180 to 370°C) and F P (LV to 2 kbar). Stable-isotope analyses indicate that most of the carbon and sulphur derive from the nearby rocks. The metals are also inferred to be derived from the metasediments.

The genesis of the gold vein deposits of the West Asturian Leonese Zone was related to regional convective hydrothermal cells that formed during and after regional metamorphism. In the deeper deposits, hydraulic fracturing and concomitant P release in a tectonic setting with low geothermal gradients led to an alkalinization of the F with precipitation of As, Au and W-bearing minerals, while the formation of metals transported as chloride complexes (Zn, Pb) was inhibited. By contrast, in the shallow and late mineralization, late cooling and F mixing precipitated additional amounts of sphalerite, galena, chalcopyrite and sulphosalts. (From authors' abstract by E.R.)

TÖRÖK, Kálmán, 1997, Hypersaline and CO_2 inclusions, associated with retrograde metamorphism of the chlorite-muscovite-quartz schist from the Sopron area (eastern Alps, W. Hungary): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 327-328. Author at Dept. of Geophys., Eötvös, L. Univ. H-1082 Budapest Ludovika tér 2., Hungary; email (torokklm@ludens.elte.hu).

The studied rock consists of mainly quartz, chlorite, muscovite, paragonite, and plagioclase with albite-oligoclase composition. Garnet and chloritoid are present in almost every sample. Unaltered biotite can be found only in the less retrograded samples and sometimes as I in garnet. Some samples contain a lot of tourmaline. Previous studies concluded that the chlorite-muscovite-quartz schist experienced greenschist facies alpine metamorphism. However, Török (1996) has shown that gneisses, which are closely associated with the chlorite-muscovite-quartz schist [had] undergone high-P metamorphism. One- or two-phase hypersaline aq and CO_2 I are found mainly in quartz veins which are parallel with the schistosity or crosscut it. Rare primary-looking I can also be found in tourmalines. The hypersaline I contain one-phase L or two-phase (L+V) CO_2 at room T. The aq phase/CO_2 ratio is highly variable in most cases.

Tm CO_2=-57.3 and -58.2°C, suggesting possible N_2 or CH_4. Th CO_2=21.6 to 24.1°C. Te=-56 to -59.4°C and Tm ice=~-36°C. Th CO_2-clathrate=-18.3 and -19.5°C. Melting of the NaCl hydrate is always metastable, well above 0.1°C. Tm NaCl=193.5 to 250.3°C. Th=unknown due to decrepitation, between 265 and 370°C. The infiltration of these fluids facilitated retrograde metamorphic reactions, like breakdown of staurolite to fine-grained muscovite-paragonite±albite±chloritoid and breakdown of biotite to chlorite. (From author's abstract by E.R.)

TÖRÖK, Kálmán, de VIVO, Benedetto and **ZUPPETTA, Agustino,** 1997, Fluid inclusions in the Niquelandia and Barro Alto complexes, Goias State, Brazil: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 329-330. First author at Dept. of Geophys., Eötvös, L. Univ. H-1082 Budapest Ludovika tér 2., Hungary; email (torokklm@ludens.elte.hu).

FI were studied from two Precambrian mafic-ultramafic layered intrusion complexes (Niquelandia and Barro Alto). These were metamorphosed to the upper amphibolite to granulite facies.

FI of the Niquelandia complex were measured from plagioclase and orthopyroxene of a granulitic host rock and from a quartz vein. Those found in the host rock are P, pure CO_2 I, occurring solitarily or in small clusters. These I have Th between -29.6 and -42.2°C. Those found in the quartz vein are S occurring along healed fractured and contain CO_2 with 7% N_2. These I have high density, characterised by metastable homogenisation (which is lower than the melting point of the CO_2) and sublimation as final phase change. Compositions were checked by Raman analyses.

FI of the Barro Alto complex are S, or in some cases they can be PS. S I were found in quartz veins cross-cutting the foliation of the rock and can be divided in two parts, according to their composition.

A. High sal aq I, with Th between 250 and 480°C. Sal range from 32 to 42 NaCl eq. wt.%. Two subtypes exist in this group, according to their composition. The first group (**A.1.**) has low eutectic points (between -54 and -59°C) and low ice melting T (about -40°C). These values imply that the I contain appreciable amount of $CaCl_2$. These I are associated with the group B.2. nitrogen I. The other group (**A.2.**) can be characterised by higher T eutectic points (about -33 and -40°C) and ice melting (between -24 and -26°C). These I are associated with the B.1. CO_2 I.

B. Gaseous I, which can be further divided in two parts: **B.1.:** CO_2 I can be found in quartz veins, associated with high sal I of group A.2. The Th distribution is bimodal, the lower density I homogenise at about 18°C and the higher density ones between +4 and -5°C. The CO_2 melting points (between -58 and -59°C) and the observed initial melting of the solid CO_2 indicates a minor amount of other gas species as well. **B.2.:** N_2 I were found both associated with high sal I and in the plagioclase of the host rock. Most of them do not show any phase change during cooling.

FI in Niquelandia are related, or sealed close to the peak P-T conditions of the granulite facies metamorphism as well as the high density CO_2 I in Barro Alto. The other I in Barro Alto (high-sal $CaCl_2$-bearing, and gaseous CO_2 or N_2-rich) can be related with the retrograde metamorphism, or some other high T post-metamorphic event. (From authors' abstract by E.R.)

TOSCANO, M., SÁEZ, R and **ALMODÓVAR, G.R.,** 1997, Hydrothermal fluid evolution during the genesis of the Aznalcóllar massive sulphides (Iberian pyrite belt): Fluid inclusion evidences: Geogaceta, v. 21, p. 211-214 (in Spanish; Engl. abst.). Authors at Dept. de Geologia, Univ. de Huelva, 21819 La Rábida (Huelva).

FI data from Aznalcóllar and Los Frailes stockworks indicate that hydrothermal F changed continuously in T and sal, both in time and space. Th values change from 140 to 380°C and sal from 0.4 to 12.4 NaCl eq. The highest values for both parameters have being found for central stockworks and later F. Statistic population analysis of FI data points to three stages of hydrothermal activity, at low (<200°C), intermediate (200-300°C) and high T (300-400°C). Sal values show similar variation trend with higher values for the last hydrothermal stage. (Authors' abstract)

TOTH, T.M. and **JUHASZ, Attila,** 1997, Geochemical and petrological evidence for a hydrologic connection between crystalline basement and overlying sediments in the Pannonian Basin, Hungary: Annual Meeting Abstracts–American Assoc. of Petroleum Geologists and Soc. of Economic Paleontologists and Mineralogists, v. 6, p. 73.

This study compares fracture filling minerals of the crystalline basement and authigenic phases of the covering sediments. Evidence from fluorescent and CL microscopy, FI microthermometry, stable isotope and electron microprobe studies of the two assemblages support evolution in a connected hydrologic system. Precipitation took place from a mixture of initial pore- and meteoric water characterized by decreasing meteoric signal towards the basin. Meteoric water was recharged from the basement highs along the shear zones. (From authors' abstract by E.R.)

TOUPIN, Denah, EADINGTON, P.J., PERSON, Mark, MORIN, Paul, WIECK, J.M. and **WARNER, D.,** 1997, Petroleum hydrogeology of the Cooper and Eromanga basins, Australia; some insights from mathematical modeling and fluid inclusion data: AAPG Bull., v. 81, no. 4, p. 577-603.

Mathematical modeling and FI data analysis are used to reconstruct the petroleum hydrogeology of the Australian Cooper and Eromanga basins. Our analysis focuses on the development of topography- and compaction-driven groundwater flow systems and their role in heat redistribution, petroleum generation, and oil and brine migration during basin evolution. Quantitative results are consistent with ^{36}Cl groundwater age measurements, vitrinite reflectance data, present-day geothermal gradient and groundwater sal data, FI paleosalinity data, and the location of proven oil reserves in the southern Cooper basin. (From authors' abstract by E.R.)

TRIELOFF, M., WEBER, H.W., KURAT, G., JESSBERGER, E.K. and **JANICKE, J.,** 1997, Noble gases, their carrier phases, and argon chronology of upper mantle rocks from Zabargad Island, Red Sea: Geochim. Cosmo. Acta, v. 61, no. 23, p. 5065-5088. First author at Max-Planck-Inst. für Kernphysik, D-69029 Heidelberg, Germany.

Three ultramafic bodies on Zabargad Island contain fresh peridotites with mostly unfractionated primitive bulk major and trace element abundances and mostly monomineralic vein rocks (pyroxenites, olivinites, hornblendites, etc.). Neutron induced argon isotopes derived from Ca, K, and Cl, and the specific degassing behaviour of major and accessory minerals enabled us to separate and identify different trapped and radiogenic argon components and their hosts. Within two clinopyroxenites trapped argon is present in (1) low T, low $^{40}Ar/^{36}Ar$ phases (serpentine and/or FI), (2) pyroxene-related Cl-rich carriers (pyroxene and/or associated microinclusions), and

(3) amphiboles which are intimately and nonseparably intergrown with pyroxene. These amphiboles can be related to recent mantle metasomatism.

Orthopyroxenite vein rock shows a well-defined correlation with crushing step that indicates the presence of two different types or generations of I, which were subjected to different degrees of contamination by atmosphere type noble gases. As I were trapped before the main deformation of the peridotite complex (Kurat et al., 1993), argon with relatively low $^{40}Ar/^{36}Ar$ ratios ($\leq$1500) was trapped in the mantle, which requires an admixture of argon of atmospheric composition to the source region of the peridotites. (From authors' abstract by E.R.)

TRIELOFF, M., WEBER, H.W., KURAT, G., JESSBERGER, E.K. and **JANICKE, J.**, 1997, Noble gases, their carrier phases, and argon chronology of upper mantle rocks from Zabargad Island, Red Sea: Geochim. Cosmo. Acta, v. 61, no. 23, p. 5065-5088. First author at Max-Planck-Inst. für Kernphysik, D-69029 Heidelberg, Germany.

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TRITLLA, J. and **CARDELLACH, E.**, 1997, Fluid inclusions in pre-ore minerals from the carbonate-hosted mercury deposits in the Espadán Ranges (eastern Spain): Chem. Geol., v. 137, p. 91-106. First author at Dept. de Cristallografia, Mineralogia i Diposits Minerals, Facultat de Geologia, Univ. de Barcelona, c/Martí Franquès s/n, E-08028 Barcelona, Spain.

FI in pre-ore minerals have been studied using microthermometry, Cryo-SEM-EDS, Raman spectroscopy and crush-leach analyses. Three P FI types have been found in quartz and dolomite: (1) type S, composed of L+V (mainly CO_2) +halite; (2) type S-V, composed of L+high-density CO_2 double bubble+halite; and (3) type V, composed of high-density CO_2-N_2 mixtures. Type S FI are preferentially trapped in Betxí-type veins, characterized by the presence of hydrothermal dolomite, whereas type-V FI are trapped almost exclusively in Eslida-type veins, which were without dolomite. From these data two different F can be inferred to occur during the period of formation of the veins: (1) a complex polysaline brine of NaCl-KCl-$CaCl_2$-($MgCl_2$, SO_4^{2-})-H_2O composition with a sal of up to 33 eq. wt.% NaCl; and a (2) CO_2-N_2-rich F. The brine halogen composition points to its S origin caused by the dissolution of underlying marine evaporites.

The formation conditions for the hypogene sulphide paragenesis are obscure but the coincidence between the preferential trapping of type-V FI, the absence of hydrothermal dolomite and the major abundance of mercury in Eslida-type veins is thought to be linked to a mercury fractionation event to the V phase during the release of the volatiles. (From authors' abstract by E.R.)

TRITLLA, J. and **CARDELLACH, E.**, 1997, Fluid inclusions in pre-ore minerals from the carbonate-hosted mercury deposits in the Espadán Ranges (eastern Spain): Chem. Geol., v. 137, p. 91-106. First author at Dept. de Cristal-lografia, Mineralogia i Diposits Minerals, Facultat de Geologia, Univ. de Barelona, c/Martí Franquès s/n, E-08028 Barcelona Spain.

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It is thought that these deposits were formed during Jurassic or Cretaceous rifting periods, as a consequence of F mixing between a high-sal S brine and connate waters. The generation of a CO_2-N_2-rich phase caused the P increase of the F that favoured the hydraulic fracturing of the enclosing rock (dolostone). (From authors' abstract by E.R.)

TSARYEVA, G.M., KOVALENKO, V.I., GIRNIS, A.V., NAUMOV, V.B. and **KONONKOVA, N.N.**, 1997, Primary picrobasaltic magma of the volcanic rocks of the Kudryavyi volcano area, Iturup Island, South Kuril Arc (melt inclusion data): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 331-332. First author at Inst. of Geol. of Ore Deposits (IGEM) RAS, 35 Staromonetny, Moscow 109017, Russia; email (vik@igem.msk.su).

We have discovered primitive picrobasaltic magma entrapped as MI in high-magnesian olivines of basalt flows of The Older Brother Volcano. These samples contain 15-25 vol.% phenocrysts of olivine (3-8 vol.%), plagioclase, clinopyroxene, orthopyroxene and Fe-Ti oxide minerals. Magnesium content of olivine with studied MI have been found to be high up to Fo87.7-89.9 like that of olivine from mantle rocks (Fo87-92); CaO concentration is 0.15-0.25 wt.% and it is a little bit higher than maximum CaO content of olivine from mantle rocks. Olivine phenocrysts contain crystalline I of Cr-spinel and

P partially crystallized MI consisting of residual glass, gas phase, daughter olivine, Al-spinel (approximately 50 wt.% Al_2O_3), Al-rich clinopyroxene and sometimes sulphide globules. Residual glass composition in MI is (wt.%) 58.0 SiO_2, 0.6 TiO_2, 22.7 Al_2O_3, 3.0 FeO, 0.1 MnO, 1.9 MgO, 7.0 CaO, 4.9 Na_2O, 0.9 K_2O, 0.35 Cl, 0.26 H_2O; (ppm) 59 Cr, 256 Ba, 22 B, 19 Li, 0.8 Be.

After heating at 1310-1330°C with graphite the MI consisted of glass and gas bubble. Composition of that glass in twelve MI is (wt.%) 42.5-44.5 SiO_2, 0.8-1.1 TiO_2 , 16.5-19.9 Al_2O_3, 8.6-11.5 FeO, 0.1-0.2 MnO, 7.6-11.9 MgO, 12.7-14.3 CaO, 2.0-2.3 Na_2O, 0.32-0.46 K_2O, 0.03-0.11 P_2O_5, 0-0.21 F, 0.10-0.18 Cl, 0.13-0.25 S, 0.06-0.09 H_2O; (ppm) 754-1140 Cr, 85-93 Ba, 6-8 B, 3.4-4.8 Li, 0.2-0.36 Be.

The presence of gas bubble in the glass of MI after heating is indicating that the optically invisible daughter olivine have not been melted completely. We have calculated the quantity of unmelted daughter olivine and estimated the composition of the homogeneous I. They contain more MgO (12.9-15 wt.%) and less Al_2O_3 (14.3-17.4 wt.%), a picrobasaltic composition. A specific feature of this picrobasaltic magma is high Al_2O_3 concentration (nepheline+leucite normative) and high concentrations of volatiles Cl, F, S. It is obvious that this olivine with MI was not a liquidus mineral of basalt [the host] but has just been transported in the basaltic magma from a primitive picrobasaltic magma. (From authors' abstract by E.R.)

TUTUBALIN, A.V. and **GRICHUK, D.V.**, 1997, Complex hydrodynamic and thermodynamic model for a convective hydrothermal system: 2. Self-mixing of solutions: Geokhimiya, 1997, no. 12, p. 1208-1220 (in Russian; translated in Geochem. Internat'l., v. 35, no. 12, p. 1071-1082.

TÜYSÜZ, Necati and **AKCAY, Migrac,** 1997, The gold occurrences in the volcanic arc of the eastern Pontides, NE-Turkey: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 331-xxx. Authors at Karadeniz Teknik Üniversitesi, Müh Mim. Fak. Jeoloji Müh Bö ., Trabson, Turkey.

The gold occurrences in the eastern Pontides are associated with volcanic and sedimentary rocks of Liassic to Eocene age and are confined to NE-SW and NW-SE trending fracture zones. The gold mineralization is mainly restricted to zones containing quartz, adularia, sericite and illite. Ore minerals include base metal sulfides, fahlore group minerals, native gold, native silver, argentite, realgar, orpiment, stibnite, zincenite and pyrite. Gold mainly occurs as free grains, 5 to 50 µm in size, in the gangue, but is also included in some ore minerals such as zincenite. Deposition of Au and Ag took place in two to three stages mainly between 340 to 270°C, 240 to 220°C, and 200 to 120°C from F with sal between 2 to 11 wt.% NaCl eq. The mineralogic, alteration and FI characteristics of these occurrences, except for the Kaletas gold occurrence, are similar to those of adularia-sericite type epithermal deposits. Gold deposition in these prospects is controlled mainly by boiling and associated cooling. However, gold deposition in the Kaletas occurrence which has the features of Carlin type deposits took place due to adsorption of gold on organic matter. (Authors' abstract)

UKHANOV, A.V., MOCHALOV, A.G. and **USTINOV, V.I.,** 1997, Fluid-driven PGE redistribution in the alkaline-ultrabasic Konder massif: Oxygen isotope data:, Geokhimiya, 1997, no. 4, p. 443-450 (in Russian, translated in Geochem. Internat'l., v. 35 no. 4, p. 386-392). First author at Vernadsky Inst. of Geochem. and Analytical Chem., Russian Acad. Sci., ul. Kosygina 19, Moscos, 117975 Russia.

A magmatic genesis is currently accepted for most minerals of platinum-group elements, including the placer-forming platinum mineralization of ring dunite-pyroxenite-gabbro and alkaline-ultrabasic massifs. For the latter group of massifs, which is exemplified by the Konder Massif on the southeastern Aldan Shield, the genetic links between PGE mineralization and ultrabasic magma were inferred from the fact that the ore mineralization is restricted to a certain intrusive phase (dunite) and chromite schlieren in it, which yield, according to some estimates, high (close to magmatic) crystallization T. A magmatic source was also ascribed to the F that participated in the deposition of platinum. The presence of these F is implied by that the platinum occurs in intergrowths with amphibole and mica. It is agreed that the hypothetical F source was F-saturated ultrabasic magma and/or younger alkaline magma, whose derivatives often occur as the outermost rings of the massifs. However, detailed studies of the placer-forming minerals from the dunites of ring dunite-pyroxenite-gabbro alkaline-ultrabasic massifs point to the F-metamorphic origin of the mineralization during the dunite recrystallization. (Authors' abstract)

USDOWSKI, E., STAHL, I. and **WAMBACH-SOMMERHOFF, K.R.,** 1997, New and revised data for solid-solution equilibria of the quinary system Na_2Cl_2-K_2Cl_2-$MgCl_2$-Na_2SO_4-K_2SO_4-$MgSO_4$-H_2O: N. Jb. Miner. Mh., 1997, no. 1, p. 15-33.

VALLANCE, Jean, BOIRON, M.-C., CATHELINEAU, Michel and **MARIGNAC, Christian,** 1997, Fluid migration in granites associated with Au-W mineralizations: The example of the Blond granite north west French Massif Central: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 333-334. First author at CREGU and EP 578, BP23, 54501 Vandœuvre-lès-Nancy cedex, France; email (vallance@cregu.cnrs-nancy.fr).

The geometry and chemistry of F migrating in granitic bodies at proximity of ore deposits were investigated. The geometry and the chronology of FIP have been investigated by combined techniques: transmitted light microscopy on oriented wafers and interactive videographic analyser adapted to such studies. P-T-V-X features and direction of F migration have been then estimated. Microthermometry and Raman microprobe investigations show three main groups of F which are dominantly aq. It is worth noting that the circulation of aqueous F occurs in the whole granite using two preferential directions (N50±10°E and N130±10°E). The F are ≤97 mol.% H_2O, CH_4+N_2 range 1-2 mol.%. NaCl is ≤1.2 mol.%. Such F have been observed either in the quartz veins or in the whole granite (up to 2 km from the mineralized quartz vein).

[From these data,] the main F activity can be related to convective F flows of meteoric waters around zones of late intrusions. These waters seem to have percolated at a lesser degree than the whole granite body. (From authors' abstract by E.R.)

VALYASHKO, V.M., 1997, Solubility, immiscibility and critical phenomena in hydrothermal solutions: *in* Proceedings of the Fifth Int'l. Symposium on Hydrothermal Reactions, Palmer, D.A. and Wesolowski, D.J., eds., 1997, Gatlinburg, TN USA, p. 101-104. Author at Kurnakov Inst. of General and Inorganic Chem., Russian Acad. of Sci., Moscow 117907, Russia.

van der KLAUW, S.N.G.C., REINECKE, T. and STOECKHERT, B., 1997, Exhumation of ultrahigh-pressure metamorphic oceanic crust from Lago di Cignana, Piemontese Zone, Western Alps; the structural record in metabasites: Lithos, v. 41, no. 1-3, p. 79-102.

The metamorphic and deformational history of coesite-bearing, ultrahigh-pressure metamorphic oceanic crust from Lago di Cignana, Valtournanche, western Alps, as recorded along the decompression and cooling path, has been resolved to derive constraints on the physical state of the crust during exhumation. Final cooling to below ca. 300°C took place at depths of 7 to 12 km, as indicated by the density of FI. Later deformation in the brittle field cannot be correlated with the P-T path. (From authors' abstract by E.R.)

VAPNIK, Yevgeny, 1997, Melt inclusion investigation in granitoids of Timna igneous complex, southern Israel: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 337-338. Author at Dept. of Geol., Ben-Gurion Univ. of the Negev, PO Box 653, Beer-Sheva 84105, Israel; email (vfrid@bgumail.bgu.ac.il).

MI in quartz were studied from a porphyritic granite and on alkali granite formed by fractionation from mantle derived monzodiorite. Three types of melting reactions were observed based on whether V disappears before, with, or after melting of solids. The melting ranges are rather wide and only a few I from each sample show the lowest T values for the incipient melting, melting of solid and dissolution of the gas phase. Most of these low-T I are the smallest (up to 5-7 μm), whereas in the biggest I (about 20 μm), these T are usually unreasonably high, up to hundreds of degrees higher. This observation may partly be due to the fact that much more than 1-3 hours of constant T is needed for the complete equilibrium in [the larger] MI.

The data show that the crystallization of the porphyritic granite was started with the cotectic crystallization of plagioclase and terminated in residual K-feldspar-rich crystallization. Crystallization of the alkali granite took place at higher T, began with K-rich alkali-feldspar crystallization and terminated in residual Na-rich eutectic crystallization. (From authors' abstract by E.R.)

VARELA, M.E., BJERG, E.A., CLOCCHIATTI, R., LABUDIA, C.H. and KURAT, G., 1997, Fluid inclusions in upper mantle xenoliths from Northern Patagonia, Argentina: Evidence for an upper mantle diapir: Mineral. and Petrol., v. 60, p. 145-164. First author at Univ. Nacional del Sur, CONICET, Bahia Blanca, Argentina.

Three generations of FI can be recognized. Dense CO_2 I were trapped in the mantle-crust boundary zone (22-36 km minimum trapping depth), along with silicate M I at 1200°C. The "late" ("pseudosecondary" and "secondary") generations of FI were classified in accordance with their Th to L CO_2 (L1) and V CO_2 (L2) phase. The minimum trapping depth for the first of the late I (L1) is about 16 km. In spite of the uncertainties related to this value, L1 inclusions indicate that the upper mantle rocks, of which samples were delivered by the basalts, had some residence time in the middle crust where they experienced a metasomatic event. The fact that this event did not destroy the earlier I places severe constraints on its duration. The second late I (L2) are low-P CO_2 I with a minimum trapping depth of only 2 km, presumably a shallow magma chamber of the host basalts. The succession of FI strongly points toward a fairly fast uprising upper mantle underneath Northern Patagonia. (From authors' abstract by E.R.)

VAVELIDIS, M., 1997, Au-bearing quartz veins and placer gold on Sifnos island, Aegean Sea, Greece: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 335-338. Author at Dept. of Mineral.-Petrol.-Economic Geol., Aristotle Univ., Thessaloniki, Greece.

The Au-bearing quartz veins and the placer gold are described in the present work. Gold contents in quartz veins reach up 12.20 ppm and 620 mg/m^3 in placer gold. Microthermometric data in the quartz veins showed Th from 240 to 475°C, with a maximum at 290°C and P up to 123 bars. Placer gold originated from two different sources (Au-bearing stratiform bodies and quartz veins). (Author's abstract)

VAVELIDIS, M., MELFOS, V. and ELEFTHERIADIS, G., 1997, Mineralogy and microthermometric investigations in the Au-bearing sulphide mineralization of Palea Kavala (Macedonia, Greece): in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 343-346. Authors at Dept. of Mineral.-Petrol.-Economic Geol., Aristotle Univ., Thessaloniki, Greece.

The Au-bearing sulphide mineralization of Palea Kavala is connected with quartz bodies in the marble/gneiss contact and in the gneiss series. The gold contents reach up to 42.60 ppm (5.80 ppm on average). The mineralogy, the chemical composition of the sulphides, sulphosalts and gold grains are also given. Textural study, S-isotopic data and microthermometric results revealed a possible hydrothermal-magmatic associated-origin of the mineralized F at 370°C and 550 bars. (Authors' abstract)

VEIGAS, J.G., ROSSEL, Laura and GARLICKI, Aleksander, 1997, Petrology and geochemistry (fluid inclusions) of Miocene halite rock salts (Badenian, Poland): Slovak Geol. Mag. 3, no. 3, p. 181-186. First author at Serveis Cientifico-Tecnics, Univ. de Barcelona, Lluis Solé i Sabaris 1-3, 08028 Barcelona, Spain.

Within Badenian evaporites of southern Poland, three sections have been selected for petrological and geochemical study. Rock salt samples from the vicinity of Wieliczka and Upper Silesia were studied in thin sections under microscope and examined by XRD analysis. A number of selected samples were tested by FI microanalysis using the Cryo-SEM-EDS methodology. As a result of this study, the mineralogical components and characteristic textures of the rock salt have been established. Fine to coarse crystalline halite is the main constituent of the rock salt. Relics of large hopper crystals are abundant in two of the studied sections. Anhydrite and gypsum are the occurring sulphate minerals, the latter being derived mainly from partial anhydrite hydration. Polyhalite is absent or very scarce. The chemical composition of P FI is in accordance with a marine origin of the deposit. The homogeneity of the FI composition in the analyzed samples suggests that the mother brines reached a steady state during the halite deposition. To reach this steady state, Na and Cl lost by halite precipitation had to be added by inflow waters enriched in both elements so that a recycling mechanism was needed. With the available data it is not possible to determine the source (marine, continental or mixed waters) of the inflow implicated in the recycling mechanism. (Authors' abstract)

VEKSLER, Ilya and **KEPPLER, Hans,** 1997, Experimental studies of the immiscibility between carbonatitic melt and aqueous fluid (abst.): GAC/MAC Annual Meeting, May 19-21, 1997, Abstract Volume, v. 22, p. A152. Authors at Bayerisches Geoinstitut, D-95440 Bayreuth, Germany.

Experimental studies of element distribution in carbonate-water systems are hampered by the fact that neither F nor M can be quenched isochemically in conventional high-P vessels. We have used two experimental techniques of phase separation: (1) double-capsule assemblages and (2) synthetic FI. The preliminary double-capsule data on the $CaCO_3$-$MgCO_3$-Na_2CO_3-H_2O system show that F/M partition coefficients for Ca and Mg are similar and several times smaller than those of Na. As the T increases from 700 to 900°C, the partition coefficient (D) for Na (calculated on anhydrous basis) decreases from 2 to 1.3, while D for Ca and Mg increase from 0.4 to 0.9.

To produce synthetic I gem-quality San Carlos olivine was used as a host. The runs were performed in rapid-quench cold-seal P vessels at 1-2 kbar and 800-850°C in sealed Pt capsules. The charges were composed of an olivine crystal, mixture of sodium and calcium carbonates and distilled water. When desired P-T conditions were achieved, the olivine crystals were fractured by dropping the capsules into the cold zone of the bomb. After the fracturing and trapping of the M and F phases into the cracks the capsules were lifted back to the hot zone and kept several days for fracture healing. The runs resulted in the formation of abundant I of carbonatite M and H_2O-CO_2 F. (From authors' abstract by E.R.)

VEKSLER, I.V. and **SOKOLOV, S.V.,** 1997, Melt inclusions in minerals from plutonic carbonatites: Implications for the composition of parental magmas: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 339-340. First author at American Museum of Natural History, Central Park West at 79th St., New York, NY 10024-5192.

We studied P MI in forsterite diopside, apatite and dolomite from Kovdor, Magan and Guli carbonatites. Bulk chemical compositions of trapped M were evaluated by electron microprobe analyses of homogenized and quenched I, and from the volume proportions of the dm in non-heated I. Four stages of carbonatite formation are traditionally recognized in Kovdor and Guli. Our data on Th of MI is in agreement with this classification. Thus, MI in apatite from the earliest calcite carbonatites (stage I) homogenize at 820-920°C, I in forsterite and diopside from the stage II calcite carbonatites have Th 755-800°C and 825-850°C. MI in dolomite (stage III) homogenize at 500-560°C. MI in Fe-dolomite from the latest Guli dolomite carbonatites (stage IV) homogenize at 490-530°C. All the I quench to brownish fine-grained crystalline aggregates. Apart from the crystallized MI, apatite often contains abundant heterogeneous and homogeneous (gas, L and dxl) FI. Assemblages of daughter phases in different host minerals are extraordinarily diverse: forsterite and diopside commonly have phlogopite and amphibole, plus magnetite, apatite, calcite, dolomite, Na-Ca carbonates and Fe-Cu sulphides. I in apatite are composed mainly of carbonates (calcite and Na-Ca phases) with minor magnetite and other minerals. The difference in daughter phase assemblages is reflected in the bulk chemistry of the I. Homogenized I in forsterite have 13.8-34.8 wt.% SiO_2, whereas homogenized I in apatite are very low in SiO_2 (0.01-0.1 wt.%). All the homogenized I in the minerals from early-stage carbonatites that were studied have low alumina contents (close to the detection limit) and high CaO bulk concentrations (20-45 wt.% in apatite and 14-26 wt.% in forsterite). Alkali contents are variable, but remarkably high. I in apatite contain 8.65-13.3 wt.% Na_2O and 4.07-4.83 wt.% K_2O; I in forsterite 2.54-7.17 wt.% Na_2O and 1.93-3.99 wt.% K_2O. Bulk concentrations of alkalies are even higher in homogenized I in dolomite from late-stage carbonatites, and potassium is more abundant in them than sodium (8.83-9.03 wt.% Na_2O and 11.8-14.7 wt.% K_2O).

The results of our study have important implications for compositions, origin and evolution of carbonatitic magmas: 1) I in coexisting forsterite and apatite, compositionally different, but nearly identical in terms of Th, imply the coexistence of L of contrasting chemical composition. These data favour the ideas of L immiscibility between silicate and carbonate L; 2) Parental carbonatitic L have high concentrations of alkalies. One may speculate that parental M of natrocarbonatite lavas and plutonic carbonatites maybe not [be] so distinct and these contrasting compositions are possibly related by crystal fractionation and/or hydrothermal processes; and 3) Fractionation of high-T immiscible aq F may play important role in the evolution of carbonatitic magmas. The F can extract highly soluble alkali crabonates and cause fenitization of country rocks associated with alkali-poor carbonatite bodies. This is supported by the broad occurrence of highly concentrated brines in apatite FI, not only in Kovdor and Guli, but in many other plutonic carbonatites. (From authors' abstract by E.R.)

VELÍCHKIN, V.I., KISELËVA, G.D., KRYLÓVA, T.L., and **NÍKONOV, B.S.,** 1997, Geological and geophysical conditions of ore-formation involving fluid-salt systems in the unique Syrymbet tin deposit: in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 27-28, ISBN 5-88918-002-9 (in Russian; English translation courtesy Dr. D. B. Brown). Authors at IGEM, RAS, Moskvá.

The ores of the unique Syrymbet tin deposit, which also contain W, Bi, rare elements, and polymetals, were formed in the zone of the Volodársk deep-seated fault, transecting the western marginal portion of the Kokchetáv median massif of Caledonian (Early-Middle Devonian) consolidation. The fault controls the position and development of intrusions of late-orogenic, multiphase, rare-metal granites and their deep-seated magmatic foci.

The unusually varied mineral complex of the Syrymbet deposit, involving 80 neogenic mineral forms, including those rare in tin deposits, was generated during the course of early skarn, late skarn, greisen-hydrothermal, and hydrothermal stages of mineral formation.

The minerals of the early skarn stage developed in association with the emplacement of early orogenic granitoids. The bulk of the cassiterite mineralization was formed during the late skarn and greisen-hydrothermal stages. The ore-forming process took place against a background of a series of separately manifested pulses of tectonic deformation. It was interrupted twice during the greisen-hydrothermal stage by injections of magmatic M, which were the late differentiates of a deep-seated focus of rare-metal Li-F granites. Major long-term flows of magmatogenic, highly-concentrated acid F, containing F, Cl, alkali metals, tin, and a number of rare and rare-earth elements, predetermined the unique scale of the deposit, and the presence on the ores of at least four generations of cassiterite, and also several fluoride and fluorine-bearing minerals (fluorite, topaz, sellaite, and fluocerite). The overwhelming development of ore mineralization in the rocks rich in bases (Ca, Mg, Fe), controlled the increased iron content of many of the neogenic minerals (amphiboles, micas, tourmaline, etc.) and the appearance of such specific minerals as danalite and sellaite, and also led to a marked neutralization of the ore-bearing F and to the mass precipitation of collomorphic and fine-grained cassiterite from them.

During the hydrothermal stage, sulphides of Fe, Bi, Cu, Zn, and Pb, associated with fluorite and quartz, were formed. The later-developed native Bi, Au, and Zn, and carbonates terminated the hydrothermal mineral formation. The most common ore element during this stage was bismuth. It is involved in the composition of nine mineral forms and is regarded as one of main components accompanying tin.

It has been established that, during the entire interval of existence of the mineral-forming system, the F retained a high salt-concentration, reaching at the beginning of each stage the levels of brine-melts.

The minerals of the late skarns and greisens crystallized out from a G-L metalliferous medium of fluoride-chloride-soda composition, which represented a heterogeneous system, consisting of a H_2O-CO_2-G F and a H_2O-salt brine-melt. P drop and degassing of the F, which occurred after the end of the greisen stage, caused transformation of the system into a hydrothermal system, containing from 47 down to 27 wt.% of salts. The early mineral associations of the hydrothermal stage were also formed during the involvement of the brines. In this instance, the salt concentration in the F over the entire interval did not fall below 25 wt.%.

The T range of mineral formation amounted to 570-200°C. Pulses of marked (up to 250°C) T increases, which subsided during lowering of concentration of salts, corresponded each time to the entry of brines into the F. The P during formation of the early associations of the greisens fell sharply from 200 to 750 bars, and subsequently decreased gradually to 200 bars.

The alternation of stages of F and magmatic activity during the process of formation of the Syrymbet deposit, the multiphase nature of the ore deposition, and the unusually high salt concentrations in the mineral forming medium, reaching the levels of brines, point to a clear genetic connection between the ore-bearing F and the intensely differentiated deep foci of the leucocratic magmas with a halogen-rare-metal specialization, and to the duration of the ore-forming process, which had already begun during the concluding phases of intrusive activity in the magma focus. These same features are a combination of those main geological-petrological and physicochemical factors which had predetermined the unique scale of mineralization of the Syrymbet deposit. (Authors' abstract)

VELICHKIN, V.I., VLASOV, B.P., KRYLOVA, T.L. and TIMOFEEV, A.V., 1997, The formation condition of the vein-type uranium mineralization in the northern part of the Bohemian massif (abst.): in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 245-246 (In Russian; Engl. translation from: English Version of the Abstracts of the Oral Presentations of the Papers of the Russian Participants, p. 57-58). ISBN 5-88918-002-9. Authors at Inst. of Geol. of Ore Deposits, Petrog., Mineral., and Geochem. (IGEM), RAS, Staromonetnyi per., 35, 109017 Moscow, Russia.

The uranium-ore mineral parageneses were fomed in the T range from 250-230° to 110°C under P of 200-300 bar. The uranium-bearing solutions had the chloride-sodium-calcium composition; in their later portions the hydrocarbonate ions are present. The I of L organic matter (with various oxidation degree) in the quartz and fluorite from uranium-bearing mineral parageneses were detected; this suggests that significant changes of the redox potential of mineral-forming medium occurred during ore deposition process. The hypothesis of the origin of ore-forming uranium-bearing F was developed. It proposes that these F were produced by the deep-seated source of specialized deeply differentiated leucogranitic M in the course of latest stage of their crystallization. (From authors' abstract by E.R.)

VERMA, S.P. and SANTOYO, Edgar, 1997, New improved equations for Na/K, Na/Li and SiO_2 geothermometers by outlier detection and rejection: J. of Volcanol. and Geothermal Research, v. 79, p. 9-23.

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: Carbonate-hosted zinc-lead deposits in the Silesian-Cracow area, Poland, Ewa Górecka, 1996, D.L. Leach and Andrzej Kozlowski, eds, p. 85-104. First author at U.S. Geological Survey, P.O. Box 25046, Mail Stop 973, Denver, CO 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 and the last galena stage were not sampled.

Although the number of analyses are limited to nine samples and two replicates and there is uncertainty about the characteristics of the FI analyzed, 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)

VIKENTYEV, I.V., 1997, Mineralogical-geochemical and paleotemperatural zoning of Tishinskoe giant sulfide deposit: Formation and Metamorphism of Massive Sulphides—Frank M. Vokes 70 Year Anniversary Symposium, March 16-19, 1997, Norwegian Univ. of Sci. and Tech. in Trondheim, Norway, Abstracts (unpaginated). Author at Inst. of Geol. of Ore Deposits, RAS, Staromonetnyi per., 35, Moscow, 109017 Russia.

The Tishinskoe deposit in the Rudnyi Altai consists of massive sulfide ores (Zn>Pb≥Cu) that were deformed at T of 200-400°C. Changes of mineral composition [with depth] correspond to paleotemperature zoning of the large ore body.

Th of FI in minerals of massive ores ranges from 155 to 325°C, indicating a subvertical thermal gradient. The paleopressure ranges from 2.2 kb at the lower levels to 1 kb at the upper ones. The contents of salts and CO_2 in the metamorphic F decrease in the same direction. T of formation of metamorphic assemblages in host rocks seems to have been from 250-350°C up to 500-550°C. (From author's abstract by E.R.)

VILLA, I.M., BAKKER, R., BOIRON, M.-C., CATHELINEAU, M. and BANKS, D., 1997, Ar isotope analysis and detailed analytical characterization of fluid inclusions from well Bruciano (Larderello geothermal field): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 341-342. First author at Mineralogisches Inst., Univ. Bern, Erlachstrasse 9a, CH-3012 Bern; email (igor@mpi.unibe.ch).

Analyses of homogenization behaviour, chemical composition and Ar isotopic comosition have been carried out on FI in a quartz from well Bru-1, at a depth of 3138 m, in the Larderello geothermal field. The quartz is dominated by regular shaped two-phase I which are volatile-rich with variable H_2O contents (about 60-80 mol.% H_2O with a sal of 2-3 wt.% eq. NaCl), no visible dm [the balance is presumably mainly CO_2 with minor CH_4 and N_2.] Total Th are to the V phase in the range of 300 to 400°C, and also comparable with the previous data from Sasso (316-400°C).

The V-X properties of these C-H-N-O-(S) I are modelled in the H_2O-CO_2-CH_4 system using the equations of state. The inferred T for the stability of the hydrothermal metamorphism at depth (biotite-tourmaline-quartz assemblage) is around 500±50°C. This is confirmed by the high K/Na ratio, around 0.35 (in wt.%) determined using crush-leach techniques. The P at that T is around 0.8 to 1.3 kb depending on V-X properties of the I, attesting of possible fluctuations around the lithostatic P at that depth during the early stages of the Larderello field activity.

The studied F is interpreted to be the result of water-rock interactions in C-rich units during the contact metamorphism which affects the Larderello basement during the intrusion of an inferred pluton at depth. This is also confirmed by the Br/Cl ratio (0.0018 in weight) found by crush-leach techniques which is similar to those of F equilibrated with metamorphic rocks.

We analysed Ar isotopes in two 5-mg aliquots by stepwise heating. Dating the formation of such young (≈4 Ma) FI was not possible, but we were successful in our isotopic characterization of the FI. (From authors' abstract by E.R.)

VOINKOV, D.M., 1997, Geochemistry of sulfur isotopes and temperature environment of hydrothermal ore deposits Fe, Sn, W, Au (by fluid inclusions): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 343. Author at State Scientific Center of Russian Federation, VNIIGeosystem.

The complex skarn Sn-W deposit Maikhura in Tadjikistan is an important commercial object. Ore deposits of quartz-garnet-pyroxene composition with cassiterite and wolframite always have pyrrotite, pyrite, chalcopyrite and sphalerite. The sulfur isotope composition has a narrow range of values $\delta^{34}S$ from -0.2‰ to +3.5‰ and Th of 470-230°C. [$\delta^{34}S$ values are given for other unnamed deposits]. (From author's abstract by E.R.)

VOLFINGER, M., RAMBOZ, C., AISSA, M. and CHOÏ, C.G., 1997, Some practical aspects of the quantitative analysis of fluid inclusion by the PIXE method: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 344-345. First author at CRSCM-CNRS, Orléans, France; email (volfinge@cnrs-orleans.fr).

Optimization of the many instrumental and sample parameters for best accuracy and precision is discussed. The Sn-borate nordensködine was identified in magmatic Sn-skarns from El Hamman and polyhalite was found as a dxl in a FI from hydrothermal quartz replacing stratabound anhydrite near the Largentiere Zn-Pb deposit. (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., 1997, Calcite in fractures in a volcanic environment (Vulcano Island, Italy); contribution of geochronological and isotopic studies to volcanotectonics: J. of Volcanol. and Geothermal Research, v. 75, no. 3-4, p. 271-282.

The southern and southeastern rim of the present caldera (La Fossa caldera) at Vulcano Island (Aeolian Islands, Italy) is crosscut by a network of fractures filled with calcite and minor chalcedony. FI studies indicate that both mineral phases were deposited from hydrothermal solutions. Several calcite samples were analyzed and their U, Sr, Nd, O and C isotopic composition was determined. U/Th geochronological data suggest two discrete depositional episodes: one at 50 ka (southern rim) and the other at 25 ka (southeastern rim). Oxygen isotopic compositions, $^{87}Sr/^{86}Sr$ and $^{234}U/^{238}U$ ratios exclude that seawater was involved significantly in the hydrothermal system, in agreement with FI studies which did not document the presence of NaCl. The Nd and Sr isotopic composition of calcite reflects the composition of the host rocks. The oxygen isotopic composition excludes a post-depositional interaction with meteoric water and suggests a depositional T consistent with that obtained from the FI study (160-170°C), assuming equilibrium conditions and a F isotopic composition close to present-day steam emissions. The positive correlation between U content and C isotopic composition indicates a rapid change in CO_2 P during calcite deposition. This observation is consistent with a rapid F ascent, likely connected to two phases of collapse of the La Fossa caldera. The ages of the calcites which fill the fractures at the La Fossa caldera indicate the activation time of the fracture systems which, in turn, are connected to the above mentioned phases of the caldera. (Authors' abstract)

Von DAMM, K.L., BUTTERMORE, L.G., OOSTING, S.E., BRAY, A.M., FORNARI, D.J., LILLEY, M.D. and SHANKS, W.C., III, 1997, Direct observation of the evolution of a seafloor 'black smoker' from vapor to brine: Earth and Planet. Sci. Letters, v. 149, no. 1-4, p. 101-111. First author at Dept. of Earth Sci. Univ. of New Hampshire, James Hall, Durham, USA.

A single hydrothermal vent, 'F' vent, occurring on very young crust at 9°16.8'N, East Pacific Rise, was sampled in 1991 and 1994. In 1991, at the measured T of 388°C and seafloor P of 258 bar, the F from this vent were on the two-phase curve for seawater. These F were very low in chlorinity and other dissolved species, and high in gases compared to seawater and most sampled seafloor hydrothermal vent F. In 1994, when this vent was next sampled, it had cooled to 351°C and was venting F ~1.5 times seawater chlorinity. This is the first reported example of a single seafloor hydrothermal vent evolving from V to brine. The 1991 and 1994 F sampled from this vent are compositionally conjugate pairs to one another. These results support the hypothesis that V-phase F vent in the early period following a volcanic eruption, and that the L-phase brines are stored within the oceanic crust, and vent at a later time, in this case 3 years. These results demonstrate that the venting of brines can occur in the same location, in fact from the same sulfide edifice, where the V-phase F vented previously. (Authors' abstract)

VOUDOURIS, P., 1997, Epithermal and porphyry type mineralizations in Kassiteres area, Thrace (Greece): in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p.683-686. Author at Dept. of Geol., Univ. of Athens, Greece.

The Kassiteres prospect is an intensively hydrothermally altered and mineralized area, located in Thrace, northeastern Greece. Three distinct periods of mineralization and associated alterations are recognized at Kassiteres: an early porphyry Cu mineralizing event was followed by alterations and mineralizations typical for epithermal high-sulfidation and low-sulfidation systems. The high-sulfidation mineralizations are characterized by the presence of alunite and barite. Low-sulfidation veins consist of quartz and chalcedony with adularia and calcite. The observed close spatial relationship between epithermal high-sulfidation, low-sulfidation and porphyry type mineralizations indicate complex processes within a magmatic-hydrothermal system in the site of an andesitic volcanic center. (Author's abstract)

Preliminary FI studies indicate the vein mineralizations in Kassiteres were formed at T between 150 and 340°C, most of them ranging from 200 to 300°C (Voudouris, unpub. PhD thesis, Univ. Hamburg, 1993). The sal range from 0.5 to 4.5 eq. wt.% NaCl. Microthermometric data from the high-sulfidation alunite-barite rich veins show that their deposition occurred at T between 210 and 250°C by low-sal F (about 2.0 eq. wt.% NaCl). Precious metals in the low-sulfidation calcite veins were introduced by hydrothermal F of intermediate T (250-296°C) and low sal (0.7-3.0 eq. wt.% NaCl), which probably were heated meteoric waters. The hydrothermal solutions responsible for the deposition of precious metals in the low-sulfidation veins were probably boiling, as indicated by the coexistence of L-rich and V-rich I, with highly variable L-V ratios in the studied vein material. (From author's text by E.R.)

VOZNYAK, D.K., GALABURDA, Yu.A. and KRAVCHENKO, G.L., 1997, Conditions promoting formation of gold-ore mineralization of the western Azov Sea region: Mineralogical J., v. 19, no. 6, p. 10-19 (in Russian; Engl. abst.).

PTX-conditions promoted formation of gold-ore mineralization and determined by I of the mineral-forming medium are described in this paper. No P I in quartz of gold-containing rocks have been found. All I studied are S and were formed when healing cracks. The following I are identified among the F ones according to their composition: water, dioxide-carbonaceous and nitogenous. Mineral-forming solutions were heterogenous. The results of the study served the ground for identifying the most gold-promising areas in the western Azov Sea territory. (Authors' abstract)

VOZNYAK, Dmytro, LITOVCHENKO, Anatolyj and KULCHYTSKA, Anna, 1997, Radiolysis of hydrocarbon inclusions in quartz: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 346-347. Authors at Palladin St., 34, 252680 Kyjiv-142, Ukraine; email (instit@mineral.freenet.kiev.ua).

FI may be exposed to radiation in nature that causes changes of their chemical composition. Study of such transformations is most expedient by using artifical radiation. Five PI in quartz crystals of "Marmarosh diamonds" type from Ukrainian Carpathians and Donetsk Basin were given $1 \cdot 10^{10}$ rad. The L saturated hydrocarbons having at least from 6 to 27 carbon atoms are synthesized when large dosages of radiation are used, which also leads to an increase of Th.

Thus, exposure to gamma-radiation of hydrocarbon I substantially changes their initial composition. On the other hand since the change of methane F composition is determined by radiation dosage such I can be used for the estimation of dosages of natural radiation impact on minerals containing them. (From authors' abstract by E.R.)

WAGNER, Thomas and **COOK, N.J.**, 1997, Mineral reactions in sulphide systems as indicators of evolving F geochemistry; a case study from the Apollo mine, Siegerland, FRG: Mineralogical Magazine, v. 61, no. 4, p. 573-590.

The textural and paragenetic relationships of sulphide and sulphosalt minerals within Cu-Pb-Sb-Bi hydrothermal vein mineralization at the Apollo mine, Siegerland, Germany, are interpreted in terms of various reaction sequences and modelling of the F during the entire mineralizing event, based on the transfer of chemical components reflected in the succession of mineral reactions. (From authors' abstract by E.R.)

WALTHER, J.V., 1997a, Determination of activity coefficients of neutral species in supercritical H_2O solutions: Geochim. Cosmo. Acta, v. 61, no. 16, p. 3311-3318.

WALTHER, J.V., 1997b, Experimental determination and interpretation of the solubility of corundum in H_2O between 350 and 600°C from 0.5 to 2.2 kbar: Geochim. Cosmo. Acta, v. 61, no. 23, p. 4955-4964.

WANG, Guozheng, 1997, Geological characteristics and genesis of the Anle tin-copper deposit, Inner Mongolia: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 3, p. 260-271 (in Chinese; Engl. abst.). Author at Surveying Team of North China Geoexploration Bureau, Sanhe 101601.

The Anle tin-copper deposit is one of the important deposits in the southwestern part of the Huanggang-Ganzhuermiao tin-polymetallic ore belt in Inner Mongolia, all close in time and interdependent in space. K-Ar isotopic ages of volcanic and subvolcanic rocks are 122.8×10^6a ~137.05×10^6a, and Rb-Sr isotopic age of granite porphyry is 134.2×10^6a, Mineralization is spatially conditioned by semiconcealed granite porphyry body, assuming ringed horizontal zoning and reverse zoning of Sn-Sn, Cu-Cu, Ag in outward and downward directions.

REE characteristics of rocks and cassiterite show duality of tin sources: HREE-enrichment type cassiterite possesses the same source as granite porphyry, whereas LREE-enrichment type cassiterite is of the same source as subvolcanic rocks. Nevertheless, the two types of cassiterite underwent the same ore-forming processes.

$\delta^{34}S$ values of ores vary in the range of -5.50‰ ~2.50‰, suggesting the derivation of sulfur from the mantle. REE components indicate that the ore-forming and rock-forming processes of the ore deposit have characteristics of mantle source. Hydrogen and oxygen isotopic compositions of cassiterite are $\delta^{18}O$ = -2.64‰ ~-3.06‰ and δD = -45‰ ~-225‰ [sic], implying that ore-forming F came mainly from meteoric water.

Mineralization underwent the whole process from high T through intermediate T to low T dominated however by intermediate-high T and exhibiting multi-stage metallogenic characteristics of the identical phase.

It is concluded that the Anle tin-copper deposit is a mesothermal-hydrothermal deposit formed by structural dynamic force, subvolcanic magma and granitic magma. (From author's abstract by E.R.)

Five analyses of FI are given for K, Na, Ca, Mg, F, Cl, SO_4, CO_2, CH_4, CO, H_2, N_2 and H_2O (E.R.).

WANG, Henian, CHEN, Jun, JI, J.-F. and **QU, X.-M.**, 1997, Geological and geochemical characteristics of the Hetai gold deposit, south China: Gold mineralization in an auriferous shear zone: Internat'l. Geol. Review, v. 39, p. 181-190. Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing 210008, PRC.

The Hetai gold deposit is contained within a ductile shear zone in low-rank metamorphic rocks. Studies of FI show that the ore-forming T varied from 200 to 280°C, the P was 57.4 MPa, and fO_2 varied from 10^{-37} to 10^{-39}. The ore-forming F are rich in HCO_3^- and CO_2, and have a relative proportion of $Na^+ > K^+ > Ca^{2+}$ and $HCO_3^- > Cl^- > F^- > \Sigma S$. The δD_{H2O} of I water ranges from -57 to -82‰ and δO_{H2O} from 5.71 to 4.28‰, implying multiple sources for the ore-forming F. The Pb-isotope composition of ores suggests that the Pb came from the upper crust–i.e., mainly from metamorphosed rocks and granites. The $\delta^{34}S$ has a range of -3.06 to -1.73‰ and is in agreement with the $\delta^{34}S$ value of the wall-rock mylonite, indicating a wall-rock source. On the basis of the above characteristics, the authors propose the following metallogenic model for the Hetai gold deposit: (1) early ductile shear deformation and metamorphism in the Hercynian-Indosinian epoch formed altered mylonite-type gold deposits; (2) the superimposition of a magmatic hydrothermal solution occurred in the late Indosinian epoch and resulted in local gold enrichment. (From authors' abstract by E.R.)

WANG, Hongmei, ZHANG, Wenhuai and **QI, Shihua**, 1997, Ore-forming fluid of Jinya gold deposit Guangxi province: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 9 (in English). Authors at China Univ. of Geosci., Wuhan, 430074.

This paper deals with the inorganic components, organic components and isotopic characteristics of ore-forming F in detail. Results show that the ore-forming F is very complex. At least two kinds of F are included in the ore-forming F. One is the organic F (oil-field water) related to strata, the other is inorganic F dominant in SO_4^{2-}. Besides, meteoric water also participates in mineralization. From the view of interconnection of organism and inorganism, the paper discusses the interaction process of the two kinds of F and indicates the microscopic prospecting markers. (Authors' abstract)

WANG, Jincao, 1997, Tectonic mechanism of formation of auriferous quartz veins in the folding process: A case study of the origin of quartz veins in the Longshui gold deposit: Geological Review, v. 43, p. 78-84. Author at Research Inst. of Geol. for Mineral Resources, CNNC, Guilin, Guangxi.

On the basis of an analysis of tectonic deformation of the Shuizhengding vertical fold and difference in deformation of auriferous or unauriferous quartz veins in the Longshui gold deposit, the author [suggests] that the diverse deformation types were chiefly caused by the change of the principal shear stress and principal compressive stress acting on rock layers with time. (From author's abstract by E.R.)

WANG, Lisheng, HE, Mingyue, WANG, Pu and **ZHANG, Jianhong** and **PARAT, Abdukadir,** 1997, Mineralogical study on ruby and sapphire deposit of Aketao, Xinjiang: Geoscience (Xiandai Dizhi) - J. of Grad. School, China Univ. of Geosci. (qtrly), v. 11, no. 1, p. 36-43 (in Chinese; Engl. abst.). Authors at China Univ. of Geosci., Beijing 100083.

The gemmiferous rocks in ruby and sapphire deposit of Aketao (Xinjiang) are characterized by augen and banded structures of migmatization. Abundant F-M I are found in the crystals of ruby and sapphire. The deposit is formed by migmatization with high T and low P. FI data is given (H.E.B.)

WANG, Ping, LU, Xinbiao and **ZHANG, Chuanling,** 1997, Characteristics of ore-bearing fluid in Liulong gold deposit, Jiangxi province: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 7 (in English). Authors at Fac. of Earth Resources, China Univ. of Geosci., Wuhan, 430074.

The F features of Liulong gold deposit, the form, composition, T, sal of FI, and their P, $f(O_2)$, $f(CO_2)$, density and mineralization depth are calculated. Furthermore, the evolution of the ore-forming F is discussed. (Authors' abstract)

WANG, Q., CAMPBELL, I.H. and **REN, S.K.,** 1997, Constraints on the timing of two-stage gold mineralisation at Kanowna Belle, Eastern Goldfields Province, Western Australia: (abst.) The Australian National Univ. Research School of Earth Sci., Annual Report 1997, p. 161.

The Kanowna Belle mine is a major new gold discovery located in the Eastern Goldfields Province of the Yilgarn Craton. Detailed mineralogical, sulphur isotope, FI and field studies have shown that there are two periods of mineralisation. The aim of the present study was to constrain the timing of the two types of mineralisation by SHRIMP U-Pb zircon geochronology. (From authors' abstract by E.R.)

WANG, Siyuan and **ZHENG, Youye,** 1997, Metallogenic dynamic mechanism of a super-high tectono-metamorphic fluid: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 2 (in English). Authors at Fac. of Earth Resources, China Univ. Geosci., Wuhan, 430074.

This paper has posed a conception of superhigh tectono-metamorphic F, i.e., it is a mixture of migma, L and G produced on the superhigh dynamic metamorphic action. The author points out this F is rich in G-water and noble metal's complex. Those F occur mainly and act in some ductile shear zones. When those shear zones from compresso-shear change into shearing tensile, the F are differentiated into magma, L and G, and occur filling-replasement mineralization. [sic] (Authors' abstract)

WANG, Yigang, YU, Xiaofeng, ZHANG, Jing and **YANG, Yu,** 1997, Application of fluid inclusions in petroleum exploration: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 10 (in English). Authors at Inst. of Geol. Exploration and Dev., Sichuan Petroleum Administration, Chengdu, 610051.

By the data of burial history, diagenetic history of reservoirs, petrological characteristics of FI, thermometry analysis, component analysis of organic I and fluorescence analysis in sedimentary basin, combining with the geological conditions, the application of FI to oil-gas exploration area is discussed in this paper. (Authors' abstract)

WANG, Zhaoyun and **CHENG, Keming,** 1997, The hydrocarbon generation mechanism and the three-stage type model of hydrocarbon generation for carbonate source rocks: Sci. in China Series D, Earth Sci., v. 40, no. 3, p. 232-238.

Indexed under FI (E.R.).

WARREN, E.A., PULHAM, A.J. and **NAAR, Joaquin,** 1997, Primary compositional control on quartz cement and porosity in deeply-buried sandstones, Cusiana Field, Llanos foothills, Colombia: Annual Meeting Abstracts - American Assoc. of Petroleum Geologists and Soc. of Economic Paleontologists and Mineralogists, v. 6, p. 122-123.

Porosity in deeply-buried (>14,000') sandstones of the lower Tertiary Mirador formation in the Cusiana Field, Llanos foothills, Colombia, is <10 p.u. However, permeability is as much as 1000 mD; which is believed to be due to the simple quartzose detrital grain composition and large grain size. The low porosity has resulted from pervasive quartz cement (10-15% bv). FI microthermometry and intergranular grain volumes indicate that the quartz cement precipitated from hot F (c. 100°C) during deep burial. (From authors' abstract by E.R.)

WARREN, J.K., 1997, Evaporites, brines and base metals: Fluids, flow and 'the evaporite that was': Australian J. of Earth Sci., v. 44, p. 149-183. Author at JK Resources Pty Ltd, PO Box 520, Mitcham SA 5062, Australia; email (jwarren1@ozemail.com.au).

Waters in modern evaporite systems are marine, nonmarine, or hybrid but mineralogies in most ancient systems are not so simple that marine and non-marine brines can be easily interpreted from the chemistry of their precipitates. Complications arise related to subsurface brine mixing and back-reactions both at the surface and in the subsurface. The precipitation order of ancient bittern salts from seawater may have been dependent on flux rates of river inflow relative to flux rates through mid-ocean ridges. In ancient continental systems the chemistry of the inflow waters was a fundamental control on the subsequent mineral paragenesis.

The various indicator textures are then used to discuss the evolution of the earth's surface waters from the Archaean till the Phanerozoic. Halite the mineral or its pseudomorphs characterise areas of widespread chemical sedimentation from the Archaean to the present. Calcium sulfate is more enigmatic. Widespread beds composed of calcium sulfate minerals or their pseudomorphs were scarce to absent up to approximately 1.8 Ga. Since then the halite/gypsum precipitates from a concentrating seawater brine reflect the same predictable succession of precipitated salts as is found in modern seawater (with possible complications in the bittern salts). This implies marine water has maintained similar proportions of major ions throughout the Phanerozoic and the Proterozoic back to 1.9-1.8 Ga. Prior to this the Archaean ocean may have been a Na-HCO_3 ocean and not the Na-Cl ocean of today. (From author's abstract by H.E.B.)

WATT, G.R., WRIGHT, Paul, GALLOWAY, Simon and **McLEAN, Chris,** 1997, Cathodoluminescence and trace element zoning in quartz phenocrysts and xenocrysts: Geochim. Cosmo. Acta, v. 61, no. 20, p. 4337-4348. First author at Geol. and Cartography Div., Oxford Brookes Uiv., Headington, Oxford, OX5 2SD, U.K.

Scanning electron microscopy CL imaging (SEM-CL) and S ion mass spectroscopy (ion microprobe) analysis (SIMS) are used here to demonstrate that quartz crystals in volcanic rocks show hitherto unrecognised internal structural and chemical zoning. (From authors' abstract by E.R.)

Pertinent to MI studies (E.R.).

WAWRZYNIEC, T., SELVERSTONE, J. and **AXEN, G.J.,** 1997, An integrated structural and fluid inclusion study of footwall unroofing along the Simplon Line, Central Alps, Switzerland: Geol. Soc. Amer. Prog. Abs., v. 29, p. A234.

WEARE, J.H., 1997, Prediction of thermodynamic properties in salt-CO_2-CH_4-H_2O: First principle simulations and equation-of-state approaches: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 214, Lunar and Planetary Inst., Houston.

WEBB, Sharon, 1997, Silicate melts: Relaxation, rheology, and the glass transition: Reviews of Geophys., v. 35, no. 2, p. 191-218. Author at Bayerisches Geoinstitut, Bayreuth, Germany.

A review, pertinent to understanding MI phenomena (E.R.).

WEBBER, K.L., FALSTER, A.U., SIMMONS, W.B. and **FOORD, E.E.,** 1997, The role of diffusion-controlled oscillatory nucleation in the formation of line rock in pegmatite-aplite dikes: J. of Petrol., v. 38, no. 12, p. 1777-1791.

WEBSTER, J.D., 1997a, Exsolution of magmatic volatile phases from Cl-enriched mineralizing granitic magmas and implications for ore metal transport: Geochim. Cosmo. Acta, v. 61, no. 5, p 1017-1029. Author at Dept. of Earth and Planet. Sci., American Museum of Nat. History., New York, NY, 10024-5192.

To understand Cl dissolution in aluminosilicate L and the exsolution of Cl-rich magmatic volatile phases, experiments were conducted to determine the solubility of NaCl, KCl, and H_2O in felsic L at 0.5 and 2 kbar. The Cl content of H_2O-poor, NaCl-saturated, and KCl-saturated silicate L is low (i.e. ≤1.3 wt.%) to very low (i.e. ≈0.2 wt.%) and varies with changes in P and composition; the Cl concentration increases with the F concentration and the molar (Al+Na+Ca+Mg/Si) ratio of the L and decreases with increasing activity of H_2O in the system.

Exsolution of a volatile phase depends on the partial P of all dissolved volatiles, and low Cl solubilities in NaCl-saturated and KCl-saturated silicate L imply that exsolution of a Cl-bearing volatile phase will occur "early" in Cl-bearing granitic magmas, i.e., prior to extensive M crystallization and/or at comparatively low water fugacities. The solubility behavior of H_2O and Cl is very similar to that of CO_2 and H_2O in felsic L. Small quantities of CO_2 are known to facilitate volatile phase exsolution (Holloway, 1976), and in a similar manner volatile phase exsolution from a CO_2-free and Cl-free haplogranite L at 2 kbar and 800°C, a Cl-rich brine will exsolve if the L contains only 1 wt.% H_2O and 0.26 wt.% Cl at the same conditions.

These new solubility data are interpreted in light of H_2O, F and Cl concentrations in felsic L, determined from silicate MI, to constrain the exsolution of Cl-bearing, magmatic volatile phases from mineralizing granitic magmas. Felsic magmas genetically associated with Cu-porphyry and Mo-porphyry mineralization contain sufficient H_2O and Cl to become saturated with respect to a hypersaline brine without strong P reduction, boiling of the volatile phase (i.e. exsolution of immiscible vapor and brine), or strong volatile enrichment resulting from extensive crystal fractionation.

Experiments were also conducted to investigate the solubility of Mo in highly saline volatile phases coexisting with granitic L at 2 and 0.5 kbar. The apparent partition coefficient for Mo in the volatile phase(s) relative to silicate L, (D^*_{Mo}), is defined as [the computed concentration of Mo in a volatile phase or phases/the measured concentration of Mo in granite glass]. D^*_{Mo} ranges from 8 to 80 as the NaCl and KCl content of the volatile phase(s) increases from 15 to 90 wt.%. Because Mo does not complex with Cl in aq F, it appears that Mo solubility may be a strong function of the activity of Na and K in alkali chloride-rich volatile phases. (Author's abstract)

WEBSTER, J.D., 1997b, Chloride solubility in felsic melts and the role of chloride in magmatic degassing: J. of Petrol., v. 38, no. 12, p. 1793-1807. Author at Dept. of Earth and Planet. Sci., American Museum of Natural History, Central Park West at 79th St., New York, NY 10024-5192.

The degassing of Cl- and H_2O-bearing magmas has been investigated experimentally at ~1 bar and 2000 bars and 800-1075°C by determining the solubility of H_2O and Cl^- in felsic to intermediate L variably enriched in F, P, B, C, and excess alkalis or aluminum. Chloride solubility in H_2O-undersaturated silicate L is low and increases with increasing values of the molar [(Al+Na+Ca+Mg)/Si] of silicate L, F content, the abundance of network-modifying Al, and P. The presence of B or P in peraluminous felsic L has no discernible influence on Cl^- solubility. The experimental solubility data are compared with H_2O and Cl^- in silicate M I from seven high-silica rhyolites and tin and topaz rhyolites of western North America. Small ranges in Cl^- concentration, minimum Cl^- contents of 600-800 ppm, large ranges in H_2O content, and steeply negative to near-infinite slopes in plots of H_2O vs Cl^- for many of the M I are similar to abundances and trends of H_2O vs Cl^- for volatile phase-saturated felsic L, suggesting that some portions of each of these magmas might have been saturated in volatile phases before M I entrapment and eruption. (Author's abstract)

WEBSTER, J.D., 1997c, Degassing of H_2O-undersaturated Cl- ± F-, B-, P-, C-bearing felsic magmas (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 80. Author at Dept. of Earth and Planet. Sci., A.M.N.H., New York, New York, U.S.A. 10024-5192; e-mail (jdw@amnh.org)

Volatiles such as Cl and CO_2 exhibit low solubilities in aluminosilicate M, and hence, small quantities of Cl or CO_2 have a pronounced effect on magmatic degassing, because the exsolution of magmatic volatile phases

(MVPs) is function of both the solubilities and natural abundances of all volatiles in M. Hydrothermal experiments have been conducted at 1 to 4000 bars and 750° to 1050°C to determine solubilities of H_2O and Cl in haplogranitic and granitic M containing various enrichments in C, F, B, P, and network-modifying Al. The results are used to constrain the P-T-X conditions under which one or more MVPs exsolve; of particular interest is MVP exsolution from volatile-enriched magmas that are *strongly water undersaturated*.

Silicate MI in phenocrysts from seven high-silica and tin/topaz rhyolites of western North America exhibit distinct variations in H_2O and Cl contents that are consistent with variations of H_2O and Cl in experimentally produced NaCl- and KCl- saturated felsic M. Comparison of these new experimental data to the MI implies that prior to entrapment of the I: (1) the rhyolite magmas had exsolved one or more Cl- and H_2O- (± CO_2)-enriched MVPs, (2) differentiation of the magmas involved crystal fractionation in the presence of a MVP or MVPs at or near isobaric and closed-system conditions, and (3) the first MVP to exsolve can be extremely saline. Furthermore, given the wide range in M compositions studied in the H_2O and Cl solubility experiments and given the abundances of H_2O and Cl in MI from most rhyolites, it can be generalized that nearly all natural rhyolitic-granitic M containing 0.2 to 0.6 wt.% Cl (even F-, P-, and B-rich M) will exsolve one or more MVPs "early"; i.e., with ≤ 2 wt.% H_2O in M at P as great as 2 to 4 kb. "Early" MVP exsolution has important consequences for magmatic-hydrothermal ore deposition and volcanic eruption. (Author's abstract)

WEBSTER, J.D., KINZLER, R.J., MANDEVILLE, C.W., MATHEZ, E.A. and RUTHERFORD, M.J., 1997, Influence of melt composition on chloride and water solubility in intermediate and mafic silicate liquids: Consequences for volcanic degassing and eruption: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F791. First author at Earth and Planetary Sci., AMNH, Central Park West at 79th St., New York, NY 10024, U.S.A.; email (jdw@amnh.org)

Natural and synthetic rock powders were equilibrated with H_2O-NaCl-KCl±$FeCl_2$ at 1000 to 1180°C and 1 to 2000 bars to determine the solubilities of chloride and water in aluminosilicate L. Chloride solubility varies strongly with M composition and less so with T and P. The chloride contents of volatile phase-saturated rhyolitic to basaltic L that contain <2 wt.% water increase with the molar ratio of [(Al+Na+Ca+Mg)/Si]. For intermediate to mafic silicate L under oxidizing conditions (>NNO), chloride solubility also varies strongly with the abundances of network-forming (Si, Al, and Fe^{3+}) and network-modifying (Na and K) cations in the L. The influence of oxygen fugacity on chloride solubility in intermediate and mafic L is currently under investigation.

MI in phenocrysts from many andesitic and basaltic volcanic rocks contain relatively high chloride contents (0.4 to >1 wt.%). Comparison of water and chloride contents of these MI with our new experimental data shows that small changes in M composition resulting, for example, from fractional crystallization will control chloride solubility in natural M. Such control will have important consequences for volcanic degassing and eruption processes. (Authors' abstract)

WEBSTER, J.D., KINZLER, R.J. and MATHEZ, E.A., 1997, Experimental constraints on the role of chlorine solubility in magmatic degassing (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 22. First author at Dept. of Earth and Planet. Sci., A.M.N.H., New York, New York, U.S.A. 10024-5192; e-mail (jdw@amnh.org)

Molten NaCl-KCl ± H_2O was equilibrated with rhyolite, latite, andesite, and basalt M at 1 to 4000 bars to determine the solubilities of Cl and H_2O in aluminosilicate M. Chlorine solubility is a strong function of M composition and is less dependent on changes in T and P. The Cl content of anhydrous NaCl- and KCl-saturated silicate M increases with the molar ratio of [Al + Na = Ca + Mg/Si]; the maximum solubility of Cl is 0.28 wt.% in rhyolite M and is >2 wt.% in basalt M at 2 kb.

Silicate MI studies show that many H_2O-poor felsic magmas contain sufficient Cl to exsolve a Cl-enriched volatile phase. The comparatively higher solubility of Cl in mafic M, indicated by experiments, appears to be matched by generally greater abundances of Cl in mafic MI. This agreement suggests that Cl-bearing, H_2O-poor mafic magmas will exsolve Cl-rich F at P>1 kb. Thus, as is observed for CO_2-H_2O bearing magmas, degassing of a H_2O-bearing F phase does not require H_2O saturation in Cl-H_2O bearing silicate magmas. (Authors' abstract) *See figure on page 235.*

WEBSTER, J.D., THOMAS, Rainer, RHEDE, Dieter, FÖRSTER, H.-J. and SELTMANN, Reimar, 1997, Melt inclusions in quartz from an evolved peraluminous pegmatite: Geochemical evidence for strong tin enrichment in fluorine-rich and phosphorous-rich residual liquids: Geochim. Cosmo. Acta, v. 61, no. 13, p. 2589-2604. First author at Dept. of Earth and Planet. Sci., American Museum of Natural History, Central Park West at 79th St., New York, NY 10024-5192.

We have investigated the magmatic evolution of a late-stage, F- and P-rich, pegmatite-forming aluminosilicate L and the geochemical controls on magmatic mineralizing processes by remelting totally-crystallized M I in quartz and analyzing the quenched glass by EPMA and SIMS. The quartz phenocrysts were sampled from a pegmatite that occurs in a Variscan granite genetically associated with cassiterite- and wolframite-mineralized greisen veins at the Ehrenfriedersdorf Sn-W deposit, central Erzgebirge, SE Germany.

The MI compositions imply that the pegmatite-forming L achieved extreme levels of chemical differentiation. It contained high abundances of Sn, F, P, Li, Rb, Cs, Nb, Ta, and Be and abnormally low concentrations of Ca, Y, Sr, and REE for a granite, and it was strongly peraluminous (the molar [Al_2O_3/CaO+Na_2O+K_2O] ranged from 1.3 to 2.0). Fractions of the pegmatite-forming L were extremely enriched in P_2O_5+F+Al_2O_3, and the molar abundances of (F+P) in the glasses correlate strongly with moles of network-modifying Al ions implying that the bulk L included F-, P-, and Al-bearing complexes. Formation of these complexes reduced the activities of F, P, and Al in bulk L, suppressed the crystallization of magmatic topaz and P-rich minerals, and allowed the L to become enriched in these constituents.

Some fractions of the Ehrenfriedersdorf aluminosilicate L contained 1000-2000 ppm Sn. These levels of Sn enrichment were up to 2 orders of magnitude greater than that ever reported for non-mineralized, metaluminous and peraluminous igneous materials and are consistent with some experimentally-derived Sn solubilities in cassiterite-saturated granitic L at geologically relevant P and

T. Ths concordance implies that cassiterite could have crystallized directly from this highly evolved, P- and F-rich peraluminous granitic L without the involvement of hydrothermal F. (Authors' abstract)

WESTPHAL, Hildegard, GOLDSTEIN, Robert and **REJMER, J.J.G.**, 1997, Sea-level fluctuations and diagenesis – periplatform carbonates from the Great Bahama Bank: GAEA 3, 18th IAS, Regional European Meeting of Sedimentology, Heidelberg, Sept. 2-4, 1997, Abstracts, p. 361-362. First author at Geomar Forschungszentrum für marine Geowissenschaften, Wischhofstr. 1-3, 24148 Kiel, Germany; email (hwestphal@geomar.de)

The position of sea-level has an effect on the composition of early diagenetic F that may move through the platform. In order to examine these relationships, an upper Pliocene periplatform succession from the core CLINO, Great Bahama Bank has been examined. Highstand deposits are characterized by high amounts of fine-grained matrix (around 85%, mainly aragonite needles). Lowstand deposits, in contrast, consist mainly of grainstones with Halimeda plates, coated grains and peloids. Lowstand deposits are characterized by the highest initial porosity and permeability. Hypersaline F may have played a role in early diagenesis of the lowstand deposits. A preliminary study of P FI in some calcite cement crystals from the lowstand deposits show ice-melting T -2.8 to -3.2°C (sal of around 50 and 60‰ seawater salt eq.). This indicates that at least some growth zones of the cement precipitated from a F that was more saline than seawater. It remains possible that other growth zones precipitated from different F.

The origin of the hypersaline F is still subject to discussion. Dissolution of underlying evaporites (not proven by drilling yet) could be a possible origin. An alternative explanation is the possibility of deep reflux of high density F from the platform top where evaportion of seawater could have caused increased sal during periods of aridity and poor circulation while seawater covered the platform top. Positive isotope values in some calcite (around +1.0 $\delta^{18}O$) support the reflux hypothesis. Our results contribute to a better understanding of how sea-level change controls the early diagenesis in carbonate platforms. (From authors' abstract by E.R.)

WHITE, Todd and **AL-AASM, I.S.**, 1997, Hydrothermal dolomitization of the Mississippian Upper Debolt formation, Sikanni gas field, northeastern British Columbia, Canada: Bulletin of Canadian Petroleum Geology, v. 45, no. 3, p. 297-316. Authors at Dept. of Earth Sci., Univ. of Windsor, Windsor, Ontario, N9B 3P4.

The Mississippian carbonates of the Upper Debolt formation show five types of dolomite: early, matrix, pseudomorphic, coarse crystalline and saddle. FI data show Th ranging from 87 to 214°C (average 135°C) for both of the last two dolomite types and sal of ca. 8 wt.% eq. NaCl. These data imply hot, slightly saline F were responsible for their formation. The radiogenic $^{87}Sr/^{86}Sr$ ratios for coarse crystalline dolomite (0.7086 to 0.7091) and for saddle dolomite (0.7087 to 0.7099) are atypical for Mississippian seawater suggesting an extraformational F. The geochemical and petrographic data, combined with the proximity of both dolomite types in relation to the thrust faults suggest that basinal F, somehow affected by meteoric waters, enriched in Mg^{2+}, radiogenic $^{87}Sr/^{86}Sr$, and depleted $\delta^{18}O$ values were funneled upwards along faults and fractures which developed during Late Cretaceous to Early Tertiary time due to the Laramide Orogeny. (From authors' abstract by E.R.)

WIECHERT, U., IVANOV, D.A. and **WEDEPOHL, K.H.**, 1997, Spinel peridotite xenoliths from the Atsagin-Dush Volcano, Dariganga lava plateau, Mongolia; a record of partial melting and cryptic metasomatism in the upper mantle: Contrib. Mineral. Petrol., v. 126, no. 4, p. 345-364.

Indexed under FI (E.R.).

WILKINS, R.W.T., 1997, The possibility of using petroleum exploration thermal maturity tools in mineral exploration (abst.): Geological Society of Australia Abstracts No. 44, p. 73. Author at CSIRO Div. of Petroleum Resources, P.O. Box 136, North Ryde, NSW 2113.

A review (E.R.).

WILKINSON, J.J. 1997, Faulting, fluid pressure fluctuations and gold mineralisation at the Croagh Patrick quartz-gold vein deposit, Ireland (abst.): Mineral Deposits Study Group Annual General Meeting, Glasgow Univ., 1997, Programme and Abstracts Volume, p. xxx. Author at Dept. of Geol., Imperial College, Prince Consort Road, London, SW7 2BP UK.

The mesothermal quartz-gold vein system at Croagh Patrick, County Mayo, Ireland, is hosted by greenschist facies Silurian quartzites which unconformably overlie imbricated ultramafic rocks and slates. The deposit was developed during late Caledonian (Lower Devonian) sinistral transpression across the Clew Bay-Fair Head line, an extension of the Highland Boundary Fault in Scotland. Mineralised veins show variations in gold grade of 5 orders of magnitue (10^{-2} to 10^{3} ppm) over several hundred metres of exposure. Detailed CL textural analysis and FI studies have show 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. Variations in gold grade are related to temporal and spatial variations in the phase separation process which was controlled by F P fluctuations during 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. Bonanza grades are developed close to intersections of the large linking veins which are inferred to be zones of maximum dilation. (Author's abstract)

WILKINSON, Jamie, BOYCE, A., EARLS, Garth, BOLAND, Mike, CAREY, Paul, FALLICK, Tony, HUTTON, Donnie, JOHNSTON, Dave, LEGE, Iain, MOLES, Norman and **PARNELL, John**, 1997, A tale of three fluids: The role of multiple sources in the genesis of the Curraghinalt vein gold deposit, Northern Ireland (abst.): Mineral Deposits Study Group Annual General Meeting, Glasgow Univ., 1997, Programme and Abstracts Volume, p. xxx. First author at Dept. of Geol., Imperial College, Prince Consort Rd., London, SW7 2BP, U.K.

The Curraghinalt quartz-gold vein deposit in County Tyrone, Northern Ireland, is hosted by late Proterozoic (Dalradian) metasediments and is spatially associated with the Omagh Thrust, part of the Highland Boundary Fault system. The age and genesis of the deposit have remained obscure since its discovery in 1983. In this study, high resolution petrography utilising SEM CD combined with FI and stable isotopic studies have shown that three F were involved in the development of the deposit.

Primary mineralisation, consisting of Au-rich electrum, bismuth and gold-silver telurides, pyrite, chalcopyrite, arsenopyrite and Sb-As sulphosalts, was precipitated due to mixing of a relatively high T (~400°C), moderate sal (~10 wt.% NaCl + KCl), CO_2-rich (~15 wt.%) F (F1) with a lower T (~180°C), low sal (-3 wt.% NaCl + KCl) F (F2). This occurred during multiple phases of reactivation and brecciation of the vein system. A secondary phase of mineralisation, characterised by the occurrence of Au-poor electrum, pyrite, chalcopyrite, sulphosalts, sphalerite and galena with accompanying phengitic mica, ferroan dolomite, ferroan calcite and barite, was formed as a result of the influx of a low T (-100°C), high sal (~25 wt.% $CaCl_2$ + NaCl) F (F3). Despite being interpreted as a remobilisation event for gold, this stage is volumetrically the most important.

Laser fluorination oxygen isotopic analysis of quartz microsamples combined with FI thermometry suggests $\delta^{18}O_{fluid}$ for F1 of ~+8‰ consistent with a magmatic origin. Quartz precipitated from F2 yields an estimated $\delta^{18}O_{fluid}$ of ~+1‰, consistent with a water of surface derivation, probably meteoric in origin. Late quartz microveinlets give an estimated $\delta^{18}O_{fluid}$ for F3 of 0‰ which, combined with the FI chemistry, is strongly suggestive of a basinal brine.

The favoured model for mineralisation involves the injection of a high T, acidic and oxidising H_2O-CO_2 F of magmatic origin into a stratified, reducing, hydrostatically-pressured formation water at several kilometres depth. Mixing was the primary control of sulphide and electrum deposition, although intermittent phase separation also occurred. Subsequently, a low T, acidic and oxidising brine, probably of evaporitic origin, infiltrated the deposit during brittle reactivation along the Omagh Thrust, probably during the Lower Carboniferous. This resulted in remobilisation of electrum into fractures in pyrite with associated coarsening and reduction in fineness. (Authors' abstract)

WILLARD, D.T. and **CLINE, J.S.**, 1997, Fluid inclusions as an exploration tool at the Vizcachitas porphyry copper project, Central Chile: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 348-349. Authors at Univ. of Nevada, Las Vegas, 4505 Maryland Parkway, Las Vegas, Nevada 89154-4010; email (willard@nevada.edu).

A FI study of the Vizcachitas porphyry copper is being conducted as part of the economic evaluation of the project and was designed to (1) determine if typical porphyry ore F were present in the system, (2) constrain the P of system formation, and (3) relate F chemistry and T to various stages of mineralization.

The following populations of I were identified, in decreasing order of abundance. Type 1 I are L-rich and contain L+V±small dxl. Type 1a I contain L+V+small opaque dxl (SO)±small translucent dxl (ST); type 1b I contain only L+V. Type 2 I contain L+V+halite (H)±SO±ST. I vary from simple, three-phase L+V+H I to a large I that contains L+V+H+hematite+rod-shaped daughter+2SO+3ST. Type 3 I contain only L+V and are L-rich. These I typically have an irregular form. Type 4 I contain L+V and are V-rich. V-rich I are quite sparse.

The common presence of opaque dxl (including triangular=chalcopyrite?) in type 1a and 2 FI demonstrates that the majority of F trapped in the samples examined were transporting significant amounts of dissolved metals. These FI are generally present in barren quartz veins, indicating that the I trapped ore F that were transporting dissolved metals, before ore precipitation. The lack of halite dxl in type 1a indicates that F immiscibility probably did not occur, and that the F exsolved directly from the M. Halite-bearing, type 2 I, which typically contain several additional dxl, could have exsolved directly from the M or been produced by aq F immiscibility. True V-rich I (type 4) are sparse to absent, suggesting that aq F immiscibility was minimal.

Collectively, the observed FI populations indicate that a single-phase ore F was trapped at submagmatic T under moderate P. The lack of truly high T I suggests that the core of the system may not have yet been penetrated by drilling. Type 1 and 2 I are present in surface samples, indicating that surface sampling can be an effective exploration tool during grassroots exploration for porphyry systems and the presence of appropriate FI in surface samples may aid in siting drill holes. The presence of S type 3 I reflects the probably influx of lower T, meteoric F, and is compatible with development of phyllic alteration. (From authors' abstract by E.R.)

WILLIAMS, A.E., 1997, Fluid density distribution in a high temperature, stratified thermohaline system: Implications for saline hydrothermal circulation: Earth and Planet. Sci. Letters, v. 146, p. 121-136. Author at Dept. of Earth Sci. and Inst. of Geophys. and Planet. Phys., Univ. of California, Riverside, CA 92521, USA.

Density distribution within the Salton Sea geothermal system, of F ranging from 20 to 325°C, has been computed using chemical and thermal data from geothermal production well tests and curve-fit models of Na-Ca-K chloride solution properties. Density corrections can easily be made to±0.01 g/cm^3 for solute effects of each of the dominant chloride salts as well as P above V saturation.

F density within the shallow, cool (<250°C), low sal portions of the system decreases markedly with increasing depth and T, from ≈ 1.0 to ≈ 0.85 g/cm^3. A sharp interface separates these relatively dilute F from hypersaline brines with TDS>20 wt.%. The density of brine climbs rapidly to near 1.0 g/cm^3 as the sal increase across this interface overwhelms the thermal effect on F density. This steep density gradient precludes all but diffusional-conductive or perhaps double diffusive-convective mass and heat transfer in this transitional regime. (From author's abstract by E.R.)

WILLIAMS, L.B., HERVIG, R.L. and **BJØRLYKKE, Knut**, 1997, New evidence for the origin of quartz cements in hydrocarbon reservoirs revealed by oxygen isotope microanalyses: Geochim. Cosmo. Acta, v. 61, no. 12, p. 2529-2538. First author at Center for Solid State Sci. and Dept. of Geol., Box 1404, Arizona State Univ., Tempe, AZ 85287, USA.

Quartz cements degrade hydrocarbon reservoir quality by choking off F flow paths, therefore, it is important to understand the sources and timing of quartz cementation. We present in situ microanalyses of oxygen isotope ratios in quartz cements from a Jurassic hydrocarbon reservoir, located offshore Norway, showing systematic variations that reveal the isotopic history of the pore F that precipitated the quartz. The data show that quartz precipitation is a continuous process during burial and that silica is derived locally from silicate reactions occurring within the sandstone reservoir. The isotopic data do not record evidence of episodic cementation from convection-driven, hot basinal F. (From authors' abstract by E.R.)

WILLIAMS, P.J., CHAPMAN, L.H. and **RICHMOND, Julie**, 1997, Role of late orogenic metasomatism in Broken Hill-type deposits: Evidence from the Cannington deposit, Cloncurry District, NW Queensland (abst.): Mineral Deposits Study Group Annual General Meeting, Glasgow Univ., 1997, Programme and Abstracts Volume, p. xxx.

Cannington is a blind, world class Pb-Zn-Ag deposit concealed by Mesozoic cover to the southeast of the Proterozoic Mount Isa Inlier in NW Queensland. It is hosted by a metamorphosed siliciclastic sequence which also contains a number of other ±Pb±Zn±Ag+Cu occurrences that have affinities with the giant deposit at Broken Hill (NSW). The BHT characteristics include high metamorphic grade host rocks, partly skarn-like gangue and spatial association with various quartz-garnet, magnetite-rich, and gahnite-bearing lithologies. Mineralization at Cannington mostly occurs in a retrograde paragenetic association, the locus of which is a pyroxene-pyroxenoid-garnet-quartz core. Complex, very high sal P FI with multiple daughter salts variously including halite, sylvite, a Pb-K chloride phase and Fe-Mn-Cl phases occur in minerals belonging to all stages of the paragenetic sequence. There is a marked concentric metal zoning pattern charcterized by an internal clinopyroxene-Zn zone enveloped by a Mn-rich pyroxenoid-Pb zone which mimics the typical zoning in metasomatic skarn deposits. Au-Cu mineralization occurs locally within the core of this zoning scheme.

In summary it seems that all the distinctive features of the Cannington deposit including the mineralization can be interpreted as products of late orogenic structurally-controlled infiltration and cooling of a reduced- high T, saline Mn-Pb-Zn-rich F. Such a F could have been evolved from oxidized magmatic brines derived from I-type plutons by interaction with the graphitic high grade metamorphic host rocks. If this is correct, then the "BHT-type" deposits near Cloncurry should be viewed as distal and coeval equivalents of the Fe-Cu-Au deposits in the district. (From authors' abstract by E.R.)

WILLIAMS, P.J., CHAPMAN, L.H. and **RICHMOND, Julie**, 1997, Alteration in Broken Hill-type deposits: Evidence from Cannington (abst.): Geological Society of Australia Abstracts No. 44, p. 74. Authors at Nat'l. Key Centre in Economic Geol. and Dept. of Earth Sci., James Cook Univ. of North Queensland, Townsville Q4811.

Cannington is a world class Ag-Pb-Zn deposit hosted by a metamorphosed Proterozoic siliciclastic rock sequence which also contains a number of other ±Pb±Zn±Ag±Cu occurrences elsewhere in the Cloncurry district that have affinities with the giant deposit at Broken Hill in New South Wales. These similarities include high metamorphic grade host rocks, presence of skarn-like Ca-Fe-Mn rich gangue, and spatial association with various quartz-garnet, magnetite-rich, and gahnite-bearing lithologies. Complex very high sal P FI with multiple daughter salts (halite, sylvite, a Pb-K-Cl phase, and Fe-Mn-Cl phases) occur in minerals belonging to all stages of the alteration sequence. The preserved features of the Cannington deposit are essentially products of late orogenic structurally-controlled infiltration and cooling of a reduced, high T, high sal, Mn-Pb-Zn-rich F. This could have evolved from oxidized magmatic brines derived from the I-type plutons through interaction with the graphitic rocks of the host sequence. The proportion of the total metal budget introduced by this late-stage F is not yet well-constrained but it should be noted that the physical evidence is consistent with the possibility that the deposit is essentially epigenetic and coeval with the Cu-Au-Fe systems. (From authors' abstract by E.R.)

WILLIAMS-JONES, A.E., OLIVO, G., SAMSON, I.M. and **MUELLER, B.**, 1997, Hydrothermal REE-fluorite mineralization in the Gallinas Mountains, New Mexico, USA: in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 687-690. First author at Dept. of Earth and Planet. Sci., McGill Univ., Montreal, Quebec, Canada.

Mineralogical and FI data are used to develop a preliminary model for the genesis of hydrothermal bastnaesite-fluorite mineralization in breccia-hosted deposits associated with hypabyssal alkaline felsic intrusives. The proposed model relates the mineralization to the exsolution of REE-F enriched orthomagmatic F and subsequent mixing of these F with Ca-bearing formation waters. (Authors' abstract)

Three types of FI have been recognized: L-rich, aq L-V (LV), aq L-V-S (LVS), and aq-carbonic I (AC). LVS I are abundant at Pinatosa but restricted to P1 fluorite (mainly P), quartz and bastnaesite. They vary considerably in the number of solids (1 to 12) and the relative proportions of solids, L and V. The solids include gypsum, barite, fluorite, quartz, celestite, bastnaesite, zircon/baddelyite, goyazite (?), prosopite (?), mirabilite (?), and galena. Many I in P1 fluorite contain a large gypsum crystal which may extend outside the FI cavity. This suggests that sites of gypsum deposition may have provided a favourable environment on the fluorite surface for the entrapment of F.

L-V I in the two deposits homogenize to the L phase at Th between 60 and 350°C. Frozen LV I from all minerals at both deposits begin melting at T between -39 and -22°C and have final ice melting T ranging mainly from -16 to -10°C. L-V homogenization of LVS I in quartz is to the L phase mainly at T between 300 and 400°C. Most solids did not dissolve on heating. (From authors' text by E.R.)

WILLIAMSON, B.J., STANLEY, C.J. and **WILKINSON, J.J.**, 1997a, Implications from inclusions in topaz for greisenisation and mineralisation in the Hensbarrow topaz granite, Cornwall, England. First author at Dept. of Mineral., The Natural History Museum, Cromwell Rd., London, SW7 5BD.

Textural and geochemical studies of I in topaz from greisens in the Hensbarrow topaz granite stock (St. Austell, Cornwall) are used to constrain the composition of F responsible for late stage greisening and mineralisation. The topaz contains an abundant and varied suite of I including aq L+V plus many different solid I. P L+V I in topaz show relatively high Th (mainly 300 to >500°C) and a narrow range of sal (23-30 wt.% NaCl eq.) compared with those in greisen quartz (150-450°C, 0-50 wt.% NaCl eq.). Textures indicate that topaz formed earlier than quartz and the FI data are interpreted as indicating a cooling of the hydrothermal F during greisenisation, mixing with meteoric waters and a decrease in P causing intermittent boiling. The presence of early-formed albite and K-feldspar as I in the topaz is likely to indicate that the greisen-forming F became progressively more acid during greisenisation. The most distinctive I in the topaz are wisp- and bleb-shaped quartz, <50 µm, which show textural characteristics indicating former high degrees of plasticity. They often have multiple shrinkage bubbles at their margins rich in Sn, Fe, Mn, S and Cl and, more rarely, contain euhedral albite, K-feldspar, stannite or pyrrhotite crystals up to 40 µm. The quartz I show similar morphologies to I in topaz from quartz-topaz rocks elsewhere which have been interpreted as trapped "silicate melt". Their compositions are, however, very different to those expected for late stage topaz-normative granitic M. From their textural and chemical characteristics they are interpreted as representing crystallised silica colloid, probably trapped as a hydro gel during greisenisation. There is also evidence for the colloidal origin of I of varlamoffite [$(Sn,Fe)(O,OH)_2$] in the topaz. These occurrences offer the first reported evidence in natural systems for the formation of colloids in high T hydrothermal F. Their high ore carrying potential is suggested by the presence of varlamoffite and the occurrence of stannite, pyrrhotite and SnCl within the quartz I. (Authors' abstract)

WILLIAMSON, B.J., STANLEY, C.J. and **WILKINSON, J.J.**, 1997b, Implications from inclusions in topaz for greisenisation and mineralisation in the Hensbarrow topaz granite, Cornwall, England. First author at Dept. of Mineral., The Natural History Museum, Cromwell Rd., London, SW7 5BD.

See adjacent item.

WITT, W.K., KNIGHT, J.T. and **MIKUCKI, E.J.**, 1997, A synmetamorphic lateral fluid flow model for gold mineralization in the Archean southern Kalgoorlie and Norseman terranes, Western Australia: Econ. Geol., v. 92, p. 407-437. First author at Geological Survey of Western Australia, 100 Plain St., East Perth, Western Australia 6004.

Gold deposits are widely distributed in the Archean southern Kalgoorlie and Norseman greenstone terranes. Available data indicate a similar $H_2O-CO_2(-CH_4)$ ore F at each deposit. Alteration assemblages vary with metamorphic grade in a manner which indicates that late tectonic regional metamorphic gradients were still in place when gold was deposited from hydrothermal F.

The spatial and temporal relationships, in combination with the apparent absence of a viable local source for the ore F at most deposits, suggest that gold was deposited from a small number of large, synmetamorphic hydrothermal systems. A model involving up-T, lateral flow of metamorphic F overcomes some of the problems associated with deeply sourced and conventional metamorphic models for the ore F and is consistent with most of the features of gold deposits. (From authors' abstract by E.R.)

WITTER, J.B. and **SELF, S.**, 1997, Petrology, volatile emissions, and atmospheric impact of the Great Kuwae (Vanuatu) Eruption of 1452-3 A.D.: 1997 Eos Trans. AGU v. 78, no. 46, Fall Meeting Suppl., p. F791. First author at Dept. of Geol. and Geophysics, Univ. of Hawaii, 2525 Correa Road, Honolulu, HI 96822; email jwitter@soest.hawaii.edu)

It has been noted that annual layers of ice dating from the period 1450-60 A.D. in ice cores from both polar regions contain acidity peaks representing fallout of sulfuric acid onto the ice caps. These acidity peaks have been attributed by others to the sedimentation of H_2SO_4 aerosols from the Kuwae event. Our studies establish that this eruption did indeed yield a large release of sulfur gases. Using the electron microprobe we analysed the S, Cl, and F contents of the dacite glass as well as the MI in phenocrysts. Through the use of the "petrologic method," we estimate the potential total atmospheric aerosol loading (which can most probably be considered as a minimum value) of the Great Kuwae eruption to be about 300 Mt H_2SO_4. Total atmospheric aerosol loading estimates obtained from the GISP2 (Greenland) and other ice cores yield comparable values. Comparing the volatile release of the Great Kuwae eruption with other large-magnitude eruptions places Kuwae as the greatest sulfuric acid aerosol producer yet studied, larger even than Laki 1783 and Tambora 1815. (From authors' abstract by E.R.)

WLODYKA, R. and **KOZLOWSKI, A.**, 1997, Fluid inclusions in hydrothermal analcimes from the rocks of the Cieszyn magma province (Poland): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 350-351. First author at Dept. of Earth Sci., Silesian Univ., Bedzinska 60, 41-200 Sosnowiec, Poland.

Sills of teschenitic rocks have been subjected to extensive analcimisation. Euhedral analcime crystals filling the veins and cavities are close to stoichiometric, with the SiO_2/Al_2O_3 mole ratio equal to 4. The analcimes filling the cavities have a composite structure: they bear a porous turbid core. Hydrothermal analcime can be used in FI research, if the heating process is appropriately fast, to prevent the I from leaking (Slaby et al. 1995).

The analcime from veins contains P FI that have Th of 220-120°C. In the core of analcime crystals from cavities there are irregular and flattened I which homogenised at a broad range of T 320-100°C. Te=-19.7 to -22.8; Tm ice=-2.7 to -0.5°C. They contain small amounts of CO_2, CH_4, ethane, N-butane and I-butene. For all analcime modifications bi- or monomodal decrepitation curves were obtained. T of the beginning of mass decrepitation of I were correlated positively with the upper range of variability of T_{hom} for the PI. (From authors' abstract by E.R.)

WOGELIUS, R.A., FRASER, D.G., WALL, G.R.T. and **GRIME, G.W.**, 1997, Trace element and isotopic zonation in vein calcite from the Mendip Hills, UK, with spatial-process correlation analysis: Geochim. Cosmo. Acta, v. 61, no. 10, p. 2037-2051. First author at Dept. of Earth Sci., Univ. of Manchester, Oxford Rd., Manchester M13 9PL, UK.

High-resolution Scanning Proton Microprobe (SPM) analyses of fissure filling calcite (from the Mendip Hills, UK) show chemical zonation patterns in Fe, Mn, Pb, Zn and Sr concentrations. We interpret these and the isotope data as resulting from three distinct F participating in the formation of these fissure fills: a low Mn-Fe, high Sr marine F; a high Mn-Fe, low Sr hydrothermal F; and a low Mn-Fe, low Sr meteoric F. The data thus document the following processes in detail: (1) the formation of a meteoric fissure system, (2) reactions with hotter and more reduced circulating F, and (3) the subsequent flooding of the system with seawater during transgression of the area. Hot, reduced F with high metal concentrations were probably forced up into these fissures by seismic pumping during movement on associated regional faults. (From authors' abstract by E.R.)

WOOD, S.A., 1997a, Calculation of the distribution of cobalt chloride complexes and the solubility of cobalt sulfides in hydrothermal solutions to 350°C: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 220, Lunar and Planetary Inst., Houston.

WOOD, S.A., 1997b, Calculation of the volatility of copper chlorides at elevated temperatures and pressures: Why is copper enriched in the vapor phases of fluid inclusions? in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 220-221, Lunar and Planetary Inst., Houston. Author at Dept. of Geol. and Geological Engineering, Univ. of Idaho, Moscow ID 83844-3022, U.S.A.; email (swood@uidaho.edu)

Heinrich et al. reported that a significant quantity of Cu was found, via PIXE analysis, to be partitioned into the V phase relative to the L phase in FI. The fugacity of [a number of Cu and Fe] species was calculated assuming equilibrium with two different O_2- and S_2-buffering assemblages: chalcopyrite+pyrite+pyrrhotite+magnetite and chalcopyrite+pyrite+hematite+magnetite, at T 600-1200 K and at 1000 bar P. In all cases, the fugacities of the Fe chlorides were several orders of magnitude higher than those of the corresponding Cu chloride species. The calculations indicate that Cu chlorides should not partition more strongly into the V phase than Fe chlorides. Indeed, the opposite is predicted. Thus, these calculations suggest that the observed strong partitioning of Cu into the V phase is probably not a result of volatilization as chloride complexes. This indirectly supports the hypothesis that Cu sulfides may be involved. (From author's abstract by E.R.)

WORDEN, R.H., 1997, Basin-scale evolution of formation waters revealed from diagenetic materials; does it help us predict reservoir quality? (abst.): Annual Meeting Abstracts - American Assoc. of Petroleum Geologists and Soc. of Economic Paleontologists and Mineralogists, v. 6, p. 126-127.

This study was initiated to assess how formation water evolves on a basin-scale and what affect the movement of water might have upon reservoir quality. Data from diagenetic minerals in wells across the Triassic of the Paris Basin, France, included FI sal, carbon and oxygen stable isotopes and strontium isotopes and were given a precise age by using FI Th in association with modelled thermal histories. The movement of formation water appears to be irrelevant to the evolution of reservoir properties. (From author's abstract by E.R.)

WRIGHT, M.C. and **McKIBBEN, M.A.,** 1997, Temperature and salinity variation within the Brawley geothermal system: A fluid inclusion and stable isotope investigation (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-156. First author at Carlisle and Anderson, Inc., 1609 Stoner Ave., Los Angeles, CA 90025.

The Brawley Geothermal System (BGS) is an active, high T (≤318°C) hydrothermal system containing metal-rich hypersaline brines located in the active continental rift setting of the Salton Trough of southern California.

Microthermometric analyses of vein calcite, sphalerite and quartz reveal that FI Tt are in close agreement with T logs and record an increase in T with depth (maximum of 310°C at 1900 m in the central part of the field and 316°C at 3600 m at the eastern edge). Ice melting T of FI indicate that the sal increase with depth from ~3 to 26 wt.% eq. NaCl while the presence of halite dm in some samples at depths ≥1422 m record salinities up to 35 wt.% eq. NaCl. The $\delta^{18}O$ and $\delta^{13}C$ compositions of vein calcite indicate progressive isotopic depletion with increasing depth and T, with values ranging from 4.5 to 8.0‰ and -5.6 to -2.9‰, respectively. Brine $\delta^{18}O$ compositions, calculated from vein $\delta^{18}O$ data, show isotopic enrichment with depth, values range from -3.7 to 1.2‰. These shifts are consistent with water-rock interaction and isotopic equilibrium at the measured reservoir T.

The thermal state of the BGS has apparently been relatively static since fracture mineralization; only minor local changes in T (<25°C) are indicated by FI data. The extent of hydrothermal alteration in the BGS is far less than that in the adjacent Salton Sea system, perhaps reflecting a younger age or lower permeability for the BGS. (From authors' abstract by E.R.)

WU, Cailai, LI, Zhaonai and **SHANG, Ruxiang,** 1997, Studies on mineral chemistry and mineral inclusion of Cenozoic volcanic rocks and their mantle enclaves in Changbai Mountains, northeast China: Acta Petrologica et Mineralogica (Yanshikuangwuxue Zazhi), v. 16, no. 4, p. 289-302 (in Chinese; Engl. abst.). Authors at Inst. of Geol., CAGS, Beijing 100037.

The Cenozoic volcanic rocks in Changbai Mountains consist of basalts, trachytes and alkali rhyolites. A lot of enclaves [xenoliths] named spinel lherzolite and pyroxenite derived from the mantle were found in alkali basalt of Miocene Naitoushan period. The main minerals in mantle enclaves and volcanic rocks of different periods are olivine, clinopyroxene, enstatite, spinel, plagioclase and alkali feldspar. The species and chemical compositions of minerals from different rocks are different, reflecting the trend of magmatic differentiation evolution. The geothermobarometric [study] of minerals indicates that the basaltic magma derived from the mantle at the depth of more than 82 km formed the deep magma chamber in the upper mantle at the depth of 55 km to 65 km. Laser Raman spectrum analysis of I in minerals from different volcanic rocks show that magma in great depth contained a lot of volatiles, and that strong exsolution occurred during the upward migration of magma. Besides, mantle volatiles decreased and crust volatiles increased in upward direction, and underground water might have played an important role in volcanic eruption. (Authors' abstract)

WU, Gang, ZHAN, Wenhuai and **LI, Chunfang,** 1997, Primary gases in the fluid inclusions and prospective mark of the gold deposit, Long Quan, China: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 6 (in English). Authors at Fac. of Earth Resources, China Univ. of Geosci., Wuhan, 430074.

The results of study on Longquan gold deposit show that Th, sal, quantities and variance of P G in the FI of quartz can be used as the micromarker of prospecting and prospective marker of gold mineralization. FI in quartz are the sample of ore-forming F, and they can indicate the gold-forming conditions, environment and the character of ore-forming F. The Th and sal of the FI can be used as the prospective marker. The P G are the important part of ore-forming F, the kinds and quantities of the G can show the source of ore-forming F and also can be used as the important prospective marker. CH_4, H_2, CO_2, O_2 and H_2O (V) are the important indicative P G in the gold deposit. (Authors' abstract)

WU, Peikang, ZHU, Weilin and **LI, Mingbi,** 1997, Oil and gas pool-forming dynamics in the north shelf basins, South China Sea: AAPG Bull., v. 81, no. 8, p. 1420-1421.

Basins in the study area experienced three developing stages: lacustrine sedimentation in the rifting stage, bay sedimentation in the transitive stage and open sea sedimentation in the postrifting stage. Diagenetic events, FI, and organic geochemical analyses, DST, and RFT indicate that expulsions of overpressure systems are in not less than 4 stages; especially the hydrocarbon-related two stages of expulsions are closely related to the regional structural movements, and the pathways of hydrocarbon thermal F flow are markedly controlled by the patterns of carrier systems in which the fault nets and sand-body frameworks are most important. (From authors' abstract by E.R.)

WYDER, R.F. and **MULLIS, Josef, 1997,** Brittle deformation and fluid impregnation of Tavetsch Kakirites (Sedrun/Gr, Central Swiss Alps): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 352-353. Authors at Mineralogisch-Petrographisches Inst. Basel, Bernoullistrasse 30, 4056 Basel, Switzerland; email (mullis@ubaclu.unibas.ch).

The northern Tavetsch and the southern Aar massifs contain large amounts of cohesionless fault rocks (kakirites). Microstructural and microthermometric studies provided insights in brittle deformation mechanisms and the P-T-t conditions of kakirite formation in the Tavetsch massif. Overprinted by several pre-Alpine (summarised as phase I) and at least five Alpine deformation phases (II to VI), phases III to VI have been responsible for the generation of cohesionless kakirites.

The loss of cohesion occurred at depths between 9-6 km below surface at T-P conditions of approximately 275°C, 2.3 kb and 190°C, 0.6 kb during deformation phases IV and V and is interpreted to have occurred during a drop in F P from lithostatic to hydrostatic regime between phases IV and V.

It could be shown that kakirites are the product of at least three brittle deformation phases, accompanied by mineral precipitation (quartz, calcite, opaques, smectite). Besides smectite, no more sheet silicates grew below 215°C. Kakiritisation occurred as a late Alpine retrograde event, post-dating the overthrust of the Gotthard onto the Aar and Tavetsch massifs and is related to differential exhumation rates between the Aar and Gotthard massifs. (From authors' abstract by E.R.)

WYLLIE, P.J. and **RYABCHIKOV, I.D.,** 1997, Carbonate-rich liquids and critical fluids in mantle plumes: in Seventh Annual V.M. Goldschmidt Conference, LPI Contribution No. 921, p. 222, Lunar and Planetary Inst., Houston. First author at Div. of Geological and Planetary Sci., California Inst. of Tech., Pasadena CA 91125, U.S.A.

A trace of carbonatite M must form within a mantle plume with some CO_2 and more H_2O than that stored in solid phases. The independent upward movement of this low-viscosity, buoyant sink for incompatible elements would contribute to the decoupling of trace from major elements in silicate magmas.

The static equilibrium phase assemblages in a simple plume form a cylinder with outer shell containing high-pressure aq V, enclosing a steep inverted cone (surface=the solidus) where V is replaced by a trace of dolomitic carbonatite magma. Rising volatile components follow different paths depending on position within a plume: (1) central: carbonatite M is incorporated into picrite magma, (2) outer: hydrous V crosses solidus, is converted to carbonatite M, which enters lithosphere, (3) intermediate: critical F may be similar to (1) or (2). The partition of trace elements among peridotite, hydrous V, and carbonatite M occurs at different depths (P) within the plume. (From authors' abstract by E.R.)

XIA, Li, 1997, Vein system and its fluid inclusion geochemistry in the Bendigo gold ore field: Implications for ore fluid evolution (abst.): 11th VUGC 1997, Monash Univ., Geol. Soc. Australia Abstracts, no. 46, p. 29.

The Bendigo ore field is hosted by Lower to Middle Ordovician, Castlemaine Supergroup in turbidite sedimentary rocks comprising alternating series of black shales and greywackes. The sequence has been metamorphosed to lower-middle greenschist facies. Gold occurs dominantly in quartz veins. Six main generations of quartz veins can be distinguished in the paragenesis and veining events: (V1) Laminated veins (Au-As-Sb-Pb-Zn-Ni); (V2) Spurs (Au-Cu-Pb-Zn); (V3) Massive veins (barren, main dilation stage); (V4). Brecciation veins (Au-As); (V5). Small quartz-ankerite veinlets; and (V6) Pure quartz veinlet/pure calcite veinlets. In the three mineralised veins V1 pre- or syndated the main deformation event, whereas V2 and V4 postdated the main deformation event.

The main types of FI have been identified at room T as follows: Type 1, two-phase, P/S $VCH_4 + LH_2O$ FI; Type II, two/three-phase, P/PS I $LCO_2 \pm CH_4$ ($VCO_2 \pm CH_4 + LH_2O$ FI with variable degree of filling, and Type III, $VH_2O + LH_2O$ I grouping into three clusters (IIIa: P/PS, V-rich, with V/L = 70-90/10-30; IIIb: P/PS, L-R, with V/L = 15-25/75-85; IIIc: S L-rich, with V/L = 10-15/85-90).

Laminated veins are characterised by Type I, II, IIIa and IIIb I. They represent a wide range of Th (220-401°C). Estimated Pt based on isochores from Bowers and Helgeson (1983) ranges from 130 to 3800 bars. The bulk compositions are $XCH_4 = 0.02\text{-}0.06$, $XH_2O = 0.91\text{-}0.96$ in Type I inclusions; $XCH_4 = 0\text{-}0.04$, $XCO_2 = 0.02\text{-}0.16$, $XH_2O = 0.83\text{-}0.97$ in Type II. Gold precipitation in laminated veins was related to CH_4-CO_2-H_2O-NaCl compositional I. Type II and IIIb I were identified in spur veins. I homogenise in the range of 254-400°C. Pt are from 667 to 3400 bars. Highest XCO_2 values (0.1-0.25), XCH_4 (0-0.10) and a corresponding decrease in XH_2O values (0.64-0.88) exist in this stage of gold-rich F.

Type II inclusions with no CH_4 component and type IIIb I occur principally in the barren, massive veins. Th and Pt range from 220-378°C, and 275-2800 bars, respectively. The lowest XCO_2 values (0.01-0.07) and higher XH_2O (0.92-0.97) in Type II inclusions are obtained in the massive veins. However, S CH_4-H_2O I are found in the massive veins, which probably corresponds to the brecciation veining (CH_4-H_2O-CO_2-Au F activity). In the brecciation vein Type II inclusions contain higher CO_2 (0.07-0.15), H_2O (0.8-0.93) and minor CH_4 (0-0.01) Th range from 220-350°C, and P from 800 to

3000 bars. Small ankerite-quartz veins dominantly host Type IIIb and minor Type II inclusions with lowest Th and Pt. In pure quartz or calcite veinlets, FI are too small to analyse. Type IIIc I are usually irregular in shape, and infrequently show necking-down phenomena. They occur within all of the veins at Central and North Deborah Mines, and have the lowest Th (145-200 1/2°C) and Pt (620 bars). Sal estimated from clathrate melting T for Type II inclusions and final melting T of ice for Type I, III inclusions are between 1.6 and 13.5 wt.% eq. NaCl. The sal of the late stage barren veins are slightly higher than those in the early stage mineralised veins.

The occurrence of non-aq CH_4 and CO_2 FI and intense carbonate alteration indicate that low sal, reduced, CH_4 and CO_2-rich F accompanied Bendigo gold mineralisation. Gold occurrences commonly corresponds to higher concentration of methane during the whole process of the F evolution. The association of gold occurrences with CH_4 -H_2O FI have been reported elweshere (e.g., Guilhaumou et al., 1990). F immiscibility, including boiling, occurred in the CH_4-CO_2-H_2O-NaCl system and is responsible for Au deposition in mesothermal gold mineralisation. (Author's abstract)

XIAO, Huiliang, FU, Dexin and **QI, Jianzhong,** 1997, Geological and geochemical characteristics of Songxi Ag-Sb deposit in Guangdong: Volcanol. & Mineral Resources, v. 18, no. 4, p. 298-307 (in Chinese; Engl. abst.). Authors at IGMR, Nanjing, 210016.

Songxi Ag-Sb deposit belongs to an epithermal deposit. Ag is found in the upper and Sb in the lower. The volcanic activity in late Yanshan provided the materials for Ag-Sb mineralization. Ag-Sb was mobilized by late hydrothermal F, resulting in enriched deposit.

FI data from gangue quartz presented (H.E.B.).

XIE, Shucheng, YIN, Hongfu, WANG, Hongmei and **ZHOU, Xiugro,** 1997, Organic ore-forming process in the Qixiashan polymetallic deposit, Nanjing City, Jiangsu Province: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 4, p. 289-297 (in Chinese; Engl. abst.). Authors at China Univ. of Geosci., Wuhuan 430074.

This paper deals with the role of organic matter and organic F in metallogenesis. Optical analysis, ultraviolet fluorescence, infrared spectroscopy, G chromatography, and G chromatography-mass spectrography were used to study hydrocarbon I detecting a series of biomarkers, and comparing the difference in extractable organic matter among host rocks, ores and I. Charactercs of organic matter in F and relationships of ore-forming elements to organic carbon and sulfur show that some ore-forming elements were transported by organometallic complexes and that organic F provided S^{2-} for the precipitation of metals. On such a basis, some ore-forming processes of the stratabound polymetallic deposits in the middle and lower reaches of the Yangtze River are discussed. (From authors' abstract by E.R.)

Three analyses are presented in terms of ratios of constituents only (E.R.).

XIE, Shucheng, YIN, Hongfu, WANG, Hongmei, ZHOU, Xiugao, FU, Jiamo, SHENG, Guoying and **ZHANG, Huizhi,** 1997, Biomarkers in fluid inclusions of polymetallic deposit of Qixiashan, Nanjing: Chinese Sci. Bull., v. 42, no. 14, p. 1206-1209 (in English). First author at School of Geosci., China Univ. of Geosci., Wuhan 430074, China.

Most previous studies of organic geochemistry in an ore deposit focus on the bitumen and kerogen associated with ores and host rocks, not on that of FI. However, only organic matter in ore-forming F is directly involved in metallogenesis. A series of biomarkers in hydrocarbon I were identified through gas chromatography-mass spectrometry (GC-MS). Comparison and contrast on extractable organic matter (EOM) was made among I, ores and host rocks. Metallogenesis related to EOM was also discussed. (Authors' abstract)

See also previous abstract (E.R.)

XIE, Shucheng, YIN, Hongfu, WANG, Hongmei, ZHOU, Xiugao and **ZHANG, Wenhuai,** 1997, Characteristics of ore-forming fluids in Pb-Zn-Ag polymetallic deposit, Qixiashan, Nanjing: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 6 (in English). Authors at China Univ. of Geosci., Wuhan, 430074.

Inorganic and organic components and $\delta^{13}C$, $\delta^{18}O$ in FI of Qixiashan Pb-Zn-Ag polymetallic deposit, Nanjing, are systematically investigated. The ore-bearing F originate from magmatic water, meteoric water and organic F. Magmatic water is dominant in the F of the early stage, while meteoric water and organic F dominant in the main stage of lead and zinc. Emhasis is laid on the organic component of the F. Series of biomarkers are identified including n-alkanes, isoprenoids, alkanes, extended tricyclic terpanes, pentacyclic triterpanes and steranes. These biomarkers indicate that organic matter in the F is derived from algae and bacteria. (Authors' abstract)

XIE, Shucheng, YIN, Hongfu, ZHOU, Xiugao and **WU, Shunbao,** 1996, 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 at 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 [occur] 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, 1997, Fluid inclusions and their relation to formation and evolution of oil-gas in a basin: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 11 (in English). Authors at Inst. of Geol., Chinese Acad of Sci., Beijing, 100029.

Studies on FI show that there is a close relation between formation and evolution of oil-gas variation of Th of FI in Cenozoic sedimentary basin with "formation, storage and coverage" conditions in east China. There appears lower matured oil field when Th of FI is 90 to 130°C. There emerges high matured oil-gas field when Th of FI is 130-155°C; there comes forth over matured G field when Th of FI is 155 to 180°C. If Th of FI is more than 200°C, oil-gas field will be destroyed, and only bitumen remains. Composition and content of organic I are also good criteria for maturity of oil-gas field. (Authors' abstract)

XIONG, Xianxiao, 1997, On the genetic classification of mineralized breccias in the Shimen realgar ore district, Hunan Province: Geological Review (Dizhi Lunping), v. 43, no. 5, p. 483-489 (in Chinese; Engl. abst.). Author at Geological Inst. for Chemical Minerals, Ministry of Chemical Industry, Zhuozhou, Hebei.

In the Jiepaiyu realgar ore district, Shimen County, Hunan Province, there exists a number of mineralized breccias which occur either in groups or as isolated steep ridges or hills. They usually take elliptical or isometrical forms at surface and conical or cylindrical forms branching upward in section, and are mostly in piercing contact with country rocks. Trace elements in cements of the breccias are similar to those in sediments from modern hot springs; the components of ore-forming F and I in breccias enriched in Na^+, Ca^{2+}, Cl^-, HCO_3^- and SO_4^{2-} are also similar to those of modern spring waters in the area. Petrological, petrochemical and trace element and REE geochemical studies indicate that the mineralized breccias in the area were formed as a result of drastic explosions of hot spring gases and related substances under the sealed and reduced conditions. There are four genetic types of mineralized breccia related to realgar deposits in the Jiepaiyu area, i.e., "intrusive," explosive, karst, and collapse breccias. The superposition of various breccias is quite conspicuous. They are good ore-hosting and -controlling bodies and hence have important significant for ore prospecting. (Author's abstract)

XU, Guojian, 1997, Origin of CO_2-rich fluid inclusions in synorogenic veins from the eastern Mount Isa fold belt, Australia: Geological Society of Australia, Abstracts No. 44, p. 75. Author at Dept. of Earth Sci., James Cook Univ., Townsville, Qld. 4811.

FI of CO_2 without a visible H_2O phase are commonly found in the synorogenic veins from the Proterozoic Eastern Mount Isa Fold Belt. Although the local presence of carbonate minerals suggests a CO_2-rich F may have been responsible for the vein formation, the occurrence of predominantly pure to nearly pure CO_2 I is nevertheless unusual for a hydrothermal F system. Many studies of similar CO_2-rich FI, mainly in metamorphic rocks, proposed preferential leakage of H_2O from H_2O-CO_2 I after entrapment. In this study however, it is proposed that phase separation of low to moderate sal CO_2-rich hydrothermal F led to the selective entrapment of the CO_2. Considering the development of similar CO_2-rich FI in the mineral deposits in this region as documented in literature (such as Dugald River Zn-Pb-Ag and Osborne Cu-Au), the F immiscibility, where volatile species such as CO_2, CH_4 and H_2S are lost from the F system is capable of triggering ore deposition by increasing the F pH.

Evidence used to support the presence of F immiscibility is mainly derived from the observations of coexisting H_2O-rich and CO_2-rich I along the same trail and widely varying CO_2 contents for apparently the same generation. In addition, these two unmixed F are also found on adjacent fractures where monophase or two phase CO_2-rich I in group or along array.

The veins investigated in this study are generally parallel to the axial plane cleavage of the regional N-S trending folds. The minerals are predominantly quartz, with variable amounts of albite-feldspar, calcite, hematite and local presence of garnet, staurolite, andalusite and kyanite. Field evidence and FI work indicate that vein formation mostly occurred during a decompressional regime following the peak metamorphism and regional D_2 deformation. In quartz grains, at least three episodes of immiscibility events are detected, each documented by the presence of a CO_2-rich and a H_2O-rich I generation. Homogenization of L plus V to L occurs between -11 and +30°C and correspond to CO_2 densities of 1.0 to 0.6 g/cm^3. In general, there appears to be no correlation between Th and I size, but in some cases small I tend to show higher Th than large ones. The presence of nearly identical densities must have been trapped at different stages during the retrograde path.

Melting T of solid CO_2 range from -56.6 to -60.6°C and show a slight asymmetric distribution toward T below the triple point of pure CO_2, indicating the presence of minor CH_4 along with CO_2 in the I, as was further confirmed by Laser Raman spectroscopy. However, a wide range of Th are recorded by pure CO_2 I, which implies Th is predominantly controlled by CO_2 F density rather than any dissolved species.

The reason for F immiscibility is possibly a decrease in P and T as a result of crustal uplift. An increase in sal due to interaction between the migrating F and evaporitic metasediments may have aided immiscibility development as there are evaporites in the regional stratigraphic succession. This episodic entrapment of unmixing F most likely resulted from the cyclic gravitational collapse during orogenesis characterized by intervening subvertical and subhorizontal foliations. The sources of CO_2 are uncertain in this case. However, given that F compositions are largely independent of the lithology in the host rocks, a magma-derived or mantle source could be employed to account for the consistent occurrence of CO_2-rich F even though decarbonation reactions would be more favorable for those preserved in carbonate-bearing rocks. (Author's abstract)

XU, Guojian, 1997, Fluid inclusions in crack-seal veins at Dugald River, Mount Isa Inlier: Implications for palaeostress states and deformation conditions during orogenesis: J. of Structural Geol., v. 19, no. 11, p. 1359-1368. Author at Dept. of Earth Sci., James Cook Univ., Townsville, Qld 4811, Australia.

An integrated geometrical investigation and microthermometric analysis of FI trails in fibrous crack-seal veins at Dugald River, Mount Isa Inlier, allowed distinction of two general types of FI: a CO_2±CH_4 rich variety and a H_2O-rich variety. At least three stages of F percolation are identified to be related to the vein formation. Trails of PS I have a constant orientation relative to the direction of the regional maximum principal shortening direction (λ_3). This relationship allows the trails to be regarded as potential structural markers. However, trails of S I generally show a deviation from the established bulk shortening direction and possibly reflect the overprinting of a later deformation event. Microthermometric data combined with knowledge of metamorphic reactions suggest that the P-T path of crack-seal deformation started at about 450°C and 2.8 kbar, then crossed 340°C and 1.2 kbar, and possibly terminated around 130°C and at near-surface P, corresponding to the regional crustal uplift. This study shows the importance of combined geometical and microthermometric studies of FI for understanding the physical conditions of crack-seal deformation, a common phenomenon in low-grade metamorphic terrains. (Author's abstract)

XU, G., YAO, S. ZHANG, C. and **WANG, P.**, 1995, A case study of Zhilingtou gold-silver deposit, Zhejiang, China: Geol., Soc. New Zealand 1995 Annual Conference, Nov. 22-24, 1995, Auckland Univ., Programme and Abstracts, published in Geological Soc. of New Zealand Miscellaneous Publication 81A ISBN 0-908678-49-5, p. 50. First author at Dept. of Earth Sci., James Cook Univ., Townsville, Qld. 4811, Australia.

The Zhilingtou Au-Ag deposit is situated in the eastern part of the complexly deformed and metamorphosed south China Caledonian fold belt. It consists of seven orebodies that are almost exclusively hosted by biotite plagioclase gneiss of the Precambrian Chencai Group. They form an apparent en echelon pattern in both cross-section and level plan. Three different ore types, based on mineralization textures, have been recognized within the Zhilingtou lode. These are Au-Ag-rich quartz veins, Au and Ag-bearing silicified rocks and Au-Ag-containing altered rocks with quartz stockworks. The mineralization is principally composed of electrum, argentite, pyrite and minor sphalerite, galena as well as traces of hessite and chalcopyrite plus a gangue assemblage of quartz, rhodonite, sericite and chlorite. FI related to Au-Ag mineralization yield a wide range of Th from 110-447°C, with two distinctive peak values at 250-300°C and 350-400°C respectively. δ^{30}Si values of quartz veins and silicification from the three stages of mineralization range from -0.1 to -0.4‰. The mineralization at Zhilingtou is interpreted as forming by recirculated meteoric water extracting ore-forming elements from metamorphic rocks due to Mesozoic volcano-magmatic activity. (Authors' abstract)

XU, Jiuhua, XIE, Yuling and **SHEN, Shiliang,** 1997, A comparison of ore-forming fluids between gold deposits in Xiaoqinling Mountains and those in Jiaodong Peninsula: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 2, p. 151-162 (in Chinese; Engl. abst.). Authors at Dept. of Geol., Beijing Univ. of Sci. and Tech., Beijing 100083.

Gold deposits both in Xiaoqinling Mountains and in Jiaodong Peninsula occur within the Precambrian granitoid-greenstone terrains, controlled by ductile shear zones or ductile-brittle fracture zones. They have many similarities in mineral paragenesis, wallrock alteration, FI and stable isotope composition.

Ore-forming F are characterized by low sal (generally<10 eq. wt.% NaCl) and relatively high CO_2 contents. FI in the main ore-forming stages are rich in CO_2; nevertheless, in earlier quartz of altered rocks, FI containing NaCl crystals can be seen. The Th vary from 250 to 350°C (even up to 450°C) during the early stage and from 150 to 250°C (even down to 100°C) in the late stage. The CO_2/H_2O ratios of FI in Xiaoqinling Mountains are higher than those in Jiaodong, suggesting that ore-forming P was higher in Xiaoqinling Mountains than in Jiaodong. K^+/N^+ ratios of FI in quartz have much to do with host rock, being usually >1.0 in gold deposits related to felsic host rock while <1.0 in vein gold deposits related to dioritic or mafic host rock.

Measured δD values of FI and calculated $\delta^{18}O_{H_2O}$ in vein quartz of both areas indicate that the water of ore-forming F was associated with meteoric water. The observed difference between the two areas may have resulted from elevation and/or continental effect. $\delta^{34}S$ values of sulfides from gold deposits in both areas indicate that sulfur might have originated from the process of granitization in the basement. However, the higher $\delta^{34}S$ values in Jiaodong than those in Xiaoqinling Mountains may also imply the influence of the underground water affected by paleo-sea water rich in $\delta^{34}S$. (Authors' abstract)

Includes 9 analyses (Tables 2 and 3, p. 153) for Na, K, Ca, Mg, Cl, SO_4, F, CO_2, H_2, N_2, CH_4 and H_2O (E.R.). *See table on page 232.*

XU, L. and **van MOORT, J.C.**, 1997, EPR characterisation of gold mineralisation in weathered terrain, Jim's Find South, Tanami Desert, NT, Australia: Modern Applications of EPR/ESR from Biophysics to Materials Science, Proceedings of the First Asia-Pacific EPR/ESR Symposium, Hong Kong, 20-24 Jan 1997, C.Z. Rudowicz, editor, p. 141-148. Authors at Geol. Dept. Univ. of Tasmania, GPO Box 252-79, Hobart 7001, Tasmania, Australia.

Electron Paramagnetic Resonance (EPR) spectroscopy can be used as a measurement of lattice defects of quartz and other silicates. EPR's association with quartz in the proximity of ore is because such quartz has a considerable amount of lattice defects. This study investigates the EPR characterisation of gold mineralisation in regolith samples from the Tanami Desert. Samples were treated with hot $HCl+HNO_3+H_2SO_4$ acid to remove weathering products. The residue consists essentially of quartz [and acid treatment is essential]. EPR results show that the acid insoluble residues associated with gold mineralisation are markedly paramagnetic. The EPR 326.6±5 mT and 326.5±6 mT X±100 mT sweeps correlate well with the P gold mineralisation and the EPR anomaly is larger than the ore body. (Authors' abstract)

XU, Shijin, SHEN, Weizhou, WANG, Rucheng, LU, Jianjun, LIN, Yuping, NI, Pei, LUO, Yaonan and **LI, Lizhu,** 1997, Characteristics and origin of Xifanping porphyry copper deposit, Yanyuan County, Sichuan: Kuang Wu Xue Bao (Acta Mineralogica Sinica), v. 17, no. 1, p. 56-62.

The ore-forming parent rock of the Xifanping porphyry copper deposit, Yanyuan County, Sichuan Province, is a Himalayan quartz-monzoporphyry. Nd, Sr, Pb and O isotope data suggest that it belongs to the syntexis type and its source rock is the terminal magmatic rock of middle Proterozoic. Quartz-containing FI in the deposit have high Th and high sal and contain rare dx of chalcopyrite. The $\delta^{18}O$ values indicate that they are composed mainly of magmatic water with minor meteoric water. Pb and S isotopic studies indicate that the ore-forming components were largely derived from the magma and partly from the country rocks. (Authors' abstract)

XU, Shunshan, YANG, Nong and **SHUN, Qing,** 1997, Metallogenic dynamic studies of the Wendeng gold deposit, Shandong Province: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 3, p. (in Chinese; Engl. abst.). First author at Inst. of Geomechanics, Chinese Acad. of Geological Sci., Beijing 100081.

The ore-forming process of the Wendong [Wendeng?] gold deposit is related to the deformation and evolution of the NS-trending Mishan fault, which underwent multiperiod activities dominated by ductile deformation at early stage and brittle deformation at late stage. Gold grade is usually higher where deformation intensity is relatively high, suggesting the existence of close correlation betwen material migration and tectonic movement. FI studies indicate that the main ore-forming process occurred during the transition from the ductile deformation mainly gave birth to auriferous metamorphic F. At the late stage, large quantities of brittle fissures were formed, boiling and cryptoexplosion of F and their eventual precipitation in favorable space. Spatial distribution of orebodies reveals the negative correlation between orebody thickness and gold grade, which reflects multiperiod activities of faults and multiple ore-forming processes. (From authors' abstract by E.R.)

YAJIMA, Taro, MATSUMOTO, Taizo, YOSHIOKA, Ken and NAKAYAMA, Ken, 1997, Geology and exploration of the Seta low sulfidation epithermal gold deposit, eastern Hokkaido, Japan: Resource Geol., v. 47, no. 2, p. 45-58. First author at Metal Mining Agency of Japan, Tokiwa Bldg., 1-24-14, Toranomon, Minato-ku, Tokyo 105, Japan.

The Seta low sulphidation epithermal gold deposit is the most recently discovered gold deposit in Japan. The deposit is characterized by well preserved near surface hydrothermal activity features such as the presence of in-situ silica sinter, kaolin deposit, mercury deposit and hydrothermal breccias. These features were the clues for discovery of the deposit. The main mineralization zone is located at approximately 250 m below the present land surface, and a very shallow depth of gold mineralization is proposed. It is proposed that it formed by mixing of following upwelling neutral hydrothermal F and low pH water percolating downwards from the aerated ground which were developed by condensation and oxidation of H_2S rich steam accompanied by reduction of the watertable. (From authors' abstract by H.E.B.).

Th from a total of 131 FI were measured from the white veins and are plotted against height above sea level. Although the T vary widely at most levels, a unimodal distribution with a mean of approximately 150-170°C is evident. Higher grade mineralization is restricted to a 150 m interval between 300 and 450 m.a.s.l. A frequency vs. T plot for the high grade analyses indicate no discernible trend, T span the range 120-260°C. (From authors' text by H.E.B.)

YAMAGISHI, H., NAKASHIMA, S. and ITO, Y., 1997, High temperature infrared spectra of hydrous microcrystalline quartz: Physics and Chemistry of Minerals, v. 24, no. 1, p. 66-74.

Indexed under FI (E.R.)

YAMAGUCHI, Yoshiaki and TADOKORO, Sakiko, 1997, Very sulfur-rich mafic magma injection into erupting magma column during Plinian eruption: Petrographic evidence from the 1783 Asama eruption (abst.): Volcanic Activity and the Environment, Abstracts, IAVCEI General Assembly at Puerto Vallarta, Mexico, January 19-24, 1997, p. 7. First author at Dept. of Geol., Shinshu Univ., Matsumoto 390, Japan.

The erupted materials of the 1783 eruption of Asama volcano in central Japan contain neither volatile- nor K-bearing phases. Chlorine and K_2O were not removed by crystallization, and the eruption provide a good opportunity to investigate the pre-eruptive sulfur and chlorine concentrations of magma and the degassing behavior during Plinian eruption, based on microprobe analyses of glass I in phenocrysts. Petrographic study of the mixed magma system indicates that the glasses can be divided into four types. 1) glass in olivine, 2) glass in the major phenocrysts (orthopyroxene, clinopyroxene, sodic plagioclase), 3) glass in the calcic rim of reversely zoned plagioclase, 4) degassed matrix glass.

Olivene is a very rare phase in the erupted materials, and occasionally includes basaltic glass having high S and low Cl (53.1 wt.% SiO_2, about 1600 ppm S, and 1000 ppm Cl). Most of the major phenocrysts were derived from the long-lived felsic magma reservoir and were unstable in the erupted mixed-magma. Glass I (>150 ppm S, and <2000 ppm Cl) trapped in the major phenocrysts do not therefore represent the true volatile concentration of the erupted mixed-magma. Instead, glass trapped in the calcic rim of reversely zoned plagioclase provide a direct evidence of the true volatile concentrations and degassing trend of the erupting mixed-magma. The petrographic study reveals that large amounts of SO_2 were supplied by oxidized mafic magma injecting into felsic-magma reservoir, supplying abundant sulfur to the Plinian eruption plume. (Authors' abstract)

YAMAMOTO, J., SANO, Y., WATANABE, M. and GAMO, T., 1997, Mantle component in fluid inclusion of fluorite: (abst.): Abstracts of 1997 Japan Earth and Planet. Sci. Joint Meeting, March 25-28, 1997, at Nagoya Univ.

In a recent study, helium and carbon isotopic ratios in mid-ocean ridge basalt (MORB) have been well documented. The data of fumarolic G from island arcs have been studied as well. However, such studies on ancient G are sparse. Marty and Jambon (1987) described $\delta^{13}C$ value and CO_2/He_3 ratios as an index indicating the origin of carbon in MORB. We have carried out this study with the aim of making clear features of ancient G and the origin of carbon in volcanic G at subduction zone from FI in fluorite. (Authors' translation)

YANG, Wenbo, SPENCER, R.J. and KROUSE, H.R., 1997, Stable isotope compositions of waters and sulfate species therein, Death Valley, California, USA; implications for inflow and sulfate sources, and arid basin climate: Earth and Planet. Sci. Letters, v. 147, no. 1-4, p. 69-82.

In this study, 95 water samples were collected in Death Valley between May 1992 and March 1994. The isotope compositions of these waters range from -15.2 per mil to +2.8 per mil for $\delta^{18}O$ and from -109 per mil to -21 per mil for δD. The isotopic variations of these waters and sulfate therein reflect changing and/or mixing of sources in the basin. (From authors' abstract by E.R.)

YANG, Yanchen, WANG, Wenxue and QIAO, Junyi, 1997, A study on the geologic feature and its origin of micro-disseminated gold deposit in Hunjiang, Jilin Province: Jilin Geology (Jilin Dizhi), v. 16, no. 1, p. 42-50 (in Chinese; Engl. abst.). First author at Changchun Univ. of Sci. and Tech., 130061.

The Hunjiang gold deposit is the first micro-disseminated (Carlin type) one which was discovered in recent years in northeast China. The orebodies are confined in the carbonate formation with rich organic matter distributed along the footwall of the Dahenglu fault.

Studies on FI and thermodynamic calculations indicate that T of ore formation were from 182 to 230°C, P, from 5.66 x 10^7 to 6.16 x 10^7Pa, and depth, 2.5 km. Ore-forming solutions were neutral to weakly basic, relatively reductive and has the character of a typical subterranian hot bittern. Geochemical studies on trace elements show Au, Pb, Zn, Sb and As [to be present in] the carbonate formation. [The] Proterozoic [rocks] are obviously higher than their average value in the upper continental crust, and their coefficients of variation indicate they are activated, and suggest that the carbonate formation is [the] ore-bearing formation. It supplied mainly ore-forming substances for Hunjiang gold deposits. The gold in source rocks was mobilized and entered the convecting meteoric water by chemical reaction and migrated as the hydro sulfide complex $[Au (HS)^2]^-$. The effective mechanism for gold deposition is the decrease in reduced sulfur activity caused by deposition of sulfides such as pyrite and stibnite [from] hydrothermal ore solution, and the decline in O_2 fugacity as well as the reduction and the absorbtion of organic matter. (Authors' abstract)

YAO, Dexian and **CAO, Jianjing,** 1997, Geology and ore-forming fluid types of the Xinzhou gold deposit, Guangdong Province: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 3, p. 254-259 and 288 (in Chinese; Engl. abst.). Authors at Dept. of Geol., Zhongshan Univ., Guangzhou 510275.

The Xinzhou medium-size gold deposit lies in the outer zone of the Fogang porphyritic biotite granite. The Sinian strata contain gold 12.3 X 10^{-9} ~29.0 X 10^{-9} with enrichment coefficients 3.3 ~7.4, thus showing character of the source bed. The thermodynamic force produced by magmatic intrusion and emplacement as well as metamorphism and wall rock alteration resulted in the migration and enrichment of gold in strata to form the ore deposit. The correlation coefficients of Au with Ag, As and S are 0.64, 0.87 and 0.54, respectively. FI and isotopic studies show that ore-forming T are 270°C ~180°C, P are (150~200) X 10^5Pa, pH = 5.5 ~6.5, and Eh = -0.25 ~-0.5 eV. The F are enriched in H_2O, CO_2, Na^+, Ca^{2+}, Cl^- and SO_4^{2-}, and have average sal of 16.7 wt.% NaCl. REE distribution patterns of wall rocks, altered rocks and ores are of similar LREE enrichment type, with the REE sources having the cognate nature. Lead isotopes show character of crustal anomalous lead. $\delta^{34}S$ values are of rich ^{34}S type in the range of 10.00‰ ~12.14‰ and -46‰ ~- 67‰ respectively. Studies show that ore-forming metals and sulfur were derived from wall rocks, whereas F were mainly mixtures of metamorphic water and meteoric water. The thermodynamic force of magmatic activity constituted the dynamic force for mineralization. The ore deposit is a mesothermal meta-hydrothermal deposit related to magmatic thermodynamic metamorphism in regional metamorphic rocks. (From authors' abstract by E.R.)

Includes analyses (p. 257) for 5 samples for K, Na, Ca, Mg, F, Cl, SO_4, CO_2, CH_4, H_2 and H_2O (E.R.).

YAO, Qinjun and **DEMICCO, R.V.,** 1997, Dolomitization of the Cambrian carbonate platform, southern Canadian Rocky Mountains: dolomite front geometry, fluid inclusion geochemistry, isotopic signature, and hydrogeologic modelling studies: American J. of Sci., v. 297, p. 892-938. First author at Dept. of Geological and Geophysical Sci., Princeton Univ., Princeton, NJ 08544.

There are two generations of dolomite. A first generation dolomite is a finely-crystalline material that preserved sedimentary structures. P FI from this dolomite have Th that average approximately 110°C and final ice Tm of approximately -25°C. The most important replacement dolomite is a second generation dolomite–a white, coarsely-crystalline material that destroyed P sedimentary textures and was a "saddle" dolomite where it is a fracture-filling cement. The Th of FI in these dolomites decreases from 200°C at the margin to 110°C tens of kilometers on the platforms, whereas the final ice melting T of FI in these dolomites remain constant at about -20°C. Brines trapped in the I appear to have a Ca^{++}/Mg^{++} of 2:1 based on crushing-leaching experiments.

The origin of the first generation dolomite is problematic, but the second generation data suggest that hot (200°C), saline brines (10-25%) migrated updip at the platform margin and eastward for tens of kilometers. T decreased from approximately 200°C at the margin to 110°C tens of kilometers back onto the platform. The flow patterns were dominantly horizontal and stratabound across large portions of the platform. (From authors' abstract by E.R.)

YAO, Yong, 1997, A mineralogical-geochemical, fluid inclusion and stable isotope study of gold ores in the Niuxinshan deosit, eastern Hebei, NE China: wall rock alteration and the role of granite in mineralization: Doctoral dissertation, Tech. Univ. Munich, 158 pp. The Niuxinshan gold deposit in eastern Hebei province is a typical example of the numerous mesothermal gold deposits. Four mineralization stages can be recognized: 1) quartz-K-feldspar stage; 2) quartz-pyrite stage; 3) quartz-polysulfide stage; and 4) quartz-carbonate stage. Gold mineralization is concentrated in stages 2 and 3, and associated with the sulfides (mainly pyrite). Zoned halos of wall rock alteration formed along borders of the quartz veins or fractures in both the granite and amphibolites. The alteration halos suggest component exchange between both alteration halos.

Three compositional types of I were identified. Type 1 (Tp1) are H_2O-CO_2 I, including P Tp1-P and secondary Tp1-S inclusions. These are found in quartz and fluorite from the greisen zones as well as in vein quartz and sphalerite from stages 1 to 3. Type 2 (Tp2-S) are secondary H_2O-CO_2 + daughter carbonate I, observed in fluorite from the greisen zones. Type 3 (Tp3-S), coexisting with type 2, are secondary H_2O-rich I with daughter carbonates. Type 1 primary I are considered to represent the ore F.

Microthermometric data from Tp1-P inclusions indicate that the ore-bearing F were mixed H_2O-CO_2-NaCl solutions with sal mainly between 3 and 11 wt.% NaCl eq. X_{CO_2} was commonly within 0.1 to 0.4, and Th dominantly from 260 to 360°C. The compositional variations in stage 1 could result from exsolution of magmatic F at various stages, but immiscibility or boiling can be ruled out. The variation in stages 2 and 3 is attributed to necking-down. The F evolved toward H_2O-rich and CO_2- and NaCl-poor compositions with time.

Isochores of I, combined with mineral assemblages and oxygen and sulfur isotopic geothermometry of vein mineral pairs, give trapping P-T conditions for the ore-bearing F. According to these results, the greisen zones in the granite formed at 425 to 270°C and 3.5 to 1 kbar; stage 1 veins in the amphibolites at 450 to 270°C and 3.5 to 1 kbar; stages 2 and 3 veins in the amphibolites at 360 to 260°C and 3 to 1 kbar. The retrograde P-T evolution was produced by uplift and cooling of ore-bearing F. The $\delta^{13}C$ values of stage 4 vein carbonates and FI CO_2

from vein quartz of stages 1 to 3 and the $\delta^{34}S$ values in the sulfides are consistent with a magmatic source of the carbon and sulfur. The $\delta^{18}O$ values from alteration-zone [minerals], and the calculated $\delta^{18}O_{H_2O}$ values from vein and alteration-zone quartz indicate magmatic F. The δD values of alteration-zone sericite and the measured δD values of FI from vein quartz of stages 1 to 3 suggest waters from a degassing magma as a source of hydrogen. Oxygen and hydrogen isotopic water/rock exchange calculations indicate partial contribution of meteoric waters to the ore-bearing F.

[The available data] suggest that the Niuxinshan gold deposit was generated by degassing magmatic hydrothermal F with partial mixing of meteoric waters. The ore-forming components were mainly derived from granitic magma.

The role of granite in mineralization is to provide both heat energy and the ore-forming components, which is supported by stable C, O, H, S and Pb isotopic compositions of ores. Thermodynamic calculations of gold complex solubility suggest that the $Au(HS)_2^-$ complex dominates in the F. Gold precipitation is mainly caused by cooling of the F and sulfidization of wall rocks, which decrease sulfur activity in the F. (From author's abstract by E.R.)

YARDLEY, Bruce, GRAHAM, James, and **SMITH, Martin,** 1997, Controls on the salinities of metamorphic fluids: Interpreting results from fluid inclusions: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 354-355. First author at Dept. of Earth Sci., Univ. of Leeds, Leeds LS2 9JT, U.K.

The many problems in establishing metamorphic F composition from FI are discussed. Origin of the I is a major problem, as there are few objective criteria. Quoting the authors, "In no circumstances should the sole criteria that the isochore passes through the inferred metamorphic P-T conditions be allowable." Some examples are used from the Central Alps and the Haast Schists of New Zealand (E.R.).

YAXLEY, G.M., KAMENETSKY, Vadim, GREEN, D.H. and **FALLOON, T.J.,** 1997, Glasses in mantle xenoliths from western Victoria, Australia, and their relevance to mantle processes.: Earth and Planet. Sci. Letters, v. 148, p. 433-446. First author at Research School of Earth Sci., The Australian Nat'l. University, Canberra, ACT 0200, Australia.

Mantle-derived xenoliths from western Victoria, Australia, contain glass in patches and veinlets, and as S I within xenolith minerals. Textures and compositions of glass and associated phases in the Victorian xenolith suite argue strongly against origins involving equilibrium partial melting of spinel peridotite, or migration of exotic metasomatic M.

Melting in the xenoliths was caused by the thermal and decompressional effects of transport in the host magma, or by thermal and metasomatic effects in the lithosphere associated with adjacent intrusion of magmas. Large inter-xenolithic variation in glass compositions was caused by variations in the nature and proportions of the precursor metasomatic assemblage, by reaction of the M with P orthopyroxene in the lherzolites and harzburgites, and by rapid, disequilibrium crystallization from the M of an assemblage of olivine, clinopyroxene and spinel in all samples. (From authors' abstract by E.R.)

YE, Qingtong, FU, Xijie and **ZHANG, Xiaohua,** 1997, Geological characteristics and genesis of the Ashele copper-zinc massive sulfide deposit, Xinjiang: Mineral Deposits, v. 16, no. 2, p. 97-106. First author at Inst. of Mineral Deposits, Chinese Acad. of Geological Sci., Beijing 100037.

The Ashele massive sulfide deposit occurs in the Ashele Devonian volcano-sedimentary basin lying on the southern margin of Altay orogenic belt. The basin was formed as a result of rift evolution on the basis of Proterozoic-Early Paleozoic continental crust, and experienced deformation of regional nappe structure. Mineralization took place at the interval between Early-Middle Devonian volcanic activities of the bimodal spilite-keratophyre volcanic suite. The deposit has two layers: an upper massive sulfide and a lower disseminated sulfide orebody. In the massive sulfide orebody there exists vertical zonation reflecting ore accumulation sequence at the bottom of the sea. Around the disseminated sulfide orebody are well-developed wall rock alterations which exhibit from the inside outward the zonation of sericite-quartz metasomatite → chlorite-sericite metasomatite → weakly hydrolytic pyroclastic rocks, suggesting characteristics of acid leaching. Studies of ore deposit geology, T-P geochemistry and stable isotope geochemistry indicate that the ore-forming F were composed of deeply-circulating sea water and magmatic water, and that the ore-forming materials were derived from the lower crust. (From authors' abstract by E.R.)

YI, T.-H., 1997, A tectogenetic origin for the deep subsurface micro-organisms of Taylorsville Basin, Virginia; thermal and fluid flow model constraints: Doctoral thesis, Princeton Univ., NJ, U.S., 202 pp.

Indexed under FI (E.R.)

YUI, T.-F, CHU, H.-T, WANG, Yunshuen and **YEH, T.-H,** 1997, Sulfide-bearing quartz veins in the Szeleng sandstone, Chinmienshan, northeastern Taiwan: A preliminary study on fluid inclusions and stable isotopes: J. of the Geological Soc. of China, v. 40, no. 4, p. 723-742 [in English]. First author at Inst. of Earth Sci., Academia Sinica, Taipei, Taiwan, R.O.C.

Sphalerite-galena-pyrite-calcite-quatz veins in the Szeleng Sandstone were found in the Chinmienshan area, northeastern Taiwan. The abundance of the sulfide minerals in some of these veins may indicate the presence of a hidden Pb-Zn deposit.

FI in the quartz veins can be divided into five types. Types I to IV FI contain variable amounts of H_2O, CO_2 and dissolved salts and may be genetically related to the F responsible for the sulfide formation. Variable CO_2 content, as well as the correlations between total Th and sal/CO_2 content of these FI (except those Type III inclusions with total Th<210°C) suggest that the responsible F could be cogenetic through F boiling (F immiscibility). On the other hand,the lack of unambiguous proof for the coexistence of F-rich and V-rich I with appropriate compositions and similar total Th also suggests that the F may have different origins. Type V I are empty due to decrepitation, which may have resulted from decompression/heating during sulfide formation.

The highest formation T of these sulfides would not have been lower than 300°C and the highest P not lower than 0.3 kbar. These sulfides are most probably genetically related to a concealed igneous intrusion. Their sulfur isotopic compositions range from +3.2 to +6.9‰, implying that either these sulfides have multiple sulfur sources or some reactions have effectively fractionated heavy sulfur during igneous evolution and/or sulfide formation. $\delta^{18}O$ values of quartz and calcite indicate that the oxygen isotopic compositions of the responsible F were mainly buffered by the rocks. The origin(s) of these F, therefore, can not be discerned based on the available data. (Authors' abstract)

ZACHARIAS, Jiri, FRICOVA, Alexandra, and **MORAVEK, Petr,** 1997, Preliminary results of fluid inclusion studies of Variscan lode gold deposit Jilove near Prague, Czech Republic: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 356-357. First author at Charles Univ., Fac. of Sci., Albertov 6, 128 43 Prague 2, Czech Republic; email (zachar@mail.natur.cuni.cz).

The vein filling consists of massive quartz (90-99%) and carbonates (Ca,Fe,Mg). Scheelite is less common in some veins. Among ore minerals pyrite is the most frequent. Gold is related to the latest stages of mineralization process, as well as the Bi-Te-Au-Ag minerals. The Jilove Au deposit has three types of lodes, but no significant differences in FI characteristics have been found between them. All P FI correspond to the H_2O-CO2 F, some S FI to the H2O F. We did not find convincing evidence for F immiscibility in the H2O-CO2 system. Sal of all FI range between 1-8 wt.% eq. NaCl. All FI types finally homogenise to L: P types wih maximum frequency between 220-250°C, S types between 170-210°C. The CO_2 content is between 3-12 and 15-18 mol.%. T of melting of CO_2 (mostly from -56.7 to -57.5°C) indicate small amounts of other gases. Some samples indicate mixing of two H_2O-CO_2 F (one with T_{FM}: -45 to -47°C, sal 2-4 wt.% eq. NaCl. and another at about T_{FM}: -35°C, sal 6-8 wt.% eq. NaCl) during the later stages of mineralization processes (preserved in S FI). The mineralising F at Jilove Au deposit fit well the mesothermal model. (From authors' abstract by E.R.)

ZÁK, Karel, DOBES, Petr and **VRÁNA, Stanislav,** 1997, Formation conditions of various calcite types and unusual alteration products of wollastonite in calcite marble near Nezdice (Varied Group of Moldanubicum), Czech Republic: J. of the Czech Geological Soc., v. 42, no. 1-2, p. 17-25 (in Engl). Authors at Czech Geological Survey, Klárov 3, 118 21 Praha 1, Czech Republic. Extensive calcite-rich replacements after wollastonite have been found in an abandoned marble quarry near Nezdice, Sumava Mts., southern Czech Republic. Because any natural reversals of wollastonite reaction both in high-T and low-T environment are rare, combined mineralogical and stable isotope study of these pseudomorphs was performed. Stable isotope and FI methods were used to study the other types of calcite for comparison purposes. A plausible scenario and several inadequate alternatives are proposed. Stable isotope analyses and FI study of calcite crystals coating some open fractures in the marble quarry indicate that this hydrothermal activity has no connection with formation of the pseudomorphs after wollastonite. (From authors' abstract by E.R.)

ZEEH, Stefan, WALTER, Uwe, KAPPLER, Paul and **KUHLEMANN, Joachim,** 1997, Fractures, cement successions, and fluid flow in the Eastern and Southern Alps (Austria, Germany, Italy and Slovenia): GAEA 3, 18th IAS, Regional European Meeting of Sedimentology, Heidelberg, Sept. 2-4, 1997, Abstracts, p. 371. First author at Geologisch-Paläontologisches Institut, INF 234, D-69120 Heidelberg, Germany.

The several phases of fracture cementation are partly resolved by FI studes (and $\delta^{18}O$ values). A trend can be observed in FI from these carbonate cements. Formation T in the southern part of the Northern Calcareous Alps are up to 300°C and decrease towards the north to T between 150 and 200°C. Therefore, a F flow from the uplifted Central Alps towards the south and the north is assumed for the second phase of carbonate cementation in fractures. (From authors' abstract by E.R.)

ZEIGLER, Dan, 1997, Cotton Valley reef trend, East Texas basin: Exploration and diagenesis model: Houston Geological Society Bull., v. 40, no. 2, p. 8.

Indexed under FI (E.R.)

ZENTILLI, Marcos, MUNIZAGA, Francisco, GRAVES, M.C., BORIC, Ricardo, WILSON, N.S.F., MUKHOPADHYAY, P.K. and **SNOWDON, L.R.,** 1997, Hydrocarbon involvement in the genesis of ore deposits: An example in Cretaceous stratabound (manto-type) copper deposits of central Chile: Internat'l. Geol. Review, v. 39, p. 1-21.

The analysis of the empirical association of organic carbon in its various forms (e.g., oil, gas, coal) with a variety of ore-deposit types can be a rewarding exercise in the formulation of genetic models and exploration. In many ore provinces, organic matter, residing in its source rocks, migrating in the form of hydrocarbons, or in transient, permanent, leaking, or degrading reservoirs, is likely to have interacted with ground waters, with hydrothermal solutions of diverse origin, or with magmas. After a brief review of these associations, we describe the ubiquitous occurrence of remnant petroleum in two representative "manto-type" stratabound copper deposits in Chile and suggest its possible genetic role and exploration significance.

Overmature petroleum (solid bitumen, pyrobitumen) is found in association with copper ores in the southern orebodies of the El Soldado copper deposit in central Chile. Textures indicate that petroleum occupied the host-rock porosity before copper mineralization. Isotopic data for C and O in total organic carbon and carbonate confirm the affiliation with organic carbon and suggest that gangue carbonates are in part the result of the oxidation of hydrocarbons. Reflectance of the solid bitumen is highest near ore (BR_O~4%), and its geochemistry (Rock-Eval) indicates that the residual hydrogen (i.e. hydrocarbon) content is very low. It is proposed that mineralizing solutions interacted with a pre-existing degraded hydrocarbon reservoir. The hydrocarbons physically prevented low-grade metamorphic minerals from sealing the porosity, were oxidized to form carbonate gangue and alteration, and possibly acted as a reductant at the site of sulfide precipitation. (From authors' abstract by E.R.)

Data from the literature are reviewed for El Soldado. See also Holmgren, 1987, and Klohn et al, 1986 and 1990, in this volume (E.R.).

ZHAI, Jianping, HU, Kai and **LU, Jianjun,** 1997, Minerogenetic mechanism of Rushan gold deposit, Shandong Province: Evidence of ore-forming fluid and H, O, Sr isotopes: Chinese Sci. Bull., v. 42, no. 3, p. 240-243 (in English). Authors at Dept. of Earth Sci., Nanjing Univ., Nanjing 210093, China.

The Rushan gold deposit, being of quartz-vein type, is located in biotite monzonitic granite of Kunyushan complex pluton in eastern Shandong, China, and the orebody No. 2 is the largest mono-vein deposit found in China. The gold mineralization can be divided into three stages according to crisscross relations of the various microlodes in the deposit: I. pre-ore stage of comb-structured milky-white quartz veins; II. main mineralization stage of multi-metal sulphides and siderite-quartz veins; III. post-ore stage of mottled cryptocrystalline quartz veins. Some researchers thought that the Rushan gold deposit was formed by mesothermal F in post stage of granitic magma, but the present [FI] study shows that the ore-forming solution of the deposit is mainly derived from meteoric water. (From authors' abstract by E.R.)

ZHANG, Dequan, XU, Honglin and **SUN, Guiying,** 1997, Geochemical characteristics and genesis of the Denggezhuang gold deposit in Mouping, Shandong: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 3, p. 204-213 (in Chinese; Engl. abst.). Authors at Inst. of Geol., Chinese Acad. of Geological Sci., Beijing 100037.

The Denggezhuang large-size quartz vein type gold deposit lies in the second-order faults of the Jinniushan shear zone within the Yanshanian Kunyushan granite. The ore-forming F are characterized by δD -77‰ ~-89‰, and $\delta^{18}O_{H_2O}$ +2‰ ~+3.2‰; the ore-forming T and P are 150~350°C and 400 X 10^5Pa respectively. The emplacement age of the gold deposit has been determined to be 118 X 10^6a. The emplacement of the gold deposit occurred <1 km (about 0.75 km) in depth, but the emplacement of their host rock took place at a depth of over 13 km, suggesting a depth difference of >12 km. The ore-forming F came from the depth of the crust and then extracted some gold from the host rocks through water-rock reaction. It is thus concluded that the deposit is of the traditional postmagmatic type. (Authors' abstract)

Includes 3 analyses of FI for Na, K, Ca, Mg, F, Cl and SO_4, and one for CO_2, H_2, O_2, N_2, CH_4, CO and H_2O (E.R.).

ZHANG, Dehui and **LIU, Wei,** 1997, Fluid inclusion compositions of Au deposits and their ore genesis significance: The discussion on the origin of ore-forming fluid of Shibangou gold deposit, Xixia, Henan Province: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 5 (in English). First author at China Univ. of Geosci., Beijing, 100083.

Available FI compositions data from some gold deposits home and abroad and the experiment results on the partitioning of Cl between aq F and granite M have shown that highly saline F w(NaCl)>30% and highly w(K+)/w(Na+) ratio (mass, >1) may be regarded as a supplementary sign discriminating ore-forming F with a magmatic origin. Applying the suggestion to the study of FI in Shibangou gold deposit, Xixia, Henan Province, it is sugested that two magma bodies intruded in different orogenic phases in the deposit appear to be genetically related with Au mineralization, most ore-forming metals may be mainly derived from Gangou pluton intruded in Jinning orogenic phase (797 Ma) as an ore-hosted rock, and the ore-forming F may be dominantly composed of magmatic F exsolved from Shitangshan granite magma intruded in Variscan orogenic phase (268 Ma). (Authors' abstract)

ZHANG, H.-L., CHEN, G.-H. and **HAN, S.-J.,** 1997, Viscosity and density of H_2O + NaCl + $CaCl_2$ and H_2O + KCl + $CaCl_2$ at 298.15K: J. Chem. Eng. Data, 1997, no. 42, p. 526-530.

ZHANG, Lisheng, 1997, Hydrothermal karst genesis of stratabound Pb-Zn-(F-Ba) deposits in northeast Yunnan: Acta Geoscientia Sinica (Diqiu Xuebao), v. 18, no. 1, sum 43, p. 41-51. Author at Chengdu Inst. of Geol. and Mineral Resources, CAGS.

These stratabound Pb-Zn-(F-Ba) deposits hosted by carbonate rock have been considered to be sedimentary or sedimentary-reworked deposits, but our observations indicate that they are typical epigenetic deposits with filling of open space by ore F. The orebodies exhibit forms of typical karst cavities, and karst collapse breccia occurs in the margin of the orebodies. The footwall of the orebodies is uneven. Inverse triangular solution caves filled with barite, fluorite, galena and sphalerite occur in the footwall.

The Th of the FI in sphalerite from these deposits range from 90 to 140°C, while those in associated fluorite and barite from 70 to 120°C. The sal of the IF are estimated to be in the range of 10.24-23.99 wt.% NaCl. The ore F had a density of 1.4-1.10 g/cm^3. Sphalerite contains a large amount of organic or CO_2 I. REE geochemistry of associated fluorite and lead isotope data of the ores suggest that the ore-forming metals were derived from upper crust other than the basalt. The δD and $\delta^{18}O$ values of IF in sphalerite and fluorite suggest that water of the ore F was derived mainly from meteoric water. (From author's abstract by H.E.B.)

ZHANG, Sheng, LI, Tongjin and **WANG, Liankui,** 1997, Thermodynamic modelling of ore-forming mechanism of the Changcheng gold-silver deposits in Guangdong Province: Acta Geologica Sinica (English Edition), v. 71, no. 4, p. 433-445.

Indexed under FI (E.R.)

ZHANG, Yigang, 1997, Molar volumes of the binary system H_2O-CH_4 at high temperatures and pressures: Scientia Geologica Sinica (Dizhi Kexue), v. 32, no. 3, p. 299-307 (in Chinese; Engl. abst.). Author at Inst. of Geol., Chinese Acad. of Sci., Beijing 100029.

The molar volumes of the binary system H_2O-CH_4 were calculated using synthetic FI data and a new least square fit equation on experimental data of CH_4 clathrate melting T and P. Comparisons of molar volumes obtained in the present study with other existing molar volume data from traditional high T and high P experiments and with existing equations of state have shown that they agree quite well among themselves. (From author's abstract by E.R.)

ZHANG, Y., MUCHEZ, P. and **HEIN, U.F.,** 1997, Chlorite geothermometry and the T conditions at the Variscan thrust front in eastern Belgium: Geologie en Mijnbouw, v. 76, no. 3, p. 267-270.

Indexed under FI (E.R.)

ZHANG, Y., MUCHEZ, Ph. and **VIAENE, W.,** 1997, Preliminary study of mineralised quartz veins in the Palaeozoic at the southern border of the Stavelot Massif (eastern Belgium): in H. Papunen, ed., Mineral Deposits: Research and Exploration Where do They Meet?: Balkema, Rotterdam, ISBN 90 5410 889 4, p. 347-350. Authors at Fysico-chemische Geologie, KU Leuven, Heverlee, Belgium.

Quartz veins along Variscan faults at the southern border of the lower Palaeozoic Stavelot Massif, eastern

Belgium, contain sulphides. A petrographic and microthermometric study of these veins indicates that the P-T-X conditions of the F which migrated along the Variscan faults changed from a H_2O-CO_2-NaCl F with a minimum T and P between 300-450°C and 130-500 MPa to a H_2O-NaCl F with a lower minimum T (225-290°C) and possibly P range (130-270 MPa). Main sulphide and gold mineralization likely occurred after peak T and P conditions. (Authors' abstract)

ZHANG, Y., SCHROVEN, K., MUCHEZ, Ph., VIAENE, W. and **GEUKENS, F.,** 1997, P-T conditions of Variscan faulting at the southern border of the Stavelot-Venn Massif (eastern Belgium): Belgian Symposium on Structural Geol. and Tectonics, in Aardk Mededel., v. 8, p. 209-212. First author at Fysico-chemische Geologie, Katholieke Univ. Leuven, Celestijnenlaan 200C, B-3001 Heverlee; email (kristof.schroyen@geo.kuleuven.ac.be).

Chlorite-quartz veins have been examined at the southern border of the Stavelot-Venn Massif. P and T conditions during the formation of these veins can be deduced by a combined study of FI and chlorite geothermometry. Total Th of the H_2O-CO_2-NaCl I give T estimates of 300-415°C. Chlorite T calculated from two empirical models and one thermodynamic model range from 380 to 435°C. From the intersection of the isochores (equal density lines) of the H_2O-CO_2-NaCl system with the independent geothermometers, P of 175-280 MPa can be obtained. These P are higher than the general metamorphic P range of 100-200 MPa in this region. (Authors' abstract)

ZHANG, Zhaochong and **LI, Zhaonai,** 1997, Physicochemical conditions for the formation of telluride-rich gold deposits as exemplified by the Shuiquangou gold orefield: Mineral Deposits, (Kuangchuang Dizhi), v. 16, no. 1, p. 41-52 (in Chinese; Engl. abst.). Authors at Inst. of Geol., Chinese Acad. of Geological Sci., Beijing 100037.

With the Shuiquangou gold orefield as the example, the authors have studied the physicochemical conditions for the formation of telluride-rich gold deposits. Located on the southern side of the Shangyi-Chongli-Chicheng deep fault (the boundary between Inner Mongolia geoaxis and Yanshan subsidence zone) in central northern margin of the North China platform, the Shuaquangou gold orefield is intimately related to Shuiquangou slightly alkaline complex in time and space. With the exception of the Jinjiazhuang gold deposit, all the gold deposits in the orefield are telluride-rich ones characterized commonly by high gold fineness, low sulfide content, (100) crystal form for pyrite, dominant Cl^- and low concentration of SO_4^{2-} in ore F, with the first feature indicating high Te_2 fugacity and the last three suggesting low S_2 fugacity. So far as physicochemical conditions are concerned, thermodynamic analysis shows that low pH values are favorable for the mobilization and migration of Te, whereas low T, high Te fugacity and high f_{Te_2}/f_{S_2} ratios are favorable for the precipitation of tellurides. Based on these [data], combined with regional distribution of telluride-rich gold deposits and geochemical background of Te, the authors have advanced three prerequisites for the formation of telluride-rich gold deposits and also pointed out that between alkaline rocks and telluride-rich gold deposits there exists indirect organic connection rather than the simple direct magmatic differentiation and evolution relationship. (Authors' abstract)

Includes Table 4 (p. 46) giving the analyses of 12 FI samples for Na, K, Ca, Mg, SO_4, F, Cl, CO_2, CH_4, H_2, O_2, N_2, and H_2O. (O2 was 0.00 in all) (E.R.).

ZHANG, Zhengwei, LIN, Qianlong, YANG, Xiaoyong and **LIU, Deliang,** 1997, The features and prospecting significance of the I from the Penggou gold deposit in Lushan County, Henan: Henan Dizhi (Henan Geol.), v. 15, no. 2, p. 85-93.

The Penggou gold deposits are hosted in the Precambrian granites of an old landmass and are controlled by the Yanshan granite-porphyry and regional ductile shear zones. On the basis of the geological characteristics of ore deposits, they belong to the low-to-moderate hydrothermal gold type. From the mineral associations, composition and isotopes of the I, the authors indicate that the mineralizing matter comes from the wallrock, the mineralizing F comes from the metamorphic water and mixed water of magmatic water and rainwater. (Authors' abstract)

ZHANG, Zhijian and **ZHANG, Wenhuai,** 1997, Relationship between organic metallogenic fluid and mineralization in the border region between Guizhou, Yunnan and Guangxi: Acta Mineralogica Sinica, v. 17, no. 4, p. 483-490 (in English). Authors at China Univ. of Geosci., Wuhan, 430074.

Fluorescent spectroscopy and Fourier transform infrared spectroscopy of individual organic I show that there is organic matter in the metallogenic F of microthermal deposits in this area, most of which are mature and overmature aromatic series, and some are aliphatic hydrocarbons. The entry of organic matter into the metallogenic F may be the reason why the microthermal deposits are paragenetic with the oil-gas accumulation zone regionally, but separate on a deposit scale, implying that the organic matter may play some important roles in the process of activation, migration and precipitation of ore-forming materials. (Authors' abstract)

ZHAO, Yiming, 1997, Metasomatic zoning in some major Pb-Zn-polymetallic skarn deposits of China: Mineralium Deposita, v. 16, no. 2, p. 120-129. Author at Inst. of Mineral Deposits, Chinese Acad. of Geological Sci., Beijing 100037.

Metasomatic zoning in some major Pb-Zn-polymetallic skarn deposits of China is very clear. From the contact zone of igneous rocks or the center of a heat source to carbonate wall rocks, there roughly exists three types of zoning sequence. Different types of skarns are closely related to respective mineralizations. Fe(Mo), Sn, Cu mineralizations are related to magnesian or calcic skarns, while Pb-Zn (Ag) mineralizations are invariably accompanied by manganoan skarns. Investigation of FI of minerals reveals that from the contact zone to carbonate country rocks, the forming T of the ore-bearing skarns are reduced gradually in order of magnetite-bearing calcic skarn (600~400°C) → Sn(Cu,Zn)-bearing calcic skarn (450~327°C) → manganoan skarn with Pb-Zn (Ag) mineralization (400~200°C). (From author's abstract by E.R.)

ZHAO, Yiming, LIN, Wenwei, BI, Chengsi and **ZHANG, Yinan,** 1997, The distribution and geological characteristics of auriferous skarn deposits in China: Mineral Deposits (Kuangchuang Dizhi), v. 16, no. 3, p. 193-203 (in Chinese; Engl. abst.). Authors at Inst. of Mineral Deposits, Chinese Acad. of Geological Sci., Beijing 100037.

In the past decade, progress has been made in the exploration of gold skarn deposits in China and some large deposits have been discovered, such as Jiguanzui and Jilingshan in Hubei Province and Xinqiao in Anhui Province. The reserves of gold skarn deposits account for about 20% of the total gold reserves in China.

They are usually associated with copper (iron or polymetal) skarn deposits. Their favorable tectonic settings are depressions and fold belts of platform margins as well as areas near deep faults within the platform. The study of FI and the compositions of coexisting pyroxenes and garnets suggest that auriferous skarns were formed by solutions with rather high oxygen fugacity and lower acidity. (From authors' abstract by H.E.B.)

ZHENG, Jianping, LU, Fengxiang, CHENG, Zhongmei and **GUO, Hui,** 1995, Study of impure components in diamond and mantle fluid: Geological Sci. and Tech. Information (Dizhi Keji Qingbao), v. 14, no. 2, p. 52-56 (in Chinese; Engl. abst.). The impure components captured in diamond can provide abundant information for the study of mantle F. The genesis of diamond, the solid I indicating mantle F, the FI and the formational factors of the F are studied in this paper. The relationship between the impure components within diamond and the mantle F is also discussed. (Authors' abstract)

ZHENG, Rongcai, LIU, Wenjun and **LI, Anren,** 1997, Fluid inclusion study of unconventional reservoirs in limestone of the Da'anzhai member of the Lower Jurassic Ziliujing formation in Northern Sichuan: Geological Review (Dizhi Lunping), v. 43, no. 5, p. 515-523 (in Chinese; Engl. abst.). Authors at Chengdu Inst. of Tech., Chengdu, Sichuan.

According to a synthetical study of the FI characteristics of unconventional reservoirs in the Lower Jurassic Da'anzhai limestone from northern Sichuan, it is suggested that the unconventional reservoirs in the limestone resulted from multiple deep hydrothermal dissolution. The development process of the reservoirs may be divided into three dissolution stages, i.e. the diagenetic stage, tectonic stage and post-tectonic stge, and divided also into five precipitation stages of S minerals, i.e. the early-middle diagenetic stage, late diagenetic stage, early tectonic stage, late tectonic stage and post-tectonic stage. The FI in the S minerals are well developed, and may be classified into two types, i.e. the inorganic and organic types. The FI of the S minerals occurring in the five precipitation stages are quite different in respect to their type, shape, abundance, Th, sal, density and composition, indicating that the hydrothermal dissolution F came from organic and inorganic F expelled from oil provenances in different evolutionary stages. The relationship between the I genetic characteristics and oil-gas evolution may serve as the indication for the prediction and evaluation of the unconventional reservoirs in the Da'anzhai limestone. (Authors' abstract)

ZHENHAO, Duan, 1997, Current status and future direction of the study of thermodynamics of geological fluids (abst.). Author at Dept. of Chem., 0340, Univ. of California, San Diego La Jolla, CA 92093-0340. Publication source unknown, as it was lost in transit from PRC to USA (E.R.).

ZHONG, Jianhua and **ZHANG, Guowei,** 1997, On the genesis of the super-large Baguamiao gold deposit in Fengxian County, Shannxi province: Acta Geologica Sinica (Dizhixue Bao), v. 71, no. 2, p. 151-160. First author at Exploration Dept., Petroleum Univ. of China, Dongying, Shandong.

The Baguamiao gold deposit occurs in low greenschist-facies semipelitic sericite phyllite and ankerite-bearing sericitic rock. The wall-rock alterations mainly include silicification and carbonatization. Gold mainly occurs in the form of native gold in pyrite, pyrrhotite, quartz and limonite. Scanty gold is scattered in the ionic or atomic state in minerals. The REE distribution patterns of seven gold-bearing rock samples are similar to ordinary sedimentary rocks, but the negative Eu anomalies of a few samples are unconspicuous. The REE distribution pattern of early-formed quartz veins of shear origin is notably different from that of late-formed quartz veins of hydrothermal origin. The δD-$\delta^{18}O$ variation diagram indicates that mineralizing hydrothermal solutions were mainly derived from deep-seated magmatic water and meteoric water. The carbon isotopic composition shows that the CO_2-rich F in the gold district is of hypogene origin. The $\delta^{13}C$-$\delta^{18}O$ discriminant diagram indicates the hydrothermal origin of ankerite. The lead isotopic composition in the strata has a wide range, whereas the leads of the ores and diorite and albite aplite dykes are similar. The μ and ω values have revealed that lead was mainly derived from the upper crust and orogens, and mantle-derived lead may also be mixed therein. The ores are strongly enriched in heavy sulphur, showing the multi-source character, and the wall rocks are moderately enriched in heavy sulphur, displaying the character of sedimentary sulphur. The Th of the I range between 364 and 180°C. They range from 364 to 238°C for the early shear mineralization stage. (From authors' abstract by E.R.)

ZHOU, Chaoxian, WEI, Chunsheng and **YE, Zaojun,** 1997, The Mississippi Valley-type lead-zinc deposits: Geol.-Geochem., 1997, Tot. no. 227, p. 65 (in Chinese; Engl. abst.). First author at Laboratory of Ore Deposit Geochem., Chinese Acad. of Sci., Guiyang, 550002.

A review in part from the first author's thesis, of the geology, mineralogy, age, geochemistry, etc., of MVT deposits, with examples from all over the world. (E.R.)

ZHOU, Fengying, ZHU, Jinchu, WANG, Rucheng and **XIONG, Xiaolin,** 1995, A study on the genesis of Shuiximiao granitic pegmatite dikes: J. of Nanjing Univ. (Natural Sciences), v. 31, no. 4, p. 641-648 (in Chinese, Engl. abst.). Authors at Dept. of Earth Sci., Nanjing Univ., 210093, Nanjing, PRC.

The granitic pegmatite dikes of Shuiximiao mine are found as upward branches from a fine-grained albite-topaz granite cupola. The albite-topaz granite is characterized by the development of "snow ball" texture of quartz and K-feldspar phenocrysts, existence of M-V I in quartz and topaz, enrichment of Na, Li, F, Ta, Nb, Sn, W, etc. elements and depletion of REE. All these features indicate its crystallization from a residual M of highly evolved granitic magmatic system.

The pegmatite dikes are steep to gentle in attitude, tabular in shape, up to 200 m long, 90 m deep and 2-15 m thick. In the internal structure, they are asymmetrically layered. The lower layers are mostly dominated by albite-rich aplite; the upper layers are mostly dominated by the K feldspar-rich pegmatite; the middle layers are mostly alternating bands of sodic aplite and potassic pegmatite. Transition between these layers is gradational. From the lower layers upwards, there is a tendency of systematic increase of SiO_2, K_2O and decrease of Al_2O_3, Na_2O, ΣFeO, CaO, MgO.

Based on the comprehensive geological, petrological and geochemical study, it is evidenced that the initial silicate M responsible for formation of pegmatite-aplite dikes was derived from the albite-topaz granite cupola. The dikes were formed at the magmatic-hydrothermal transitional stage of evolution and differentiation of the volatile and F-rich granitic M when the silicate M phase, crystal phase and free F phase coexist. Their asymmetrically layered structure was developed in the crystallizing system where the volatile concentration in the M changed from the undersaturated towards the oversatuated. (Authors' abstract)

ZHOU, Lixia and **TANG, Yaolin,** 1997, The geological characteristics and genesis of the Diaoquan silver-copper deposit, Shanxi: Huabei Dizhi Kuangchan Zazhi (J. of Geol. and Mineral Resources of North China), v. 12, no. 2, p. 122-136.

The Diaoquan deposit, a large Ag-Cu deposit, is present in the contact zone between a marble and granite porphyry. The ore-forming process can be divided into two stages, and the country rocks show strong alteration. Trace element geochemistry of rocks and sulfides suggests that the ore-forming F are endogene hydrothermal solutions. The stable isotope studies reveal the enrichment of $\delta^{34}S$ and show all positive values with an obvious tower effect. Ore lead and biotite quartz monzonite have similar and relatively stable composition implying that they might have been derived from the lower crust. Carbon and oxygen isotopic compositions exhibit features of magmatic hydrothermal solutions. I thermometry gives the ore-forming T 185-400°C; sal 40-46 wt.%. The Diaoquan deposit is regarded as a mesothermal-epithermal Ag-Cu deposit. A metallogenic model has been established in this paper. (Authors' abstract)

ZHOU, Taihe and **ADSHEAD, N.D.,** 1997, Physicochemical conditions and aqueous geochemistry during copper-gold mineralisation at the Osborne deposit, Cloncurry district, NW Queensland: Geological Society of Australia, Abstracts No. 44, p. 80. Authors at Nat'l. Key Centre in Economic Geol. and Dept. of Earth Sci., James Cook Univ., Townsville, Qld. 4811.

FI, oxygen isotope and thermodynamic studies on the early alteration assemblages indicate they equilibrated with high T ($\geq 450°C$), high sal (≈ 60 wt.% NaCl eq.), moderately oxidised F that were unusually Cl-Fe-Na-K-Ca enriched and had a moderate sulphur content ($\log\Sigma S \approx -1$) whereas during the main period of Cu-Au deposition, the hydrothermal F was cooler ($\approx 320°C$) and less saline (<20-37 wt.% NaCl eq.).

The decrease in T between the period of pre- mineralisation alteration and Cu-Au deposition may simply reflect a cooling of the hydrothermal system but it may also be partly controlled by phase separation. The concomitant decrease in F sal, however, appears to at least partly reflect the locally extensive, Cl-bearing silicate wall rock alteration (indicating the sal was rock-buffered) because the oxygen isotope data provide little evidence for F mixing and dilution. Thermodynamic modelling indicates the effect of the significant T decrease and sal reduction on the metalliferous hydrothermal F would have reduced the solubility of copper and gold by more than three orders of magnitude. Consequently, the changes in these physicochemical parameters are regarded as important in the deposition of economic concentrations of copper and gold at Osborne. (From authors' abstract by H.E.B.)

ZHOU, Taihe and **ADSHEAD, N.D.,** 1997, Physicochemical conditions and aqueous geochemistry during copper-gold mineralisation at the Osborne deposit, Cloncurry District, NW Queensland: Abstracts - Geological Society of Australia, v. 44, p. 80.

Indexed under FI (E.R.)

ZHOU, Wenwen, 1997, Study by means of the organic inclusion on the migration of oil and gas in Zhu III depression, Pearl River mouth basin: (abst.): Abstracts of Chinese Fluid Inclusion Research Conference, China Univ. Earth Sci., Wuhan, Oct. 6-8, 1997, p. 11 (in English). Author at Offshore Oil Exploration and Development Research Center, Gaobeidian, 074010.

By studying the relationship between the organic I and the diagenesis of the reservoir in Zhu III depression, Pearl River Mouth basin, it is suggested that the distribution of hydrocarbon accumulation space is influenced by the diagenesis. The purpose of studying the reservoir is to seek the S pore development zone in Zhuhai formation. The subphase A of late diagenesis is the main phase of migration of oil and G, the timing of oil and G migration is Middle and Late Pliocene to Quaternary, which possesses a best space match to the formative time of the structure and seal. As a result, it provides the favorable condition for prospecting big oil and G fields. The migrational mode, channel and water medium condition are also analysed. There are the vertical and lateral migration in this area. The fault, sandstone and unconformity surface are the channel of oil and G migration. The analysis of aq solution shows that Zhuhai formation is a good zone of hydrocarbon accumulation in Zhu III Depression.

ZHUANG, Hanping, LU, Jialan, FU, Jiamo, LIU, Jinzhong and **SHI, Jixi,** 1997, Preliminary study on light hydrocarbons in ore-forming F of gold and antimony deposits in southwestern Guizhou, China: Chinese Sci. Bull., v. 42, no. 20, p. 1708-1711 (in English). First author at Guangzhou Inst. of Geochem., Chinese Acad. of Sci., Guangzhou 510640, China.

It is suggested that organic matter in ore-forming F is one of the best media which show the role of organic matter in ore genesis [sic]. Because mineralizing T of many ore deposits exceeded the stable ranges of L hydrocarbons, only light hydrocarbons were preserved well in I. In this note, the typical gold and antimony deposits in southwestern Guizhou (Lannigou gold deposit and Dachang antimony deposit) have been selected for experimental study on light hydrocarbons in mineral I. (From authors' abstract by E.R.)

ZIMMERMANN, J.L., GIULIANI, G, CHEILLETZ, A. and **ARBOLEDA, C.,** 1997, Mineralogical significance of fluids in channels of Colombian emeralds: A mass-spectrometric study: Internat'l. Geol. Review, v. 39, p. 425-437. First author at Centre de Recherches Pétrographiques et Géochimiques–Centre National de la Recherche Scientifique (CRPG-CNRS), BP 20, 54520 Vandœuvre-lès-Nancy, France.

Quadrupolar mass-spectrometric study of F trapped in I and channels is used to characterize the qualitative and quantitative composition of F within emeralds from 10 deposits located on the eastern and western margins of the Eastern Cordillera of Colombia. F in channels and in FI have the same qualitative composition. The bulk composition of the F phase is: H_2O (80 to 92 mol.%), N_2 (3 to 10%), CO_2 (2.5 to 5%), H_2 (1 to 5%) CO (0.1 to 1.5%), CH_4 (<0.5%), organic compounds (<0.05%), and inert G. Hydrogen and carbon monoxide in large part come from H_2O and CO_2 reduction. F trapped during emerald growth belong to an aquo-carbonic F phase with CO_2/N_2 ratios near 1 (0.8 to 0.84 in FI, 1 to 1.3 in channels). F contents in channels are higher by ~20% in emeralds from the western group compared to those in the eastern deposits. The concentration of H_2O in channels in emeralds from the eastern group is lower ($1.35<H_2O<1.45$ wt.%) than those of the western group ($1.63<H_2O<2.19$ wt.%) and it corresponds to the lowest contents of H_2O found worldwide for emeralds from different deposit types. Colombian emeralds are quite different because their hydrothermal-sedimentary genesis is unique.

Emeralds from the western zone also have higher Na_2O contents than those from the eastern zone. A strong correlation exists between channel H_2O and Na_2O in the emeralds, which also is the case for beryls and emeralds from different geological environments. Such an enrichment is indicative of the presence of Na^+ in the structural channels of beryl. This correlation between channel H_2O and Na_2O of the crystal is evidence for the introduction of channel H_2O as Type-II water molecules in beryls. (Authors' abstract)

ZIMMERMANN, J.L. and **VEEKEN, P.C.H.**, 1997, Permanent fluids in coals from the Fohnsdorf basin, Austria: A preliminary quadrupolar mass spectrometric study: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 358-359. First author at CRPG-CNRS, BP 20, 54501, Vandœuvre-lès-Nancy cedex, France; email (jlzim@crpg.cnrs-nancy.fr).

In connection with a possible European coalbed methane project, a study has been undertaken on the gas contents of two coal samples from the Fohnsdorf Basin, Austria. In the present study, the gases are extracted by continuous linear or stepwise heating under vacuum. They are subseqeuntly analysed using a quadrupolar mass spectrometer. Continuous liberation curves have been determined for the most abundant F: H_2, CH_4, CO_2, H_2O, N_2 and CO. Also the liberation rates for H_2S, SO_2, C_2H_2, C_2H_6 are given; the onset of their release starts at around 350°C with a maximum occurring close to 500°C. Incremental heating analyses, with successive steps at 350, 600, 850 and 1000°C, permit determination of the quantities of the extracted gases for each increment. H and CO represent basically analytical artifacts related to the heating of the coal under vacuum at relatively high T. (From authors' abstract by E.R.)

ZIMMERMANN, Rolf, GOTTSCHALK, Matthias, HEINRICH, Wilhelm and **FRANZ, Gerhard,** 1997, Experimental Na-K distribution between amphiboles and aqueous chloride solutions, and a mixing model along the richterite–K-richterite join: Contrib. Mineral. Petrol., 1997, no. 126, p. 252-264. First author at Fachgebiet Petrologie, Technische Univ, Berlin, EB 310, Straβe des 17, Juni 135, D-10623 Berlin, Germany.

The cation exchange equilibrium between richterite and K-Na chloride solutions has been investigated by hydrothermal experiments at 700 and 800°C at 200 MPa. The Na-K distribution coefficients between F and amphiboles of the richterite–K-richterite join are close to unity at 700°C and 800°C at 200 MPa. We suggest that the composition of richterite solid solutions can be used as a sensor for NaCl/KCl-ratios in metamorphic F. (From authors' abstract by E.R.)

ZINCHUK, I.M. and **RED'KO, L.R.**, 1997, Thermobaric study of inclusions in alkalic basalts and some xenoliths in them from Nuratau and Gissar Mountains (Tien-Shan): abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 360. Authors at Inst. of Geol. and Geochem. of Combustible Minerals, Naukova Str., 3a, 290053 L'viv, Ukraine.

Samples of alkalic basalts and their xenoliths from various diatremes were investigated. Thermal peculiarities of crystallization of pyroxenes, olivine and apatite were determined by thermometry of P I. The highest T of crystallization were found for Surhantau and Gissar Mountains (1340-1315 and 1390-1221°C, respectively). Lower T were found for Nuratau basalts (1285-1175°C). The important feature of I is high level of saturation by volatiles. The gases, as determined by mass spectrometry, were presented by nitrogen and carbon dioxide in equal quantities, or with prevailing nitrogen. No methane or its homologues were determined. During some heating experiments, after melting of crystalline phases, the I were quenched. In such I, the L carbon dioxide was found in the bubble. Due to high level of volatilisation of basaltic M, the heterogeneous state of system was common during long time of crystallization. Two types of immiscibility were established.

The first type was caused by immiscibility of silicate and sulphide M (liquation) and its presence was determined both in basalts and xenoliths in them. The second type of immiscibility is presented by boiling of supersaturated [fluids]. Gas I were found in olivine and pyroxenes of alkaline basalts and in pyroxenes, olivine and garnets of megacrysts and xenoliths in them. The maximum determined density of L CO_2 in P I in olivine megacrysts are 1.16 g/cm^3, very close to the maximum, reported in literature (1.18 g/cm^3 for Dreiser Weiher maar, Germany). Corresponding P taking into account the T of MI homogenisation, fluctuate in the range 6.0-12.6 kbars for garnet, olivine and pyroxenes from various xenoliths and megacrysts. We think that boiling is the main driving force for fast ascent of the basaltic M column and of forming of diatremes at near surface conditions. (From authors' abstract by E.R.)

ZINK, Stephen and **IHINGER, Phil,** 1997, Microscopic IR investigation of water in gemmy quartz crystals: Growth histories revealed (abst.): Geol. Soc. America, 1997 Annual Meeting, Abstracts with Programs, v. 29, no. 6, p. A-91–A-92. Authors at Dept. of Geol. and Geophys., Yale Univ., P.O. Box 208109, New Haven, CT 06520-8109; email (phil.ihinger@yale.edu).

Quartz crystals are present in sedimentary, igneous, and metamorphic environments, and although natural quartz is nearly pure SiO_2, it is well known that trace amounts of impurities can be measured in crystals grown in every natural environment. We document internal variations in the hydroxyl content of hydrothermal vug quartz crystals collected from Brazil and show that these crystals serve as "tape recorders" of the metamorphic conditions from which they grew. Three types of H-bearing species show regular variations as a function of time of incorporation (age) in the crystal, including water associated with (a) a sharp IR absorption at 3380 cm^{-1} assigned to Al-OH, (b) a sharp absorption at 3480 assigned to either Fe3- or Li-OH, and (c) a broad absorption centered at 3400 assigned to sub-microscopic F (smf) I. We show that order-of-magnitude variations in the respective concentrations of each species are entirely due to processes acting at the time of crystal growth, and that no post-crystallization alteration of H-bearing species has taken place. We note that two processes play a significant role in the partitioning of species (a) and (b) into a growing crystal: (1) the concentration of the impurity in the host F and (2) the rate at which the crystal grows. We may expect that only process (2) significantly affects incorporation of smf-I. By normalizing the band absorptivities of species (a) and (b) to that of (c), we document smooth changes in the concentration of impurities with age in the Brazilian crystals. We observe that the normalized concentration of species (a) increases with age, whereas that of (b) decreases with age, thus reflecting the relative compatibilities of the two elements between the evolving F and the solid phases precipitating on the vug walls. The normalized impurity concentrations serve as isochrons and define hexagonal and/or triangular bulls-eye patterns in sections cut perp. to the c-axis. Furthermore, the concentration of smf-I recorded in simultaneously active growing crystal faces are different and reflect different growth rates. The variation in crystal-face growth rate is manifested in crystal morphology, and we show that the three faces that terminate the crystal today were not present during earlier stages of crystal growth.

In order to use the IR measurements to extract the actual F compositions from which the quartz crystals grew as well as their actual growth rates, a series of experiments under controlled F (and M) compositions and T is required. These calibrations would serve to "decode" the information stored in crystal structures and allow for the recovery of information contained in quartz crystals derived from other natural environments. (Authors' abstract)

ZONOVA, I.A. and **SHMULOVICH, K.I.**, 1997, Thermogradient migration of fluid inclusions in quartz: abst., XIV ECROFI, Proc. of the XIVth European Current Research on Fluid Inclusions Meeting, July 1-4, Nancy, France, M.C.Boiron and J. Pironon, eds., CNRS-CREGU, BP 54501 Vandœuvre-lès-Nancy, France, p. 361-362. Authors at Inst. of Experimental Mineral., RAS, Moscow district, Chernogolovka; email (zonova@prima.iem.ac.ru).

The velocity of FI mobility along the "c" axis of quartz at the average T of 275°C, T gradients of 14°C/cm and 4°C/cm, the experiment duration up to 55 days and 12 month corresponding has been experimentally determined. The medium inside the I is 1 M NaOH solution. The rates of movement of frontal I surface were measured as 1-5 μm per day at thermogradient 14°C/cm that in calculating for the normal nature thermogradient (30°C/km) gives the movement velocity for pure water natural I with the densities of 0.7-0.8 g/cm^3 and size 10-20 μm from 0.5 to 1.5 mm for 10 Ma. The rates of migration FI at thermogradient 4°C/cm were measured as 0.3-1 μm/day. This result agrees satisfactorily with preceding data for FI, which size is up to 150 μm. The duration of one metamorphic stage and of the entire stage of orogenesis in particular is sufficient for the most water I in quartz from metamorphic rocks to move into the intergranular space. (From authors' abstract by E.R.)

ZVÁGINA, O.N., BÓRTNIKOV, N.S., NÓSIK, L.P., VIKÉNT'EV, I.V. and **SAZÓNOV, V.N.**, 1997, Stable isotopes of carbon, oxygen, and sulphur in the Berëzovskoe gold-quartz deposit, Urals, Russia: in N.P. Laverov, ed., Principal Genetic Problems Related to Mineral Deposits of Magmatic Affiliation, IGEM-RAS Symposium, Moscow, April 8-10, 1997 [Betekhtin Symposium], p. 37-38, ISBN 5-88918-002-9 (in Russian; English translation courtesy Dr. D. B. Brown). First author at Lomonósov Moskva State Univ., Russia.

The Berëzovskoe deposit is regarded as a typical example of mesothermal gold-quartz deposits, associated with intrusive rocks (Borodáevskaya and Rozhkóv, 1974). The area of the deposit consists of mica schists, serpentines, and metamorphosed sedimentary rocks. A large number of dykes, in which the gold-quartz veins are located, have been injected into this sequence. The gold-quartz veins are accompanied by beresitization and listvenitization of the country rocks (Sazónov, 1975). For the purposes of revealing the F sources and the dissolved components, we have carried out an investigation of the stable isotopes of C, O, and S.

The carbon- and oxygen-isotopes of the carbonates. The $\delta^{18}O$ and $\delta^{13}C$ values of carbonates from the metamorphic rocks vary from +16.5 to +23.3‰ (SMOW) and from -8.0 to -2.1‰ (PDB), which indicates a heterogeneity in the isotope composition of the country rocks of the gold mineralisation. The carbonates from the listvenites, formed as a result of substitution of talc-carbonate rocks, enriched as compared with them in the light isotopes of C and O: the $\delta^{18}O$ and $\delta^{13}C$ values in them occur respectively in the field from +24.4 to +27.8‰ and from -3.0 to -6.8‰. The minerals from the listvenites that replaced the diabase porphyrites are distinguished by lower values for $\delta^{18}O$ and $\delta^{13}C$, which occur respectively in the ranges of +16.6 to +26.7‰ and -5.4 to -11.8‰. Carbonates from the quartz-carbonate-sericite-albite metasomatites are marked by the most significant variations in the C and O isotope ratios: from +15.0 to +23.3‰ and from +0.2 to -12.8‰. The differences in the C- and O-isotope composition in the carbonates vis-à-vis the metasomatites, formed from different rocks, suggest that the isotope composition of the P rocks had an influence on them.

The $\delta^{18}O$ and $\delta^{13}C$ values for the carbonates from auriferous veins fall withn the range, established for minerals from metasomatic rocks: $\delta^{18}O$ is +18.1 to 22.7‰, whereas $\delta^{13}C$ varies from -6.1 to -8.4‰. The similarity between the isotope composition of the carbonates from the metasomatic rocks and the auriferous veins points to the involvement of a F, arising from a single source, in their formation.

The $\delta^{13}CO_2$ value of the F, calculated on the assumption that CO_2 was the predominant compound in it, and that the T of mineral-formation on average amounted to 250°C (Bórtnikov et al., 1997), was -7‰. Such a C-isotope ratio is typical for CO_2 of magmatic origin (Ohmoto and Rye, 1979). However, it is also suggested that carbon, entering from the country rocks, was also involved in the mineral-forming system.

The oxygen-isotopes of the quartz. The $\delta^{18}O$ values for quartz from the auriferous veins lie in a narrow range from +9.7 to +11.7‰ (SMOW). The $\delta^{18}CO_2$ value in equilibrium with quartz, deposited at 300°C, is +4.1‰. This figure is less than the values regarded as typical of magmatic water (+5.5 to +9.5‰, Sheppard, 1986). Enrichment of the F in the ^{16}O isotope is associated with separation of the F into L and G phases (Bórtnikov et al., 1997; Bowers, 1991). Consequently, the data obtained indicate the participation of a magmatogenic F in the Berëzovka hydrothermal system.

The sulphur-isotopes of the sulphides. The $\delta^{34}S$ values for pyrite, galena, chalcopyrite, and the fahlores vary significantly from +12.7 to -2.5‰ (CDT). Assuming that the deposition of sulphides took place in the T range of 200-300°C from a F in [which] the predominant compound of sulphur was H_2S, the calculated value of $\delta^{34}S_{H2S}$ in the F must vary from +13 to +20‰ (fractionation coefficients -4.5‰ for PbS (200°C, -0.6‰ for FeS (300°C), and 0‰ for $CuFeS_2$ (200-400°C) (Ohmoto and Rye, 1979). Such a significant difference in the sulphur-isotope ratios in hydrogen sulphide could arise from the mixing of sulphur, differing in isotope composition and drawn from different sources, or because of the separation of the volatile components, which led to the fractionation of the light sulphur-isotope in the residual L phase (Ohmoto, 1986; McKiblen and Eldridge, 199 [sic]). The second mechanism is the more likely because it conforms with the results of the study of FI (Bórtnikov et al., 1997). In this case, the original $\delta^{34}S_{H2S}$ value was not less than +13‰. Such a sulphur-isotope ratio is not typical of sulphur derived from a magmatic source and is usually attributed to a sulphur extracted from sedimentary rocks. This approach seems over-simplified because it has been shown in recent years that granitoids may be enriched in the heavy sulphur-isotope, owing to assimilation of the country rocks (Ohmoto, 1986; Poulsen et al., 1991). Consequently, it is reasonable to assume the involvement of sulphur from the country rocks in the Berëzovka hydrothermal system. However, this proceeded during ... [sic] injection of the granite magma. The F, separated during crystallization of such a magma, could have been enriched in the $\delta^{34}S$ isotope.

Thus, the studies carried out point to the participation of a magmatic F and components in the formation of the Berëzovka gold-quartz deposit. (Authors' abstract)

ZWAAN, J.C., KANIS, Jan and PETSCH, E.J., 1997, Update on emeralds from the Sandawana Mines, Zimbabwe: Gems & Gemology, v. 33, no. 2, p. 80-100. First author at Mineral. Dept., Nat'l. Museum of Natural History, Leiden, The Netherlands.

Characteristic FI are illustrated and discussed. (H.E.B.)

APPENDIX

Illustrations

- From page 146—**O'REILLY, C., FEELY, M., HOLDSTOCK, M.P. and O'KEEFE, W.G.**, 1997, Fluid inclusion study of the unexposed Kentstown Granite, Co. Meath, Ireland.

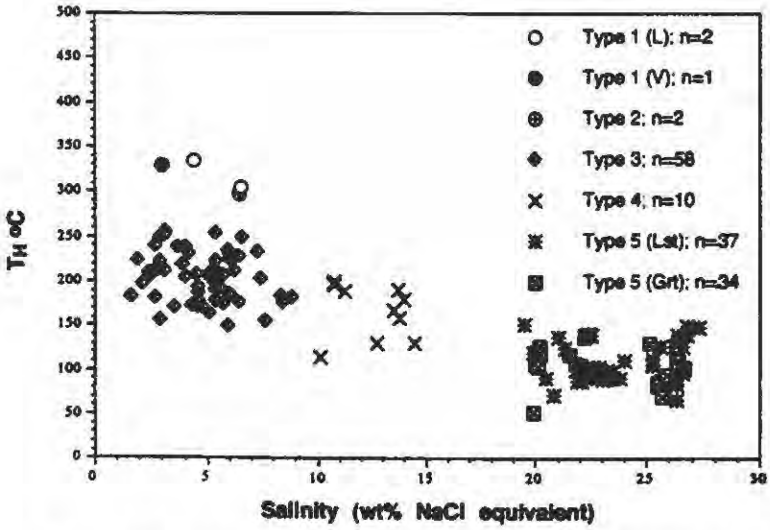


Fig. 3 Plot of T_H versus salinity, equiv. wt% NaCl, for all fluid inclusion types in Kentstown borehole. Salinities for type 1 and type 2 inclusions calculated from their clathrate dissolution temperatures;[5] salinity values for all type 3, 4 and 5 inclusions calculated from their ice melting temperatures.[2,5] Type 5 (Grt) inclusions are type 5 inclusions in granite-hosted V_1 veins or V_2 veins. Type 5 (Lst) inclusions are type 5 inclusions in limestone-hosted V_2 veins

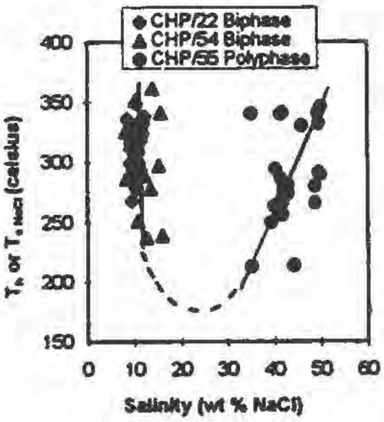
- From page 218—**XU, Jiuhua, XIE, Yuling** and **SHEN, Shiliang**, 1997, A comparison of ore-forming fluids between gold deposits in Xiaoqinling Mountains and those in Jiaodong Peninsula.

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)He, et al. 1989. 1992. 3)Xu. 1992. 4)Yang. 1984 Wang and Wang. 1991

- From page 75—**GUHA, Hillol** and **MISHRA, Biswajit,** 1997, Fluid inclusion studies in quartz-wolframite veins, Chhendapathar, Bankura District, West Bengal, India:



360°C, 1.6 KB; 400°C, 2.35 Kb and inclusions show a strong positive temperature

◆

From page 88—**JENKIN, Gawen, O'REILLY, Cian, FEELY, Martin** and **FALLICK, Tony,** 1997, Fluid inclusion and stable isotope evidence for Triassic fluid mixing forming base-metal veins in Connemar, Ireland (abst.):

	EM1	EM2
T (-C)	205	125
S [sal] (wt.% NaCl eq.)	12	21
$\delta^{18}O$ (‰)	1.2	-3.0
δD (‰)	-17	-45
$\delta^{13}C$ CO_2 (‰)	-4 to 0	-10 to -19
$\delta^{34}S$ SO_4 (‰)	13	20 to 23

◆

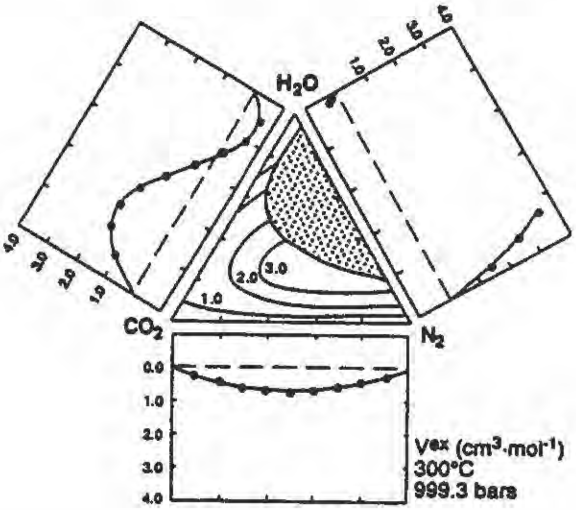
From page 102—**KOVALENKO, V.I. and NAUMOV, V.B.,** 1997, Magmatic volatiles and their part in ore-forming fluids generation (abst):

Table. Mean Abundances (Wt.% of Volatile Components in Various Types of Natural Igneous Melts from the Studies of Melt Inclusions in Minerals and Quenched Glasses from the Ocean Floor).

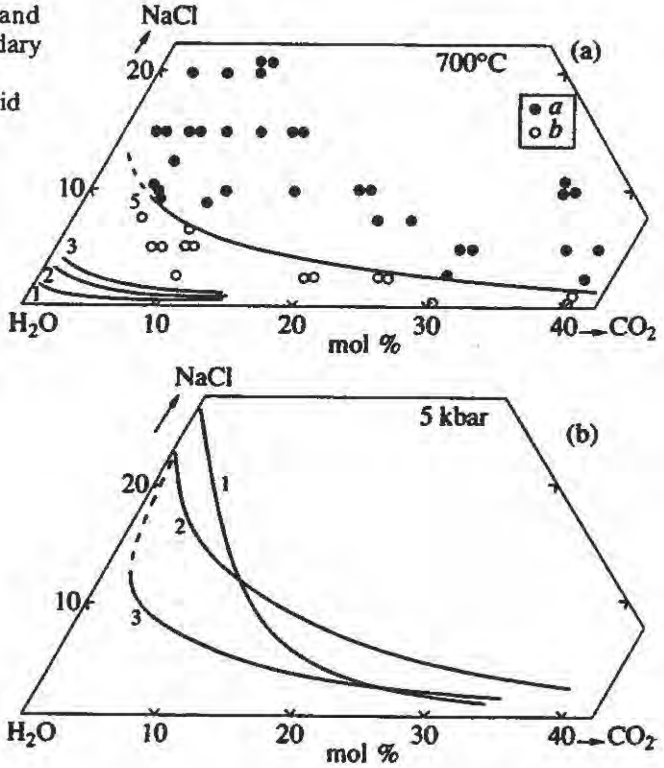
Volatile Component	Igneous Melt Type					
	1	2	3	4	5	6
H_2O	0.802 (531)	1.344 (53)	2.260 (213)	2.998 (416)	1.338 (106)	3.292 (46)
Cl	0.063 (239)	0.346 (160)	0.251 (267)	0.172 (438)	0.212 (169)	0.498 (84)
F	0.029 (169)	0.398 (19)	0.118 (45)	0.184 (330)	2.100 (166)	0.273 (41)
CO_2	0.056 (265)		0.119 (17)	0.010 (56)		
S	0.111 (327)	0.161 (135)	0.073 (130)	0.023 (73)		

Note. 1, 2-ultrabasic and basic M (SiO_2=40-53%, 1-K_2O<1.3%, 2-K_2O>.3%); 3-intermediate M SiO_2=53-64%); 4-6-acid M SiO_2>64%) including normal M (4th type), F-rich M (5th type-topaz rhyolites, ongonites, Li-F granites, and pegmatites), and Cl-rich M (6th type-pantellerites, comendites, alkali granites). Numbers of analyses are given in parentheses. (From authors' abstract by E.R.)

- From page 176—**SEITZ, J.C. and BLENCOE, J.G.**, 1997, Experimentally determined volumetric properties and solvus relations for H_2O-CO_2-N_2 mixtures at 300°C and pressures<1000 bars (abst.)

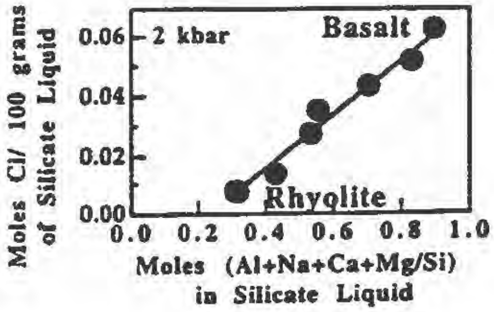


- From page 100—**KOTEL'NIKOVA, Z.A.** and **KOTEL'NIKOV, A.R.**, 1997, Phase boundary in the system H_2O-CO_2-NaCl at 700°C and a pressure of 5 kbar: Evidence from synthetic fluid inclusion data.

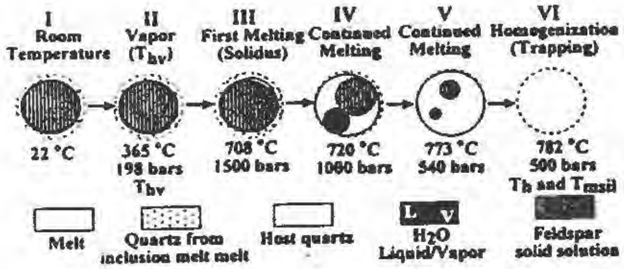


Phase boundaries in the H_2O–CO_2–NaCl system (based on the study of fluid inclusions in quartz). (a) Isotherms at 700°C; numbers left side of curves specify the pressure (in kbar): (1, 2, and 3) adopted from [3, 4]; (5) our data; (*a*) heterogeneity field and (*b*) homogeneous fluid field. (b) Isobars at 5 kbar: (1) at 500°C [5]; (2) at 500°C [6]; and (3) at 700°C (our data).

- From page 209—**WEBSTER, J.D., KINZLER, R.J.** and **MATHEZ, E.A.**, 1997, Experimental constraints on the role of chlorine solubility in magmatic degassing (abst.)

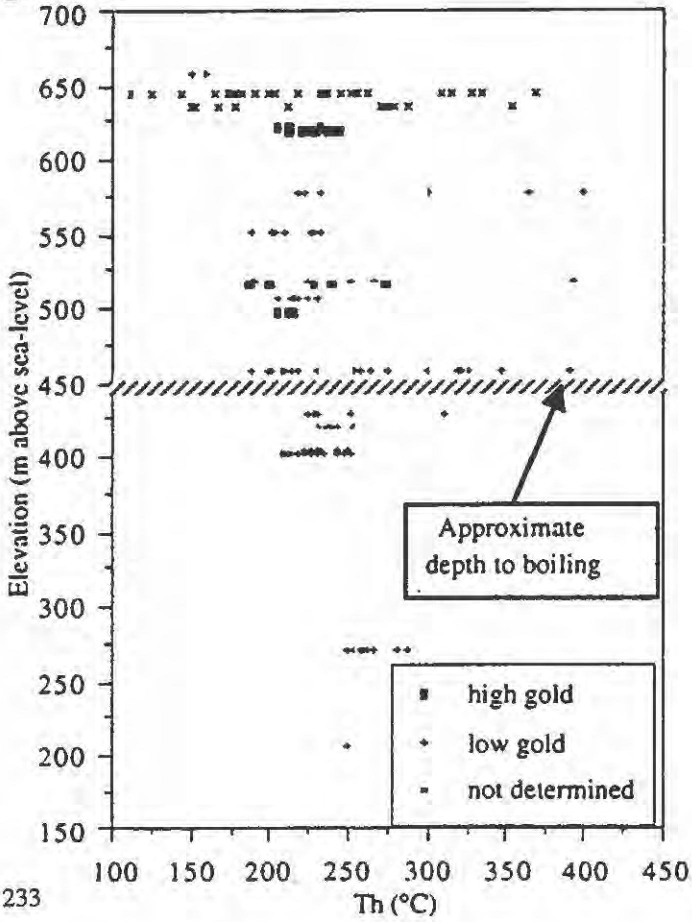


- From page 188—**STUDENT, J.J.** and **BODNAR, R.J.**, 1997, Modeling the P-V-T-X properties of haplogranite melt inclusions during heating and cooling.



- From page 94—**KILIAS, S., CHELIOTIS, I., CONSTANDINIDOU, E., CROSSINGS, J., NADEN, J., SHEPHERD, T.J.** and **SIMOS, I.**, 1997, Epithermal gold mineralization in the Aegean: The Profitis Ilias deposit, Milos Island, Greece (abst.)

Figure 2. Depth-Th relationships for the Milos ore stage fluids.



- From page 166—**RYAN, C.G., KHIN Zaw, HEINRICH, C.A., JAMIESON, D.N.** and **ACHTERBERGH, E. van,** Probing ore forming processes using the scanning proton microprobe, abst.

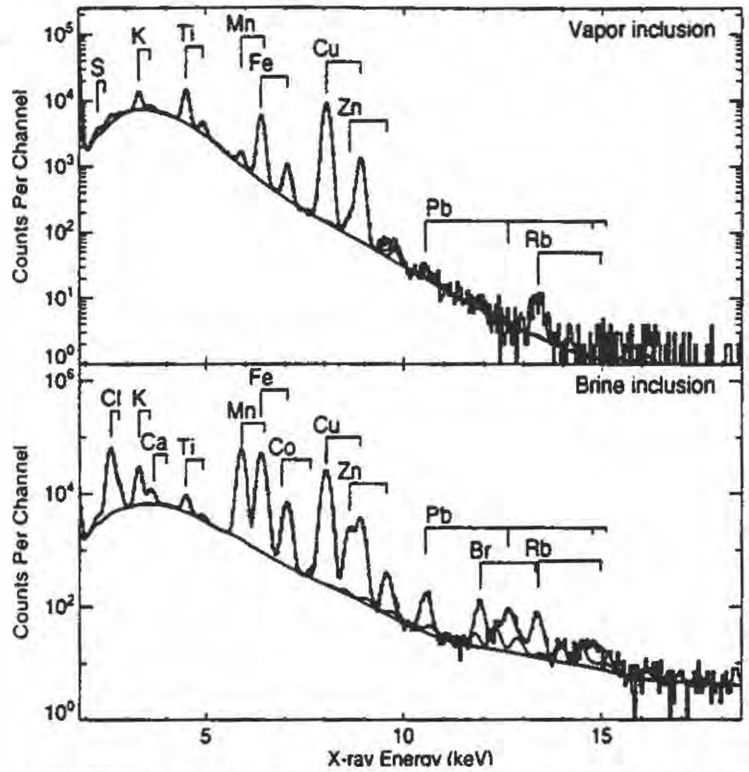


Fig. 1 PIXE spectra from vapour (top) and brine (bottom) fluid inclusions in quartz from the Kidston copper-gold deposit, Queensland, analyzed using a 3 MeV proton beam. Note the strong partitioning of Cu into the vapour phase.

- From page 182—**SIMMONS, S.F.** and **BROWNE, P.R.L.,** 1997, Saline fluid inclusions in sphalerite from the Broadlands-Ohaaki geothermal system: A coincidental trapping of fluids being boiled toward dryness.

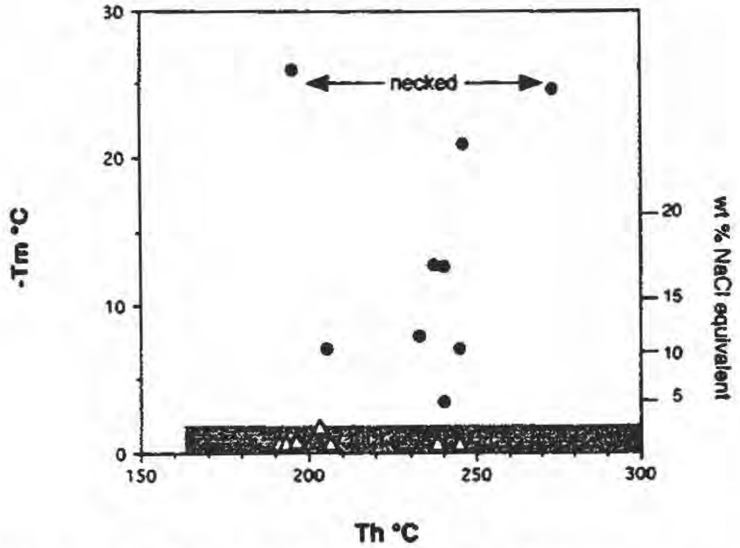


FIG. 3. Plot of T_m vs. T_h for sphalerite-hosted fluid inclusions in sample16-302. Low-salinity inclusions are distinguished from high-salinity inclusions on the basis of composition alone and are shown as open triangles and filled circles, respectively. That high-salinity fluid inclusions plot at near-uniform T_h, but variable T_m, supports the boiling to dryness interpretation discussed in the text. The shaded area at the bottom of the graph shows the range of T_h and T_m measured in Broadlands-Ohaaki fluid inclusion studies by Browne et al. (1976), Hedenquist and Henley (1985), and Simmons and Christenson (1994).

◆ From page 4—**ANDERSON, A.J., MAYNOVIC, R.A., HORN, Ingo, JACKSON, Simon** and **THOMAS, Rainer**, 1997, Element partitioning and ore-metal transport in a two-phase hydrothermal system: Evidence from fluid inclusions in pegmatites and associated polymetallic sulfide veins in the Saxonian granulite massif, Germany

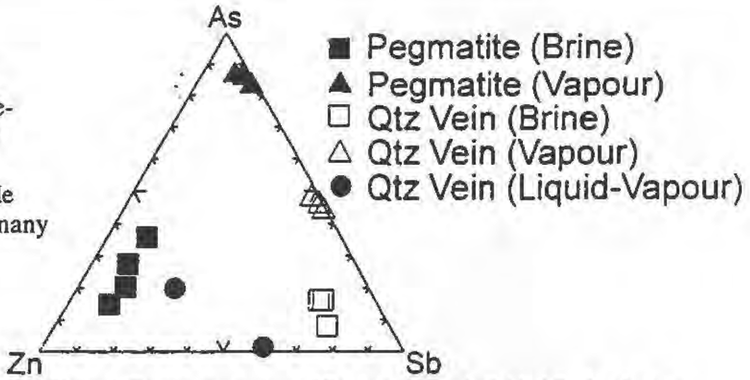


Figure 1. Ternary percentages of Zn, As and Sb in individual fluid inclusions.

◆ From page 5—**ANDREEVA, I.A., NAUMOV, V.B., KOVALENKO, V.I.** and **KONONKOVA, N.N.**, 1997, Primary phosphate-silicate melts for the rocks of the magmatic alkaline-carbonatitic complex from the Mushugai-Khuduk, South Mongolia: Results of melt inclusions study

Chemical composition of homogenized glasses of melt inclusions in apatite, wt.%

Component	1	2	3	4	5	6
SiO_2	62.93	43.12	35.05	58.16	30.75	21.96
TiO_2	0.06	2.28	4.29	0.83	3.76	2.61
Al_2O_3	19.93	14.76	10.78	15.52	10.98	8.42
FeO	0.54	4.31	8.37	4.93	7.35	5.47
MnO	0.00	0.19	0.25	-	-	-
MgO	0.08	9.66	10.13	2.35	9.46	7.10
CaO	2.34	10.39	13.39	6.52	16.98	22.94
BaO	0.69	0.71	0.63	0.24	1.66	1.57
SrO	0.39	0.29	0.24	0.86	0.65	0.82
Na_2O	4.64	1.48	3.03	2.45	0.82	0.84
K_2O	8.31	4.62	4.81	5.47	6.91	5.39
P_2O_5	0.03	7.12	8.70	2.30	10.99	20.51
Ce_2O_3	0.23	0.34	0.42	0.04	0.08	0.17
La_2O_3	0.04	0.14	0.14	0.00	0.01	0.06
F	0.06	0.40	0.33	0.08	0.27	0.50
Cl	0.02	0.05	0.31	0.02	0.03	0.00
S	0.05	0.14	0.24	0.13	0.25	0.25
Total	100.37	100.03	101.11	99.67	101.19	98.70

◆ From page 18—**BIN, Liu, LU, H.-Z.** and **KUN, Shen**, 1997, Discovery of high-P metamorphic minerals and rocks, characteristics of FI and P-T-t path metamorphism in east Tianshan, Xinjiang, China

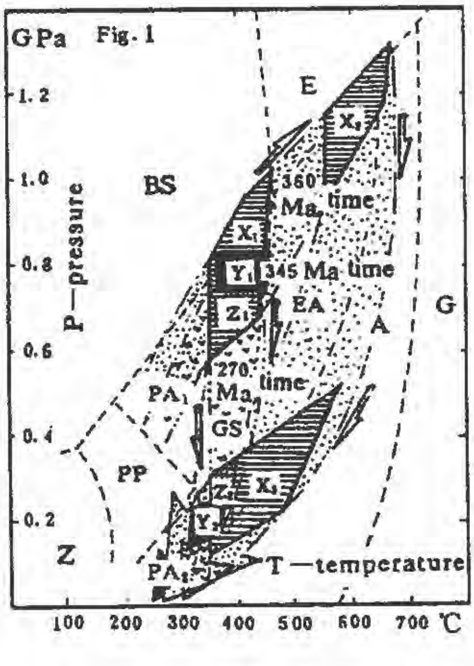
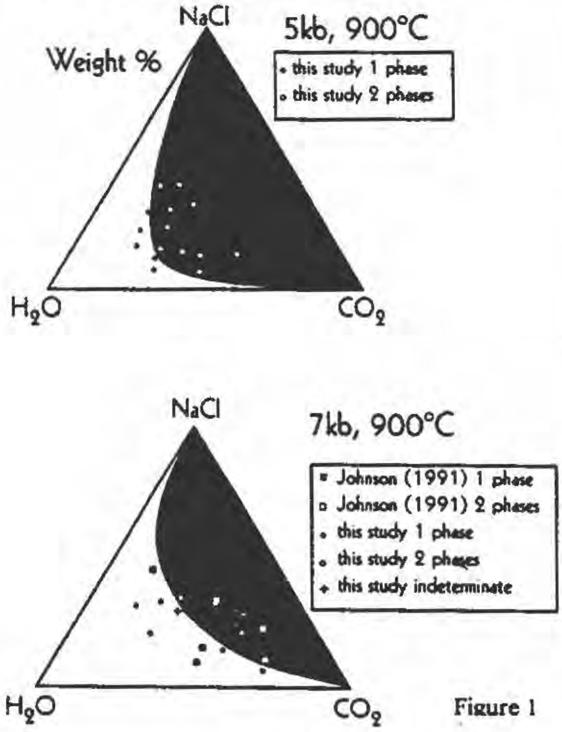


Fig. 1 The P-T-t path for tectonometamorphic evolution in East Tianshan Mountain areas. X_1-X_2-X_3: The Tonghuashan high-P metamorphic belt; Y_1-Y2: The Wushitong high-P metamorphic belt; Z_1-Z_2: The Houxia high-P metamorphic belt; BS: Blueschist facies; E: Eclogite facies; EA: Epidote-mphibolite facies; A: Amphibolite facies; GS: Greenschist facies; PA_1: Pumpellyte-Actinolite facies; PA_2: Prehnite-Actinolite facies; PP: Prehnite-Pumpellyte facies; Z: Zeolite facies; G: Granulite facies.

- From page 67—**GIBERT, François, GUILLAUME, Damien** and **LAPORTE, Didier**, 1997, Experimental study of fluid immiscibility in H_2O-NaCl- CO_2 at 5-7 kb and 900°C using synthetic fluid inclusions.



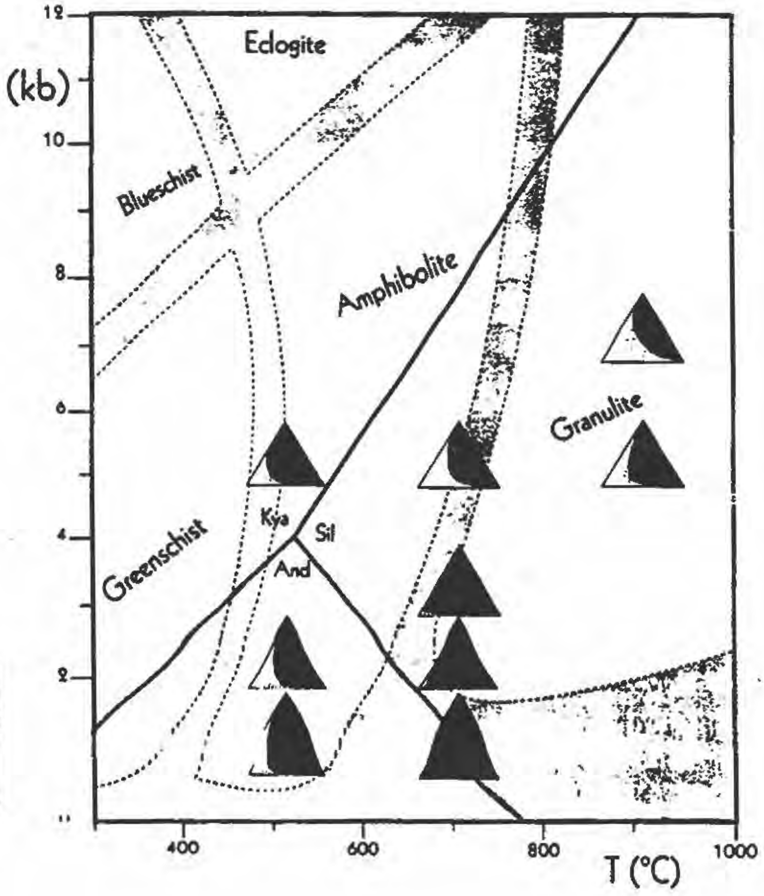
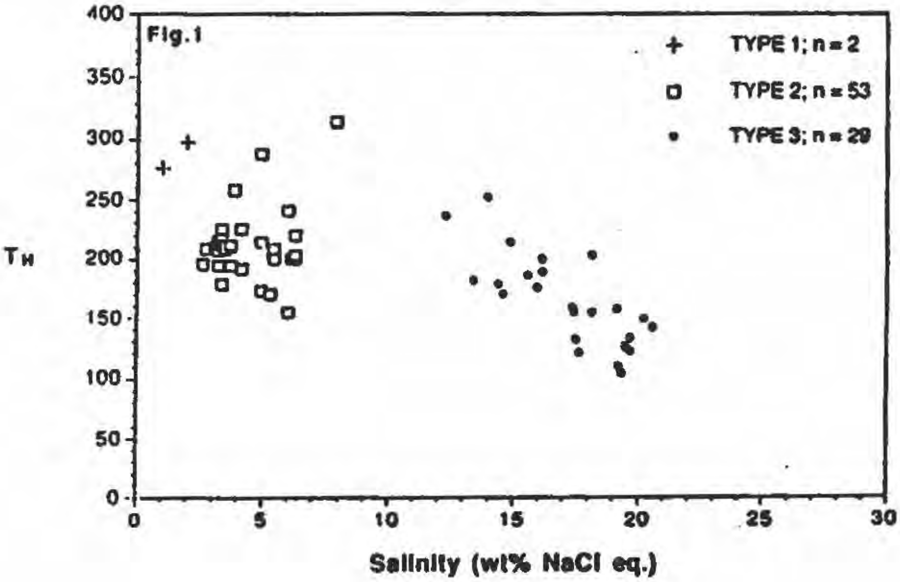
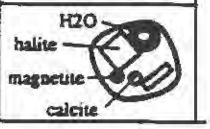


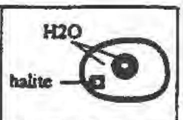
Figure 1

- From page 136—**MORAN, R.A., FEELY, Martin** and **KENNAN, P.S.**, 1997, Fluid inclusion studies of the Late Caledonian Leinster granite and its quartz veins in SE Ireland.



- From page 165—**ROTHERHAM, J.F.**, 1997, Fluid conditions of post-metamorphic ironstones and mineralisation at the Starra Au-Cu deposit, Cloncurry District.

STAGE 2	Type 1 - CO_2 vapour-rich	Density - 0.72-1.0g/cm^{3}	
	Type 2 - Multiphase	345-615°C 34-52wt.% NaCl equiv.	

STAGE 3	Type 3 - 2 phase, Liquid-rich +/-1 solid	8-27wt.% NaCl equiv.	
	Type 4 - Multiphase/ multisolid	225-360°C 30-42wt.% NaCl equiv.	

Types of fluid inclusions hosted within quartz from stage 2 (ironstones) and stage 3 (mineralisation)

- From page 102—**KOVALENKER, V.A., SAFONOV, Yu.G., NAUMOV, V.B.** and **RUSINOV, V.L.**, 1997, The epithermal gold-telluride Kochbulak deposit (Uzbekistan).

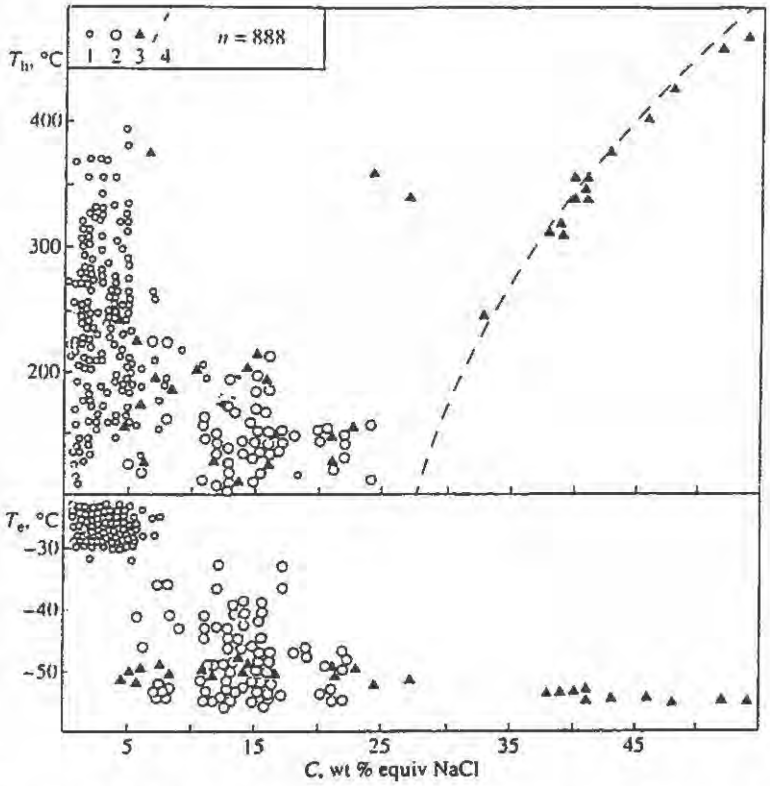
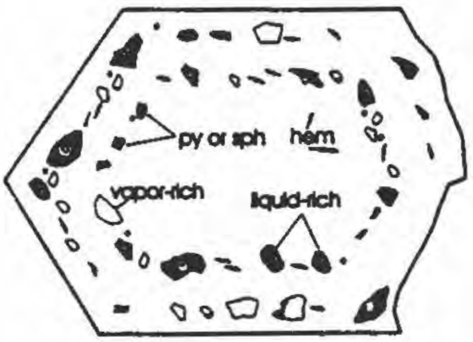


Fig. 9. Thermo- and cryometric data for individual fluid inclusions in transparent minerals from ores of the Kochbulak deposit. 1-3—solutions of types I, II, and III in fluid inclusions, 4—saturation curve in the H_2O-NaCl system; n—number of fluid inclusions studied.

- From page 118—**LOTT, D.A.** and **COVENEY, R.M., Jr.**, 1997, Fluids associated with Ni-Mo sulfide beds from China.

Fig. 1—quartz from Hunan



- From page 6—**ARCOS, D.** and **AYORA, C.**, 1997, The use of fluid inclusions in halite as environmental thermometer: An experimental study.

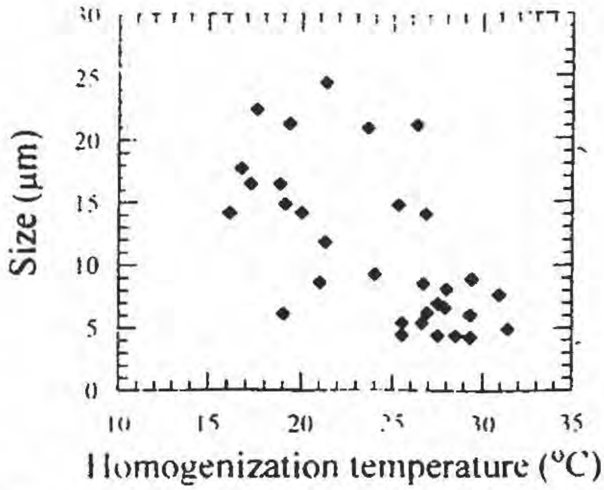


Fig. 2. Homogenization temperature- inclusion size diagram for the 30°C experiment.

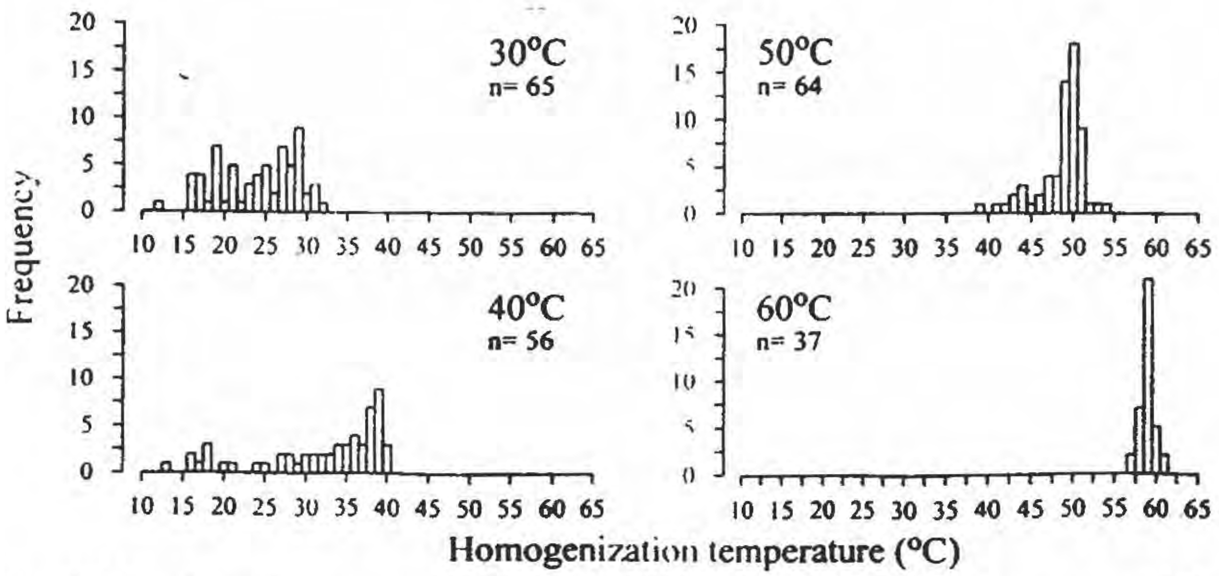


Fig. 1. Homogenization temperature histograms for the four temperature experiments at 30°, 40°, 50°, and 60°C.

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 appear 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 resulting from use of 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.

Age determination, dating by inclusions, effect of inclusions on, and relation to mineralization—Brannon, Chen, Henry, Krol, Pettke, Qin, Qiu
  Topaz—Holzhev
Analysis, data and discussion, aqueous (non-melt) inclusions. Includes gas inclusions in igneous rocks. *See also* Analysis methods; Daughter minerals; Complexes; Isotopes (Minor concentrations ignored).
  Adularia—Craw
  Ag—Bodnar, Borisenko, Háber, Hayashi, Kovalenker
  Al—Ozgür, Reyf
  Apatite—Fuertes-Fuente, Sheets,
  Ar—Kawakami, Konnikov, Norman, Pettke, Salvi
  Arsenopyrite—Brown
  As—Anderson, Dong, Moran, Shepherd
  Au—Hayashi, Shepherd
  B—Calvache, London, Nabelek, Reyes, Schreyer
  Ba—Dong, En-Naciri, Essarraj, Lüders, Molnár
  Barite—Kovalenker
  Be—Markl
  Beryl—Banko, Fuertes-Fuente, Giuliani
  Bicarbonate—Ridley
  BO_3—Tecce
  Br—Appel, Banks, Berndt, Brown, Cathelineau, Channer, Chi, Crespo, de Ronde, Dobes, Essarraj, Galamay, Gleeson, Graupner, Marignac, Richards, Ryan, Savoye
  Bromine—Berndt, de Ronde, Galamay
  Ca—Anderson, Bachiller, Boiron, Bortnikov, Cesaretti, Chi, de Ronde, Dobes, Dominy, Dong, En-Naciri, Fanlo, Foley, Fonarev, Grawinkel, Harlov, Hill, Hurai, Khmelevska, Kontak, Kozlowski, Levasseur, Li, Lodemann, Marhsall, Ozgür, Reyes, Richards, Rodger, Ryan, Shepherd, Slobodnik, Smith, Souissi, Suchy, Tecce, Taberner, Veigas, Wilkinson, Yao
  $CaCl_2$—Török
  Carbonate—Ridley
  CH_4—Azimov, Baranova, Barker, Berger, Bodnar, Boni, Borisenko, Bortnikov, Brown, Canals, Cassidy, de Ronde, Dobes, Dudok, Durisova, Essarraj, Evans, Fonarev, Fortes, Freitas-Silva, Fuertes-Fuente, Gebre-Mariam, Glebovitsky, Graupner, Green, Grishina, Háber, Harlov, Juhász-Bodnár, Kaindl, Knoll, Konnikov, Leach, Liu, Mesquita, Montomoli, Norman, Noronha, Ortega, Richards, Sackett, Sakaguchi, Salvi, Samson, Sasaki, Sawaki, Schmidt-Mumm, Smelik, So, Souza Neto, Srikantappa, Thalhammer, Tomilenko, Xia, Xu, Zhang
  C_nH_m—Glebovitsky
  C_2H_6—Fortes, Li
  Cl—Anderson, Appel, Banks, Berndt, Borrok, Boudreau, Brown, Calvache, Cathelineau, Cendón, Channer, Chevychelov, Chi, Crespo, de Ronde, Dubessy, Essarraj, Gleeson, Graupner, Háber, Icenhower, Kawakami, Khmelevska, Kholodnov, Kovalenker, Kovalevich, Kozlowski, Lasarenko, Li, Lowenstein, Marignac, Moles, Ozgür, Petrichenko, Prokof'ev, Rebbert, Reyes, Reyf, Richards, Ryan, Sato, Savoye, Scambelluri, Shaidetska, Shepherd, Souissi, Tecce, Tritlla, Veigas, Velíchkin, Von Damm, Webster, Williamson, Zhang,
  Clinopyroxene—Sheets
  CO—Baranov, Bortnikov, Konnikov, Ryan

CO_2—de Ronde, Lowenstein
CO_3—Cesaretti, Tecce
Cs—Tecce, Webster
CSO—Grishina
Cu—Anderson, Audétat, Bodnar, Chen, Dong, Háber, Hezarkhani, Hurai, Kovalenker, Maeda, Reyf, Ryan, Shepherd, Wood
Enargite—Arribas
F—Borrok, Bortnikov, Boudreau, Chen, Dobes, Háber, Li, Icenhower, Kholodnov, Kovalenker, Lasarenko, London, Malinin, Markl, Ozgür, Samson, Savoye, Seltmann, Sokolov, Solovóva, Velíchkin, Wang, Williams-Jones, Webster, Xu, Yao, Zhang,
Fe—Anderson, Bachiller, Bodnar, Borisenko, Bortnikov, Dong, Foley, Háber, Kontak, Kovalenker, Maeda, Marfil, Mayanovic, Molnár, Ozgür, Reyf, Ryan, Smith, Williamson, Wogelius, Wood
Fe^{3+}—Li, Ozgür
Fluorite—Boni, Michallidis
Ga—Lüders
Garnet—Fuertes-Fuente
Gases—Banerjee, Barker, Chen, Durisova, Fonarev, Fortes, Freitas-Silva, Giuliani, Green, Guedes, Kaindl, Knoll, Lasarenko, Leach, Lidwin, Liu, Mathieu, Melcher, Miller, Muramatsu, Newman, Norman, Noronha, Parilov, Prohl, Sasaki, Sawaki, Tomilenko, Török, Tritlla, Wang, Xu, Yao, Zhang, Zimmerman, Zimmermann
General—Chen, Dobes, He, Liu, Tritlla, Wang, Xu, Yao, Zhang
H_2—Bortnikov, Cunningham, Konnikov, Prohl, Salvi, Zink
Halite—Stasiuk
HC—Bodnar, Freitas-Silva, Grishina, Konnikov, Leach, Salvi
HCO_3^-—Cesaretti, Chen, He, Li, Ozgür
He—Konnikov, Norman, Pettke
HF—Taylor
Hg—Bodnar
Higher hydrocarbons—Salvi, Smelik. Smith
HS—Bondarenko
HSO_4^-—Bondarenko
H_2S—Akinfiev, Arias, Banerjee, Barker, Bondarenko, Bortnikov, Fortes, Freitas-Silva, Gamo, Lasarenko, Leach, Morales-Ruano, Norman, Suleimenov, Thiersch
Hydrocarbons—de Ronde
I—Channer, Essarraj, Gleeson, de Ronde, Richards
K—Anderson, Bachiller, Boiron, Borisenko, Bortnikov, Cendón, Chi, de Rond, Essarraj, Háber, Harlov, Khmelevska, Kontak, Kovalevich, Li, Lüders, Marignac, Marshall, Nabelek, Ortega, Ozgür, Peryt, Pettke, Pokrovskii, Reyes, Richards, Ryan, Shaidetska, Shepherd, Siemann, Smith, Suchy, Taberner, Tecce, Wilkinson, Xu, Zimmermann
Li—Boiron, Cathelineau, Chen, Essarraj, Nabelek, Richards, Seltmann, Solovóva, Tecce, Velíchkin, Webster
Mg—Cendón, Cesaretti, Chi, Dobes, Foley, Gamo, Khmelevska, Kovalevich, Li, Ozgür, Reyes, Shaidetska, Shepherd, Siemann, Smith, Suchy, Taberner, Tecce, Yao
Mg^{2+}—Li, Ozgür
Mn—Anderson, Bodnar, Borisenko, Dong, Maeda, Molnár, Reyf, Ryan, Sokolev, Williamson, Wogelius
Mo—Chevychelov
N_2—Baranov, Baranova, Barker, Bebout, Berger, Borisenko, Bortnikov, de Ronde, Dobes, Durisova, Fonarev, Fortes, Grishina, Háber, Harlov, Kaindl, Knoll, Konnikov, Lasarenko, Norman, Ortega, Richards, Sawaki, Schmidt-Mumm, Souza Neto, Tomilenko, Török, Tritlla, Zimmerman
Na—Anderson, Bachiller, Boiron, Borisenko, Bortnikov, Cathelineau, Cesaretti, Chi, de Ronde, Dobes, Dong, Essarraj, Gleeson, Grawinkel, Háber, Harlov, Hill, Hurai, Khmelevska, Kovalevich, Kozlowski, Li, Lüders, Marignac, Marshall, Moles, Ortega, Ozgür, Peryt, Petrichenko, Reyes, Richards, Rodger, Shaidetska, Siemann, Smith, Souissi, Suchy, Tecce, Veigas, Webster, Wilkinson, Xu, Zimmermann
Nb—Sokolov, Taylor, Webster
NH_3—Bortnikov, Dobes
NH_4—de Ronde, Dobes, Tecce
Ni—Hurai
Nitrogen—Bebout, Borisenko, Bortnikov, Glebovitsky
P—Anderson, London, René, Shepherd, Webster
Pb—Anderson, Bodnar, Borisenko, Chevychelov, Dong, Háber, Kovalenker, Maeda, Molnár, Ryan
PGE—Wang, Wood
Phenakite—Fuertes-Fuente
Pt—Wang
Pyrite—Brown
Rb—Pettke, Ryan, Tecce, Webster
REE—Alёshin, Bouabdellah, Ghaderi, Levasseur, Lewis, Seltmann, Taylor, Velíchkin, Xiong, Zhong
S–Cunningham, Shepherd, Williamson
S^0—Bondarenko
S_2O_3—Bondarenko, Dobes, Kucha
Sb—Lüders, Anderson
Scheelite—Espinola
Sn—Velíchkin, Webster, Williamson
SO_2—Bondarenko
SO_4—Bondarenko, Cesaretti, Crowley, Dobes, Fanlo, Gamo, Háber, Kovalenker, Kovalevich, Lewis, Li, Ozgür, Reyes, Richards, Savoye, Shaidetska, Siemann, Taberner, TecceZhang,
Sphalerite—Boni, Kovalenker
Sr—de Ronde, Kontak, Lodemann, Pettke, Tecce, Wogelius
Stibnite—Brown
Sulfate—Bondarenko, Gamo, Lewis
Ta—Taylor, Webster
Th—Moine, Pettke
Ti—Ryan
Tl—Bodnar
Tridymite—Krylóva
U—Pettke, René, Shepherd, Sturchio
V—Shepherd
W—Chevychelov, Eichhorn, Guha, Malinin, Reyf
Y—Taylor
Zn—Anderson, Bodnar, Borisenko, Chevychelov, Dong, Háber, Hurai, Kovalenker, Lüders, Maeda, Mayanovic, Ryan, Shepherd
Zr—Kasimova, Taylor

Analysis, data and discussion, silicate melt inclusions. Includes gas inclusions in igneous rocks. *See also* Analysis methods; Daughter minerals. Only special items listed under individual elements. Ordinary multiple-constituent analyses listed only under General analyses
Anhydrite—Mountjoy
Apatite—Fleet
Ar—Trieloff, Villa

B—Belkin, Calvache, de Vivo, Eiler, Gurenko, Kent, Kovalenko, Naumov, Webster
Ba—Garrido, Kovalenko, Mitchell, Naumov
Be—Kent, Kovalenko, Naumov, Webster
Br—Harms, Kholodnov, Villa
C_2-C_4 hydrocarbons—de Ronde
Ca—de Ronde, Dong, Trieloff
C—Odling
Ce—Naumov
Cl—Belkin, Borrok, Boudreau, Calvache, Chevychelov, Chupin, de Vivo, Dixon, Esser, Halter, Harms, Kent, Kholodnov, Mangas, Mitchell, Naumov, Panina, Raia, Schiano, Tolstykh, Trieloff, Tsaryeva, Villa, Webster, Williamson, Witter, Yamaguchi
Clinopyroxene—Eiler
Cordierite—Cesare
Cs—Kovalenko, Seltmann, Webster
Dolomite—Mountjoy
F—Borrok, Boudreau, Breiter, Calvache, Harms, Kholodnov, Kovalenko, Kuzmin, Naumov, Panina, Raia, Ronde, Seltmann, Sharygin, Tsaryeva, Webster, Witter, Zhou
Fe—Dixon, Williamson
Garnet—Cesare, Tomilenko
Gases—Barashkov, Bratus', Dixon, Fulignati, Golovin, Huraiová, Konnikov, Kuzmin, Naumov, Panina, Tomilenko, Villa, Zinchuk
General—Ahamdach, Andreeva, Belkin, Breiter, Capasso, Chabiron, Chupin, Danyushevsky, Della-Pasqua, de Vivo, Dietrich, Frezzotti, Kent, Kuzmin, Litasov, Malíkova, Naumov, Nikogosian, Panina, Schiano, Sharygin, Taylor, Tolstykh, Tsaryeva, Veksler H—Kent, Konnikov, Odling
HC—Kasimova, Potter, Tomilenko, Wlodyka
Hf—Kovalenko
Higher hydrocarbons—Bratus'
H_2O—Belkin, Calvache, Eiler, Kent, Sharygin, Student, Tomilenko, Webster
H_2S—Fulignati, Han
I—Kholodnov
K—de Ronde, Dong, Esser, Trieloff, Villa, Yamaguchi
La—Naumov
Li—Belkin, Breiter, de Vivo, Kent, Kovalenko, Naumov, Seltmann, Webster
Methane—Berdnikov, Bratus', Konnerup-Madsen, Konnikov, Potter, Stachel, Tomilenko
Mn—Dong, Williamson
Mo—Chevychelov
N_2—Cartigny, de Ronde, Golovin, Panina, Sharygin, Tomilenko
Na—de Ronde, Villa
Nb—Garrido, Naumov, Seltmann, Webster
NH_4—de Ronde
Noble gases—Dixon
P—Breiter, Webster
Pb—Chevychelov
Po—Seltmann
Rb—Breiter, Dietrich, Eiler, Garrido, Kovalenko, Seltmann, Webster
REE—Belkin, de Vivo, Eiler, Fleet, Kovalenko, Seltmann, Titov
S—Dixon, Kent, Mangas, Naumov, Tsaryeva, Williamson, Witter, Yamaguchi
Sillimanite—Cesare
Sn—Kovalenko, Seltmann, Webster, Williamson
SO_2—Harms, Raia
SO_3—Belkin, de Vivo, Panina
Spinel—Cesare
Sr—Belkin, de Ronde, de Vivo, Dietrich, Eiler, Kovalenko, Naumov
Ta—Dietrich, Garrido, Seltmann, Webster
Th—Belkin, de Vivo, Garrido, Kovalenko
Ti—Moine
U—Chabiron, Garrido, Kovalenko
W—Chevychelov, Webster
Y—Belkin, de Vivo, Naumov
Zircon—Chupin
Zn—Chevychelov
Zr—Belkin, de Vivo, Dietrich, Eiler, Kovalenko, Moine, Naumov
Analysis, methods
Atomic absorption spectrometry. *See* Inductively coupled plasma—Belkin
Atomic emission spectroscopy—Dubessy, Reyf
Capillary electrophoresis
Capillary ion analysis (CIA)—Hallbauer
Cathodoluminescence—Cole, Sun, Toth, Watt, Wilkinson
Confocal scanning laser microscope—Macleod, Pironon
Crushing procedures (for opening and for gas pressure)—Boiron, Bonev, de Ronde, Lu, Marignac, Miller, Norman, Salvi, Tritlla, Villa, Yao
Decrepitate analysis—Chi, Foley, Kontak, Palmer
CRYO-SEM-EDS—Fanlo, Shepherd, Tritlla, Veigas
Diamond anvil cell—Schmidt
Electron microprobe—Armstrong, En-Naciri, Fan, Philippot
Electron paramagnetic resonance (EPR)—Russell, Xu
Fourier transform infrared spectroscopy (FT-IR)—Arcos, Banerjee, Beran, Cathelineau, Kagi, Koss, Li, Libowitzky, Pironon, Thomas, Xie, Yamagishi, Zhang, Zink
Gas chromatography-ion chromatography (GC-IC)—Ozgür, Richards, Salvi, Sasaki, Sushchevskaya, Xie
Gas chromatography-mass spectrometry (GC-MS)—Baranov, Bratus', Richards, Smith, Xie,
1H MAS NMR (1H Magic-angle-spinning nuclear magnetic resonance spectrometry)
Inductivity coupled plasma-emission spectroscopy—Ozgür
Inductively coupled plasma-mass spectrometry (ICP-MS)—Ozgür
Infrared laser MS
Infrared microscopy—Arribas, Xie,
Ion chromatography (IC)—Channer, Dobes, Richards, Savoye, Viets
Ion microprobe (SIMS) (SHRIMP)—Armstrong, Belkin, Eiler, Harms, Li, Odling, Rapien, Stachel
Ion specific electrode—Nikogosian, Ozgür, Rapien, Shimizu, Watt
Laser ablation microprobe-Inductively coupled plasma-Mass spectrometry (L-ICP-MS, LA-ICP-MS, LAM-ICP-MS, or LAMP-ICPM-MS)—Alëshin, Anderson, Audétat, Boiron, Cabri, Günther, Hayashi, Ishiyama, Li, Schafer, Shepherd, Sylvester, Taylor
Laser ablation stable isotope ratio micro-analysis system (LASIRMAS)—Dubessy, Palin
Laser ablation optical emission spectrography (LA OES)—Moissette
Laser Raman spectroscopy (LRS) Only special applications—Anderson, Bondarenko, Chazallon, Dong, Dubessy, Han, Hänni, Knoll, Li, Mathieu,

  Ronchi, Savary, Schmidt-Mumm, Silva, Tomilenko, Tritlla, Xie
  Leaching—Boiron, Cathelineau, Essarraj, Lu, Marignac, Shepherd, Villa
  Luminescence microspectography—Dobes, Eadington, George, Jarmolowicz, Li, Rizzi, Stasiuk, Toth, Xie, Zhang
  Mass spectrometry—Barker, Bratus', Giuliani, Miller, Sawaki, Zimmermann
  Microextraction chemical analysis (MECA)—Shepherd
  Neutron activation (INNA, for instrumental neutron activation analysis and RNNA for radionuclide neutron activation analysis)—Damarupurshad
  Proton (and deuteron) induced X-ray emission (PIXE)—Anderson, Armstrong, Dong, Khin, Kontak, Ryan, Shepherd, Volfinger, Wogelius
  Synchrotron IR microspectrometry—Guilhaumou, Maeda
  Synchrotron x-ray absorption fine structure (XAFS)—Mayanovic
  Synchrotron X-ray fluorescence (SXRF)—Anderson, Bodnar, Maeda, Ménez
  X-ray fluorescence (XRF, XAFS, and X-ray CT)—Anderson, Mayanovic, Nakajima, Nakashima, Sturchio

Books, journal volumes, symposia. *See also* Reviews—Barnes, Mél'nikova, Papunen, Roedder, Taylor

Boreholes and dredging (sea)—Appel, Gamo, Haak, Kamenetsky, Kovalevich

Boreholes (land). *See also* Geothermal—Cathelineau, Dobes, Durisova, Grawinkel, Johnson, Kanev, Komninou, Lodemann, Matveev, McConnell, Moeller, Ohtani, Pagel, René Sawaki, Smith, Smithson

Brines-sedimentary and igneous rocks—Appel, Boullier, Chi, Fritz, Harlov, Hill, Leslie, Moles, René, Wilkinson, Wright

Complexes, metal-inorganic, metal-organic, stability, solubility—Anderson, Baranova, Bortnikov, Chen, He, Cameron, Cheng, DeSchutter, Essarraj, Fein, Freitas-Silva, Frietsch, Gammons, Ghazban, Kovalenker, Krylóva, Kucha, Mayanovic, McLeod, Ozgür, Shock, Souza Neto, Sverjensky, Tauson, Tornos, Wang, Walther, Webster, Wood, Xie, Yang, Yao,

Computer programs, development and use, modeling. *See also* Modeling—Alëshin, Bakker, Blencoe, Darrozes, Knupp, Kontak, Ryzhenko, Sharygin, Tutubalin, Williams, Zhang

Daughter minerals in <u>aqueous</u> (non-melt) inclusions and their significance. Includes phases developed below room temperature. May include some trapped solids.—Lindenmayer, Liu, Reyes, Rhodes, Willard
  Albite—Darling
  Andradite—Sokolov
  Anhydrite—Cepedal, Dong, Meinert, Pintea, Sheets
  Baddelyite—Williams-Jones
  Barite—Liu, Williams-Jones
  Bastnaesite—Williams-Jones
  Bitumen—Liu
  $CaCl_2$—Lindenmayer
  Calcite—Anderson, Cepedal, Liu, Rotherham, Sokolov
  Ca chloride—Bachiller
  Carbonate—Lindenmayer, Yao
  Celestite—Williams-Jones
  Chalcopyrite—Chen, Maeda, Meinert, Pintea, Willard, Xu
  Chlorides—Sheets, Pintea, Williams
  Cristobalite—Darling
  Diaspore—Bolder-Schrijver, Peretti
  Diopside—Sokolov
  FeCl—Anderson, Bachiller, Pakhmora, Reyf
  $FeCl_2$—Kodera
  Fe-Mn-Cl–Dong, Williams
  Ferropyrosmalite–Dong, Fluorite—Sokolov, Williams-Jones
  Galena—Williams-Jones
  Goyazite—Williams-Jones
  Graphite—Silva
  Gypsum—Liu, Maeda, Panigrahi, Samson, Williams-Jones
  Halite—(many not listed) Anderson, Bachiller, Cepedal, En-Naciri, Liu, Maeda, Meinert, Pintea, Willard, Williams
  Hematite—Lindenmayer, Maeda, Meinert, Pakhomova, Pintea, Sheets, Willard
  Hydrohalite—Hill
  Iron chloride—Pakhomova
  Jamesonite—Anderson
  K chlorides—Bachiller
  K-Fe-Cl—Pintea
  K-Pb chlorides—Dong
  Magnesite—Bolder-Schrijver
  Magnetite—Pintea, Rotherham, Sokolov
  Melilite—Sokolov
  Mirabilite—Williams-Jones
  Mn-Cl—Pintea, Reyf
  Monticellite—Sokolov
  Nahcolite—Bolder-Schrijver, Ridley
  Nordensködine—Volfinger
  Opaque—Maeda, Willard
  Pb-Cl—Pintea
  Pb-K–Williams
  Pb-K-Cl—Williams
  Phlogopite—Sokolov
  Polyhalite—Volfinger
  Portlandite—Sokolov
  Prosopite—Williams-Jones
  Pyrite–Liu, Pintea
  Quartz—Williams-Jones
  Sillimanite—Bolder-Schrijver
  Sphalerite—Liu
  Sulfide—Cepedal
  Sylvite—Anderson, Bachiller, Cepedal, En-Naciri, Kodera, Kontak, Lindenmayer, Maeda, Meinert, Pintea, Reyf, Williams
  Wavellite—Anderson
  Zircon—Williams-Jones
  Zn-Cl—Pintea

Daughter minerals in <u>melt</u> (non-aqueous) inclusions and their significance. Includes phases developed below room temperature. May include some trapped solids
  Albite—Williamson
  Alkaline amphibole—Andreva
  Al-spinel—Tsaryeva
  Amphibole—Schiano, Veksler
  Anhydrite—Andreeva
  Apatite—Andreeva, Raia, Saal, Veksler
  Ba-rich carbonate—Mitchell
  Barite-celestite—Andreeva
  Biotite—Saal, Sobolev
  Calcite—Andreeva, Fulignati, Veksler
  Cancrinite—Fulignati

  - Clinopyroxene—de Vivo, Nikogosian, Schiano, Shimizu, Tsaryeva
  - Cristobalite—Darling
  - Cu-S—Kogarko
  - Diopside—Andreeva, Melcher
  - Dolomite—Veksler
  - Enstatite—Melcher
  - Fe—Kogarko
  - Fe-Cu sulphides—Veksler
  - Fe-oxides—Fulignati
  - Ferroball—Liu
  - Fluorite—Chabiron, Fulignati
  - Forsterite—Melcher
  - Gregoryite—Mitchell
  - Halite—Fulignati
  - Ice—Kagi
  - Ilmenite—Saal
  - Kaersutite—Saal
  - K-feldspar—Williamson
  - K-Na feldspar—Andreeva
  - Magnetite—Andreeva, Veksler
  - Mg carbonate—Schiano
  - Muscovite—Erokhin
  - Na-Ca carbonates—Veksler
  - Nahcolite—Samson
  - Na-Phlogopite—Melcher
  - Ni—Kogarko
  - Nyerereite—Mitchell
  - Olivine—Kuzmin, Tsaryeva
  - Oxide—de Vivo, Raia
  - Pargasitic amphibole—Melcher
  - Parisite—Chabiron
  - Phlogopite—Andreeva, Sobolev, Veksler
  - Polylithionite—Chabiron
  - Potassium neighborite—Mitchell
  - Pyrite—Fulignati
  - Pyrrhotite—Andreeva, Williamson
  - Rhönite—Kuzmin
  - Rutile—Schiano
  - Scapolite—Fulignati
  - $SnCl_2$—Williamson
  - Sodalite—Andreeva
  - Sodian sylvite—Mitchell
  - Sphene—Saal
  - Spinel—Della-Pasqua, Saal
  - Stannite—Williamson
  - Sulphide—Tsaryeva
  - Sulphide globules—Saal
  - Sylvite—Fulignati
  - Ti-augite—Kuzmin, Saal
  - Varlamoffite—Williamson
  - Zinnwaldite—Chabiron

- **Diffusion**—Abart, Arcos, Bickle, Brown, Cartwright, Darling, Freda, Guilhaumou, Harms, Hussain, Kent, Matsumoto, Renard, Shimizu, Thomas, Webber, Williams
- **Equilibrium COH speciation**—Barker, Barrenechea, Gibert, Guedes, Matveev
- **Equipment for extraction, freezing, heating, crushing, etc.**—Pironon
- **Experimental systems.** *See also* Fluids, physical and thermodynamic properties; Gases in inclusions; Complexes
  - Aqueous-gas—Akinfiev, Anovitz, Blencoe, Frost, Holness, Matveev, Murphy, Schiano, Seitz, Smelik, Suleimenov, Tagirov, Teng, Zhang
  - Aqueous-metal—Anderson, Baranova, Gammons, Malinin, Shock, Sverjensky, Tauson
  - Aqueous-salt(s)—Aranovich, Berndt, Bondarenko, DuBois, Hu, Schmidt, Shibue, Thiery, Usdowski, Verma, Zhang
  - Aqueous-silicate (and other volatiles)—Aksyuk, Dingwell, Noto, Rimstidt, Schreyer, Zimmermann
  - Other—Bondarenko, Fleet, Halas, Icenhower, Kerkhof, Stalder, Veksler, Walther, Webster
  - Rocks—Chevychelov, Holl, Icenhower, Kawamoto, Kogiso, Lee, Lyakhovsky, Schmidt, Sonin, Tatsumi, Webster
- **Exploration, use of inclusions in, ore deposits, petroleum**—Asensio, Bouabdellah, Chen, Crummy, de Groot, Eadington, Gao, Guo, Kang, Kilias, Klemd, Kozlowski, Li, Liu, Macleod, Mernagh, Moran, Ou, Pinho, Reyes, Roedder, Russell, Samson, Shi, Smith, Suchy, Taberner, Takagi, Toupin, Voznyak, Wang, Warren, Wilkins, Willard, Williams, Wu, Xiong, Xu, Yajima, Zeigler, Zhou
- **Fluids and gases, equations of state**—Akinfiev, Amend, Blencoe, Frost, Malinin, Schiano, Seitz, Thiery, Zhang
- **Fluids and gases, physical and thermodynamic properties**—Akinfiev, Amend, Anderson, Anovitz, Aranovich, Bakker, Barker, Blencoe, Duan, Fritz, Hu, Larrieu, Levelt Sengers, MacLeod, Pokrovskii, Ryzhenko, Schmidt, Seitz, Shibue, Shmulovich, Shock, Suleimenov, Sverjensky, Tagirov, Thiery, Tomilenko, Valyashko, Walther, Williams, Zhang
- **Fluid flow.** *See also* Origin, cracking of rocks—Andre, Ayt Ougougdal, Baranov, Bickle, Candela, Capasso, Conrad, Cox, Craw, Garcia, Grobe, Guo, Hayba, Ilchik, Jamtveit, Janssen, Kesler, Kesler, Lespinasse, Liu, Losh, Lowry, Macaulay, Mongelli, Mountjoy, Muchez, Nesbitt, Newell, Nivlet, Nogueira, Ohtani, O'Reilly, Parente, Parnell, Pettke, Pitman, Ramboz, Rizzi, Sakaguchi, Sausse, Savary, Savoye, Tutubalin, Vallance, Worden, Yao, Zeeh, Zhang, Zhou
- **Gas hydrates**—Bakker, Chazallon, Murphy, Smelik, Török
- **Gases and fluids, mantle, deep seated.** *See also* Inclusions in diamonds; Kimberlites; Xenoliths; Helium—Aranovich, Bebout, Boudreau, Burnard, Carpenter, Cartigny, Chazot, D'Alessandro, Danyushevsky, Draper, Durisová, Frezzotti, Fyfe, Hawkesworth, Hirschmann, Honda, Kennedy, Kogarko, Markl, Marty, Matsumoto, Matveev, Moreira, Nishio, Odling, Rampone, Rao, Rehkämper, Sasada, Scambelluri, Simakov, Smit, Sobolev, Sonin, Stachel, Stevens, Tatsumi, Tomilenko, Trieloff, Varela, Wiechert, Wu, Yamamoto, Zheng
- **Gases (volatiles) in igneous rocks, magmas, and volcanism.** *See also* Analysis, data, gases—Allard, Baranov, Belkin, Burnard, Calvache, Capasso, D'Alessandro, Danyushevsky, Demény, Dixon, Freda, Harms, Jendrzejewski, Larsen, Miller, Nabelek, Naumov, Navon, Papale, Pearson, Rapien, Reyes, Roggensack, Sawaki, Seltmann, Stachel, Stevens, Takagi, Tedesco, Thomas, Tomilenko, Webster, Yamaguchi
- **Geothermal fluids and systems, active and fossil.** *See also* Mineral deposits, Epithermal; Dredge samples—Barragan, Bolognesi, Bortnikov, Candela, Capasso, Channer, Christenson, Conrad, Cox, Cunningham, Craw, Dai, de Ronde, Etoh, Foley, Gamo, González Hayashi, Izquierdo, Jean-Baptiste, Johnson, Knupp, Lewis, Liu, Lodemann, Lott, Lüders, Lutz, Manac, Matveev, McConnell, Michallidis, Mongelli, Moore, Muramatsu, Norman, Noto, Ohtani, Ozgür, Partida, Ren, Reyes, Ruggieri, Sasaki, Sawaki,

Simmons, Takagi, Tecce, Verma, Villa, Voltaggio, Von Damm, Williams, Xiong

Geothermometry
  Decrepitation data—Li, René, Wlodyka
  Decrepitation theory, methods, and comparison with other methods—Li, Suchy
  Freezing data, interpretation (gases or liquids)—Bakker, Bortnikov, Lidwin, Murphy, Smelik, Tomilenko
  Homogenization, aqueous ≥ 500°C—Andersen, Arribas, Blake, Borrok, Brauer, Calagari, Chen, Christenson, Dong, Ellis, Ferkous, Fuertes-Fuente, Hébert, Hedenquist, Henry, Hurai, Kashima, Kodera, Konnerup-Madsen, Lang, Levasseur, Markl, Matviyenko, Meinert, Mutemeri, Niu, O'Reilly, Pakhomova, Poritskiy, Potter, Rhodes, Rotherham, Ruggieri, Sheets, Thomas, Velíchkin, Williams, Williamson, Zhao
  Homogenization method, accuracy, comparison with other methods, and factors affecting—Frimmel, Hasenberger, Henry, Kalyuzhnyi, Kovalevich, Liu, Pagel, Paniagua, Pottorf, Verma, Zhang
Immiscibility. *See also* Experimental systems; Gases in igneous rocks, magmas, and volcanism; Vesiculation
  Aqueous liquid-CO_2—Blencoe
  Aqueous liquid-vapor (boiling, condensation), (too many entries to list). *See also* Geothermal
  Silicate-carbonate—Frezzotti, Kogarko, Lee, Mitchell, Nielsen, Nikogosian, Saal, Veksler
  Silicate-saline melt—Chang
  Silicate-silicate—Andreeva, Hurai
  Silicate-steam—Shen
  Other types—Hurai, Kogarko, Liu, Mitchell, Rhodes, Zinchuk
Inclusions, aqueous (non-melt), in host minerals, and discussion (includes oil and gases in non-igneous materials)
  Adularia—Ohtani
  Ag—Borisenko
  Alexandrite—Marcos-Pascual
  Alkali feldspars—Kawakami
  Alunite—Cunningham, Voudouris
  Anhydrite—Charef, Crowley, Green, Izquierdo, Lu, Meinert, Muramatsu, Ohtani, Peryt, Sawaki, Tecce
  Ankerite—Dobes, Durisova, Kling, Zhong
  Apatite—Durisova, Rhodes, Sachan, Sasada
  As—Anderson, Borisenko
  Axinite—Durisova
  Barite—Charef, Chen, Chi, Crowley, Dill, Dobes, Dubois, Durisova, Everett, Kesler, Kilias, Kling, Lawrie, Lüders, Moles, Parilov, Polliand, Sierra, Steele, Sushchevskaya, Voudouris, Zhang
  Bastnaesite—Niu, Samson, Williams-Jones
  Bertrandite—Markl
  Beryl—Banko, Bushev, Liu, Markl, Schmetzer, Zimmermann, Zwaan
  Calcite—Sasada
  Carbonate—Sushchevskaya
  Cassiterite—Gomez, Haapala, Wang, Velíchkin
  Cesanite—Tecce
  Cl—Anderson
  Clinopyroxene—Edraki, Sachan
  Cordierite—Rajesh, Tomilenko
  Corundum—Frost, Hughes, Li, Peretti, Smith, Wang
  Danalite—Velíchkin
  Diopside—Rhodes, Sasada
  Dolomite—Bouabdellah, Dobes, Duggan, Durisova, Everett, Ghazban, Green, Grobe, Leach, Messelles, Moles, Mountjoy, Newell, Parente, Rizzi, Singh, Smith, White, Yao
  Dravite—Bushev
  Emerald—Marcos-Pascual
  Epidote—Ayshford, Izquierdo, Petko
  Fe—Anderson, Borisenko, Kontak
  Fe sulfides—Viets
  Fluocerite—Velíchkin
  Fluorite—Alëshin, Borisenko, Borrok, Brannon, Dobes, Durisova, Gomez, Günther, Kesler, Koss, Kozlowski, Liu, Melchor, Morales-Ruano, Paniagua, Pauly, Solovóva,Souissi, Velíchkin, Williams-Jones, Yamamoto, Yao, Zhang
  Forsterite—Sasada
  Galena—Bonev, Leach, Viets
  Garnet—Bell, Bin, Bolder-Schrijver, Darling, Durisova, Edraki, Henry, Kaindl, Kodera, Liou, Rao, Tomilenko, Zhao
  Gases—Smith
  Gemstones—Hänni
  Gorgeyite—Tecce
  Graphite—Barrenechea
  Gypsum—Bortnikov, Lu
  Halite—Charef, Fanlo, Galamay, Grishina, Khmelevska, Koehler, Kovalevich, Peryt, Petrichenko, Roberts, Shaidetska, Shepherd, Taberner, Veigas
  Hibonite—Gübelin
  Hübnerite—Gomez
  Ice—Chazallon, Legrand
  Kyanite—Kaindl
  Laumontite—Ruggieri
  Magnesite—Singh
  Melilite—Nielsen
  Mesoperthite—Durisova
  Monticellite—Sasada
  Niocalite—Sokolov
  Olivine—Boullier
  Orthopyroxene—Török
  Perovskite—Sasada
  Phenakite—Marcos-Pascual, Markl
  Plagioclase—Henry, Tomilenko. Török
  Potassium feldspar—Gomez
  Pyrite—Thomas
  Pyroxene—Meinert, Zhao
  REE—Moine
  Rhodochrosite—Knox
  Sapphires—Gübelin
  Scapolite—Frietsch, Rebbert
  Scheelite—Baksheev, Durisova, Kilias, Kozlowski, O'Reilly
  Sellaite—Velíchkin
  Siderite—Kling, Pauly, Prochaska, Rezaee, Schandl
  Sillimanite—Durisova, Tomilenko
  Sphalerite—Bonev, Chi, Duggan, Durisova, Everett, Foley, Giles, Grobe, Hill, Ishiyama, Kesler, Kilias, Kodera, Kozlowski, Leach, Liu, Lüders, Mulshaw, Parente, Sushchevskaya, Simmons, Smith, Viets, Yao, Zhang
  Staurolite—Bell
  Sulfide—Dobes
  Sylvite—Grishina, Prohl
  Topaz—Bushev, Chang, Chen, Haapala, Holzhey, Velíchkin, Zhou
  Tourmaline—Gomez, Török
  Tridymite—Krylova
  Wairakite—Noto, Sawaki
  Wolframite—Liu

Wollastonite—Zák
Zeolite—Bargar
Inclusions, melt, sulfide melt in host minerals, and discussion. *See also* Silicate melt inclusions
Aegirine-augite—Niu
Alexandrite—Smirnov
Alkali feldspar—Sobolev, Wu
Amphibole—Matsumoto, Trieloff
Analcime—Wlodyka
Anorthoclase—Esser
Apatite—Ahamdach, Andreeva, Bernikov, Chupin, Kerkhof, Kontak, Li, Marty, Matsumoto, Panina, Sharygin, Veksler, Zinchuk
Beryl—Smirnov
Chromite—Melcher, Schiano, Shimizu
Chrysoberyl—Smirnov
Clinopyroxene—Belkin, Carpenter, Della-Pasqua, de Vivo, Golovin, Huraiová, Litasov, Rapien, Stachel, Portnyagin, Raia, Saal, Wu, Yamaguchi
Coesite—Han
Cordierite—Kerkhof, Kontak
Corundum—Henn, Peretti, Smirnov, Wang
Cr-spinel—Carpenter, Shimizu
Diamond—Barashkov, Bratus', Damarupurshad, Deines, Gorshkov, Kagi, Kasimova, Liu, Meyer, Novgorodov, Ogasawara, Simakov, Sobolev, Sonin, Stachel, Stalder, Tomilenko, Cartigny, Wyllie, Zheng
Diopside—Guilhaumou, Hòa, Marianelli, Navon, Sharygin, Veksler
Dolomite—Veksler
Emerald—Smirnov
Enstatite—Wu
Feldspar—Breiter, Chupin
Fluorite—Niu
Forsterite—Veksler
Garnet—Cepedal, Chupin, Darling, Henry, Kasimova, Stachel, Tomilenko, Zinchuk
Hauyne—Harms
Hornblende—Huraiová
Ilmenite—Navon
K-feldspar—Huraiová
Kyanite—Han
Leucite—Belkin, de Vivo, Sharygin
Magnetite—Navon
Melilite—Nielsen
Monazite—Chupin
Olivine—Allard, Belkin, Danyushevsky, Della-Pasqua, de Vivo, Eiler, Garrido, Guilhaumou, Gurenko, Hòa, Johnson, Kamenetsky, Kasimova, Kent, Kogarko, Kozlowski, Kuzmin, Litasov, Mangas, Matsumoto, Naumov, Nikogosian, Odling, Panina, Portnyagin, Rampone, Saal, Sharygin, Stachel, Tsaryeva, Tolstykh, Tomilenko, Trieloff, Wu, Yamaguchi, Zinchuk
Omphacite—Han
Orthopyroxene—Golovin, Kerkhof, Rapien, Stachel, Trieloff, Tolstykh, Yamaguchi, Yaxley
Pegmatite—Li
Periclase—Tomilenko
Perovskite—Nielsen
Phlogopite—Hòa, Navon, Sharygin
Plagioclase—Belkin, Berdnikov, Calvache, Danyushevsky, de Vivo, Henry, Huraiová, Kerkhof, Kuzmin, Naumov, Panina, Rapien, Titov, Tolstykh, Wu, Yamaguchi
Pyroxene—Cepedal, Kuzmin, Marianelli, Naumov, Panina, Trieloff, Zinchuk
REE—Taylor
Salite—Marianelli
Sanidine—Fulignati, Sharygin
Spinel—Smirnov, Wu
Ti-augite—Golovin
Topaz—Breiter, Chang, Chen, Haapala, Kovalenko, Seltmann, Solovóva, Webster, Williamson, Zhou
Tourmaline—Gomez
Zircon—Chupin, Gilliam, Hartmann, Li
Inclusions in rocks. *See also* appropriate minerals
Alkaline—Andreeva, Dingwell, Dixon, Kogarko, Lee, Nielsen, Nikogosian
Amphibolite—Lidwin
Andesite—Calvache, Maaløe, Rapien, Rhodes, Tolstykh
Ankaramite—Della-Pasqua, Tolstykh
Anorthosite—Berdnikov
Basalt. *See also* MORB, tholeiite—Allard, Burnard, Dixon, Hirschmann, Kogiso, Kuzmin, Manac, Marty, Matsumoto, Melcher, Moreira, Neumann, Nishio, Odling, Panina, Schiano, Tolstykh, Webster, Wu, Yamamoto, Zinchuk
Basanite—Golovin, Litasov
Boninite—Danyushevsky
Carbonatite—Andreeva, Kogarko, Lee, Meier, Nielsen, Palmer, Sasada, Sokolov, Wyllie
Charnockite—Fossum, Kerkhof, Rajesh, Shen
Cinerite—Ahamdach
Dacite—Cesare, Danyushevsky, Dietrich, Panina, Rapien
Diorite—Brauer, Christenson, Pearson, Rapien, Reyes, Ryzhenko, Titov, Witter
Eclogite—Adam, Azimov, Bin, Chupin, Deines, Han, Melcher, Sachan, Scambelluri, Simakov, Tomilenko, Lidwin
Evaporite—Arcos, Banks, Boullier, Bouzenoune, Cendón, Crowley, Dudok, Fanlo, Galamay, Jenkin, Koehler, Kovalevich, Leslie, Lu, Moles, Peryt, Petrichenko, Prohl, Roberts, Shaidetska, Shepherd, Siemann, Taberner, Tritlla, Veigas, Viets, Warren
Gabbro—Berdnikov, Harlov, Konnikov, Ryzhenko
Granite—Arcos, Ayt Ougougdal, Bachiller, Berdnikov, Brauer, Brieter, Candela, Cao, Cathelineau, Chen, Decitre, Dingwell, Edraki, Garcia, Glebovitsky, Giuliani, Gomez, Guerci, Guha, Günther, Haapala, Halter, Henry, Jang, Jenkin, Kontak, Kovalenko, London, Lowry, Markl, Marshall, Menuge, Moran, Nabelek, Nanbu, Ohtani, O'Reilly, Panigrahi, Patrier, Poty, Prokof'ev, Quílez, Recio, Reyf, Rub, Salvi, Sasaki, Sato, Savary, Savoye, Sawaki, Schafer, Schmidt, Seltmann, Shepherd, Shibue, Shnip, Sobolev, Solovóva, Srikantappa, Stemprok, Stevens, Student, Takagi, Thomas, Titov, Vallance, Vapnik, Velíchkin, Webster, Williamson, Yao, Zhou
Granulite—Andersen, Anderson, Berdnikov, Bhowmik, Bin, Bolder-Schrijver, Darling, Eichhorn, Fossum, Gibert, Harlov, Kashima, Lidwin, Liu, Markl, Moine, Pili, Rajesh, Rao, Shen, Stevens, Tomilenko, Török
Greisens—Arcos, Borisenko, Giuliani, Halter, Kontak, Malyshev, Markl, O'Reilly, Velíchkin, Williamson
Harzburgite—Danyushevsky, Draper, Eiler, Kogarko, Kozlov, Melcher, Schiano, Stachel, Tomilenko, Yao, Yaxley
Kimberlite—Deines, Panina, Sobolev, Tomilenko
Komatiite—Appel, Della-Pasqua, Shimizu
Lamproite—Hòa, Panina, Pettke, Sharygin

Lamprophyre—Demény
Lherzolite—Chazot, Della-Pasqua, Draper, Eiler, Golovin, Hirschmann, Kogarko, Matsumoto, Schiano, Stachel, Tomilenko, Wu, Yaxley
Melilitolite—Kozlowski, Nielsen
Metamorphic, contact—Ortega, Sasaki
Metamorphic, low/medium grade—Arvanitidis, Bickle, Evans, Guedes, Hill, Ixer, Kozlowski, Küster, Lee, Zák, Zhang
Metamorphic, medium/high—Andersen, Azimov, Baker, Bin, Castleberry, Chi, Dasgupta, de Ronde, Dinter, Durisova, Fossum, Giesecke, Green, Han, Harlov, Hébert, Henry, Hurai, Kaindl, Kashima, Konnerup-Madsen, Lamb, Lidwin, Martin, Philippot, Pili, Schreyer, Selverstone, Shen, Smithson, Srikantappa, Tomilenko, van der Klauw, Wang, Xu
Metamorphic P-T paths—Andersen, Bhowmik, Bin, Bodnar, Bolder-Schrijver, Durisova, Evans, Fossum, Guha, Henry, Lamb, Liou, Lu, Marshall, Mullis, Rantitsch, Rao, Sachan, Stevens, van der Klauw, Wawrzyniec, Xu
Meteorite, tektite, impactite, lunar. *See also* Inclusions in rocks, Meteorites—Beran
Migmatite—Shen, Srikantappa, Wang
MORB—Burnard, Eiler, Fisher, Honda, Jendrzejewski, Kent, Kogiso, Matsumoto, Moreira
Ongonite—Kovalenko
Ophiolite—Melcher, Petko, Pettke, Portnyagin, Rampone, Schiano
Pegmatite—Anderson, Boiron, Bushev, Chalokwu, Decitre, Fuertes-Fuente, Giuliani, Kontak, Kovalenko, Kozlov, Larsen, Levasseur, Lozano, Li, Lu, Markl, Matviyenko, Nanbu, Rajesh, Rampone, Salvi, Sawaki, Shepherd, Sirbescu, Webber, Webster, Zhou
Peridotite—Adam, Boullier, Chazot, Deines, Draper, Eiler, Franz, Frezzotti, Garrido, Hirschmann, Kawamoto, Konnikov, Neumann, Odling, Rehkämper, Saal, Scambelluri, Stachel, Trieloff, Wiechert
Picrite—Della-Pasqua
Phonolite—Andreeva, Eiler, Panina
Pyroxenite—Golovin
Rhyolite—Chabiron, Dietrich, Jenkin, Lyakhovsky, Navon, Panina, Rub, Taylor, Webster, Wu
Sedimentary, authigenic, diagenetic, cements, overgrowths, basins—Alderton, Awwiller, Ayt Ougougdal, Baranov, Barker, Baskin, Bilal, Bjørlykke, Bodnar, Boni, Bouabdellah, Bouzenoune, Boyce, Carignan, Cathelineau, Cesaretti, Chi, Coetzee, Crowley, Dobes, Dominy, Dudok, Duggan, Dunne, Elliott, Essarraj, Everett, Fanlo, Franks, Frimmel, Ghazban, Gleeson, Guo, Hall, Huang, Jarmolowicz, Jenkin, Juhász-Bodnár, Kesler, Kesler, Kirste, Koehler, Kovalevich, Krieger, Kyle, Leach, Lewis, Li, Liu, Macleod, Malíkova, Marfil, Messelles, Morales-Ruano, Moritz, Mountjoy, Muchez, Mukherjee, Newell, Parnell, Patrier, Pearson, Peryt, Pinti, Pitman, Prochaska, Ramseyer, Ren, Rizzi, Rodger, Samuelsson, Selleck, Shen, Shikazono, Solomon, Sotak, Suchy, Taberner, Tobin, Toth, Toupin, Viets, Wang, Warren, White, Wilkinson, Williams, Worden, Wu, Xie, Yang, Yao, Yi, Zeigler, Zimmermann, Zhou
Speleotherms, vadose zone—Dublyansky, Newman
Syenite—Hodson, Meier, Patrier, Recio
Tholeiite—Appel, Dixon, Gurenko, Nikogosian
Trachyte—Kuzmin, Panina, Wu
Ultrabasic—Kogarko, Konnikov, Nielsen, Trieloff
Websterite—Golovin

Inclusions, inherited, melt or aqueous—Huff

Isotopes, data, fractionation, exchange, etc. (on inclusion fluids). *See also* Analysis data, noble gases.
  Argon—Burnard, Calagari, Esser, Fisher, Hu, Kent, Krol, Marty, Pettke, Philippot, Qin, Trieloff, Villa
  Boron—Gurenko
  Carbon—Billström, Nishio, Ozgür, Sackett
  Chlorine—Boudreau, Lodemann, Markl
  General principles, fractionation, exchange, analytical procedures, equilibria—Abart, Adabi, Cunningham, de Groot, Huner, Noto, Pettke, Rosenbaum, Sackett, Sheppard
  Helium—Allard, Burnard, Calagari, Fisher, Honda, Hu, Hussain, Kennedy, Nishio, Pettke, Tedesco, Yamamoto
  Hydrogen—Alderton, Berger, Billström, Bonev, Borrok, Calagari, Giuliani, Hurai, Kesler, Koehler, Kovalenker, Liu, Lusk, Nesbitt, Ozgür, Park, Recio, Thiersch, Wang, Xu, Yao, Zhang
  Lead—Pettke
  Neon—Burnard, Honda, Marty, Matsumoto
  Nitrogen—Bebout
  Noble gases—Burnard, Kozlov, Matsumoto, Moreira, Pinti, Sasada, Trieloff
  Oxygen—Alderton, Bonev, Borrok, Calagari, Jean-Baptiste, Kesler, Koehler, Kovalenker, Liu, Lusk, Noto, Ozgür, Park, Recio, Xu, Zhang
  Rubidium—Pettke
  Strontium—Pettke
  Sulfur—Gamo, Xu
  Xenon—Fisher

Magmatic differentiation—Freda

Mantle metasomatism—Adam, Appel, Fan, Frezzotti, Golovin, Kogiso, Stachel, Varela, Wiechert

Metastability—Arcos, Ayt Ougougdal, Cepedal, Darling, Kalyuzhnyi, Lyakhovsky, Murphy, Navon, Poole, Tecce, Török

Mineral deposits. *See also* Locality Index; Inclusions in minerals; Analysis, data, for appropriate elements.
  Antimony—Akçay, Baker, Baranova, Dill, Hu, Kucha, Lang, Lehmann, Leroy, Liang, Ortega, Ozgür, Paniagua, Polliand, Wagner, Wilkinson, Xiao, Zhuang
  Arsenic—Baker, Cioflica, Cooke, En-Naciri, Essarraj, Kucha, Lang, Lehmann, Leroy, Li, Lott, Paniagua, Tornos, Xiong, Yao
  Barite—Crowley, Michallidis, Mukherjee, Polliand, Souissi, Zhang
  Beryllium—Liu, Markl
  Bismuth—Baker, Fomin, Lang, Lasarenko, Leroy, Pinho, Velíchkin, Wagner, Wilkinson
  Chromite—Melcher, Schiano
  Cobalt—Dong, En-Naciri, Essarraj, Garcia Iglesias, Wood
  Copper—Asensio, Blake, Cepedal, Chang, Cioflica, Cooke, Dong, El Kazzaz, Frietsch, Garcia Iglesias, Háber, Haggerty, He, Holmgren, Jin, Kilias, Klohn, Kontak, Kostina, Leroy, Li, Lindenmayer, Liu, Meier, Meinert, Moles, Molnár, Norman, Ortega, Palmer, Panigrahi, Qiu, Rotherham, Ruggieri, Ryan, Sierra, So, Sun, Wagner, Wang, Williams, Wood, Xu, Ye, Zhao, Zhou, Zentilli
  Epithermal and hotspring—Alderton, Bodnar, Dobes, Durisova, Ebert, Gammons, Garcia Iglesias, Gatter, Háber, Hayba, Hedenquist, Koh, Kovalenker, Leroy,

Moles, Mulshaw, Norman, Paniagua, Parilov, Simmons, So, Thiersch, Voudouris, Xiao, Zhang
Fluorite—Alёshin, Arcos, Brannon, Menuge, Michallidis, Morales-Ruano, Samson, Souissi, Williams-Jones, Zhang
Gold (major entries)
  BIF—DeSchutter, Rotherham
  Carlin—Ilchik, Cameron, Cheng, Tüysüz, Yang
  Epithermal—Alderton, Arribas, Begg, Berbeleac, Bi, Boden, Camprubí, Cioflica, Cooke, Cox, Crummy, Cunningham, Demoustier, Etcheverry, Foley, Háber, Hedenquist, Henry, Ji, Kilias, Kovalenker, Lawrie, Lehmann, Leroy, Lockwood, Lutz, Norman, Ozgür, Paniagua, Richards, Ruggieri, Schalamuk, Sillitoe, Simmons, Thiersch, Tüysüz, Voudouris, Yajima, Zhang, Zhou
  Mesothermal—Askerova, Baker, Beurlen, Bi, Bortnikov, Boullier, Boyce, Cole, Frimmel, Gebre-Mariam, González, He, Hoa, Ixer, Ji, Klemd, Kontak, Kovalenker, Lang, Lockwood, Marshall, Oberthür, Ridley, So, Tornos, Wilkinson, Witt, Wood, Xia, Yao, Zacharias, Zhai, Zhang, Zhou, Zvágina
  Metamorphic—Berger, Blake, Brown, Cassidy, Chen, Cheng, Chupin, Cooper, Cox, El Kazzaz, Foley, Freitas-Silva, Frimmel, Goldfarb, González, Graupner, Ji, Kontak, Loizenbauer, Mapani, Mesquita, Moritz, Murphy, Mutemeri, Nie, Pettke, Pinho, Rotherham, Samson, Schmidt-Mumm, Shibetskiy, Silva, Thalhammer, Tornos, Wang, Witt, Xia, Xu, Yao, Zhong
  Porphyry—Begg, Berbeleac, Chen, Foley, González, Lawrie, Richards, Shinohara, Sillitoe, Spry
  Skarn—Arcos, Cepedal, Lang, Meinert, Souza Neto, Zhao, Zhou
  VHMS—Foley, Hunns, Schandl
  Includes unknown type—Arias, Baranova, Begg, Bengochea, Berbeleac, Beurlen, Billström, Borrok, Bortnikov, Chen, Cheng, Cole, Durisová, Essarraj, Feng, Ferkous, Fortes, Gao, He, Hu, Huang, Konnikov, Kucha, Jiang, Lasarenko, Li, Liang, Liu, Lott, Meinert, Molybdenite, Petersen, Poritskiy, Prokof'ev, Russell, Ryan, Schmidt-Mumm, Shi, Silva, Taylor, Vallance, Vavelidis, Voznyak, Wang, Wilkinson, Wu, Xu, Zhang, Zhou, Zhuang
Gold, lesser deposits, minor mention (geochemistry, etc.)—Bachiller, Baranova, Beurlen, Boiron, Cox, Crummy, Dobes, Dong, Durisova, Ebert, En-Naciri, Fomin, Frietsch, Gammons, Ghaderi, Hayashi, Klemd, Kucha, Marshall, Nogueira, Ortega, Palacios, Paniagua, Pirajno, Prokofyev, Tauson, Velíchkin
Graphite—Barrenechea
Iron (including siderite and BIF)—Ayshford, Blake, Bouzenoune, Channer, Foley, Fonarev, Frietsch, Kodera, Leroy, Maineri, Prochaska, Rhodes, Rotherham, Sheets
Kuroko—Lusk
Lead and lead-zinc—Arne, Baker, Bjørlykke, Bortnikov, Bouabdellah, Bouzenoune, Charef, Chi, Chu, Costagliola, Dobes, Dong, Everett, Giles, Gleeson, Haggerty, Hayba, He, Höller, Kozlowski, Kyle, Leach, Li, Liu, Lu, McCuaig, Moles, Morales-Ruano, Mulshaw, Pakhomova, Parilov, Pearson, Rantitsch, Rizzi, Rodger, Smith, Souissi, Tornos, Viets, Wagner, Williams, Xie, Xu, Yui, Zhang, Zhao, Zhou
Manganese—Marrescotti, Pearson, Xie
Massive sulfide, VHMS—Baranov, Bjørlykke, Chang, Foley, Goodfellow, Hunns, Khin, Konnerup-Madsen, Khin, Liu, Lusk, Moura, Naumov, Pinho, Schandl, Scott, Solomon, Sushchevskaya, Toscano, Vikentyev, Ye
Mercury—Akçay, Baker, Fein, Ozgür, Tritlla, Yajima
Mississippi Valley—Arcos, Arne, Bjørlykke, Boni, Bouabdellah, Bouzenoune, Carignan, Chi, Dubois, Grobe, Kozlowski, Leach, Lehmann, Liu, Moles, Morales-Ruano, Ramboz, Rantitsch, Rodger, Selleck, Slobodnik, Smith, Souissi, Sturchio, Viets, Zhou
Molybdenum—Alёshin, Baker, Chabiron, Jenkin, Kryl6va, Lang, Lott, O'Reilly, Ortega, Panigrahi, Quílez, Zhao
Nickel—Garcia Iglesias, Lott, Molnár
Niobium—Qiu
Platinum and PGE—Hauck, Konnikov, Lott, Melcher, Molnár, Rehkämper, Ukhanov
Polymetallic—Alёshin, Anderson, Baker, Boyce, Camprubí, Cao, Dobes, Fkihech, Foley, Fomin, Háber, Jenkin, Kovalenker, Kryl6va, Lang, Lavado, Leroy, Li, Liu, Lopez, Maineri, Melchor, Michallidis, Noronha, Ortega, Pakhomova, Parente, Polliand, Solomon, Souissi, Steele, Velíchkin, Wagner, Williams, Xie, Zacharias, Zhao
Porphyry Au—Cameron, Gammons, Háber, Spry, Xie
Porphyry copper (±Au)—Armstrong, Begg, Bodnar, Calagari, Chen, Cioflica, Cooke, Ellis, Hedenquist, Hezarkhani, Lawrie, Lehmann, Maeda, Pintea, So, Voudouris, Webster, Willard, Xu
Porphyry Cu and Mo (±Au)—Arribas, Calagari, Cioflica, Garrido, Maeda, Shinohara, Sillitoe, Webster
Porphyry Mo (Au)—Spry, Webster
Porphyry Sn—Chabiron, Chen, Dietrich
Potash—Cend6n, Grishina, Taberner
Pyrite *See also* Massive Sulfide—Baranov, Kostina, Toscano
Quartz—Arvanitidis, Crespo, Poty
Rare earth elements (REE)—Cao, Niu, Samson, Williams-Jones
Rare metal deposits (Soviet usage)—Brieter, Bushev, Chalokwu, Kovalenko, Levasseur, Lu, Seltmann, Solov6va
Selenium—Pinho
Sedex—Bjørlykke
Silver—Alderton, Boden, Bortnikov, Camprubí, Chen, Cioflica, Costagliola, Cunningham, Demoustier, Dong, Ebert, El Kazzaz, Essarraj, Etcheverry, Foley, Fomin, Giles, Hayba, Henry, Höller, Kyle, Lasarenko, Lehmann, Li, Lott, McCuaig, Melchor, Mulshaw, Norman, Pakhomova, Pinho, Polliand, Poritskiy, Rub, Ruggieri, Schalamuk, Steele, So, Thiersch, Tüysüz, Wilkinson, Williams, Xiao, Xie, Xu, Yao, Zhang, Zhao, Zhou
Skarn—Arcos, Ayshford, Calagari, Cepedal, Edraki, Gübelin, Háber, Kodera, Malyshev, Meinert, Melchor, Souza Neto, Velíchkin, Voinkov, Volfinger, Williams, Zhao, Zhou
Talc—Loth, Park
Tantalum—Qiu
Tellurium—Alderton, Begg, Cioflica, Fomin, Kovalenker, Lehmann, Poritskiy, Spry, Wilkinson, Zhang

  Thorium—Pauly
  Tin—Adabi, Baker, Borisenko, Cao, Chen, Crespo, Dominy, Erokhin, Garcia, Gomez, Haapala, Halter, Ivanova, Kontak, Lang, Malyshev, Markl, O'Reilly, Quílez, Rub, Ryzhenko, Shepherd, Velíchkin, Voinkov, Volfinger, Wang, Webster, Zhao
  Tungsten—Appel, Baker, Baksheev, Baranova, Cao, Crespo, Eichhorn, Erokhin, Garcia, Gomez, Guha, Hu, Ivanova, Lang, Leroy, Liu, Narasimhan, Noronha, O'Reilly, Quílez, Reyf, Tornos, Vallance, Velíchkin, Voinkov, Webster
  Uranium—Ahamdach, Alëshin, Chabiron, He, Liu, Mathieu, Patrier, René, Rigali, Savary, Shikazono, Shock
  Vanadium—Chen,
  Zinc—Chang, Hill, Melchor, Palacios, Ye

Modeling of ore deposits and basins. *See also* Computer—Abart, Dudok, Durisova, Endres, Guerci, Gunter, Hayba, Ilchik, Komninou, Seltmann, Solomon, Sotak, Suchy, Takagi, Tobin, Toth, Toupin, Warren, Williams, Worden, Zhang

Movement of inclusions or bubbles. *See* Origin and changes of inclusions.

Nuclear waste sites—Dublyansky, Fritz, Gunter, Huner, Mathieu, Rigali, Savoye, Tobin

Organic compounds, Bitumen, Vitrinite, Coal etc.—Arcos, Awwiller, Baskin, Boni, Buseck, Cathelineau, Cesaretti, Dobes, Dudok, Durisova, Green, Hallager, Pagel, Parnell, Savary, Sotak, Sturchio, Suchy, Voznyak, Xie, Yang, Zentilli

Organic compounds, oil and gas field, maturation, migration, exploration—Awwiller, Barker, Baskin, Bilal, Bodnar, Cesaretti, Dobes, Dudok, Duggan, Eadington, Franks, George, Grishina, Grobe, Guo, Hall, Hallager, Hobson, Hollmann, Huang, Jarmolowicz, Kirste, Krieger, Liu, Macaulay, Macleod, Marfil, Messelles, Mountjoy, Ou, Parnell, Pironon, Pottorf, Ramseyer, Ren, Shen, Smith, Sotak, Suchy, Toupin, Wang, Wilkins, Williams, Wu, Xie, Zheng, Zhou

Organic compounds, General. *See also* Analysis data, higher hydrocarbons, acetate, etc.—Amend, Barker, Bennett, Bodnar, Bushev, Dudok, Guo, Hall, Kasimova, Kesler, Legrand, Macleod, Munz, Ou, Potter, Rigali, Salvi, Savary, Shnip, Smith, Stasiuk, Taylor, Tomilenko, Xie

Organic compounds in ore deposits—Alderton, Arcos, Boni, Cepedal, Dominy, Haggerty, Jenkin, Kozlowski, Li, Liu, Lusk, Parnell, Rantitsch, Rodger, Silva, Souissi, Wang, Xie, Yang, Zhang, Zhuang, Zentilli

Origin and changes in inclusions. *See also* Synthetic inclusions
  Chronology of generations—Andersen, Bell, Henry, Lespinasse, Nakashima, Ohtani, Simmons, Yardley
  Cracking of rocks or minerals, decrepitation in nature or laboratory, hydrolytic weakening. *See also* Fluid flow—Andre, Ayt Ougougdal, Beeler, Coetzee, Garcia, Golovin, Henry, Jang, Küster, Matsumoto, Nakashima, Sausse, Schiano, Tomilenko
  Crystal growth phenomena—Arcos, Bell, Bonev, Borisenko, Mizota, Tomilenko, Watt, Xu, Zink
  Deformation, dislocations—Küster, Lee, Renard
  Leakage (in or out), refilling—Breiter, Fossum, Kovalevich, Kozlowski, Lawrie, Lusk, Matsumoto, Morales-Ruano, Mullis, Solovóva, Thomas, Yui
  Recrystallization and re-equilibration effects-necking down—Beeler, Brauer, Dunne, Henry, Kontak, Kozlowski, Lusk, Tecce, Tomilenko, Zonova
  Stretching (and collapse)—Andersen, Arcos, Golovin, Gonzalez, Henry, Kovalevich, Ruggieri
  Trapping mechanisms—Beeler, Bell, Bonev, Borisenko, Chazallon, Simmons, Smirnov, Tomilenko, Williams-Jones, Williamson, Zink
  Wetting phenomena—Arcos, Franz, Holness, Navon, Renard

Paleoatmospheres and paleoclimates, paleoseawater. *See also* Inclusions in ice; Inclusions in rocks, speleotherms—Banks, Bouabdellah, Channer, Chazallon, de Ronde, Fanlo, Kovalevich, Legrand, Marty, Matsumoto, Roberts, Sasada, Taberner, Warren, Westphal, Xu

Partial pressure (also fugacity, activity) H_2 (and pH)—Beurlen, Cheng, Chou, Háber, Hezarkhani, Kovalenker, Liu, Ryzhenko, So, Thiersch, Tomilenko, Williamson, Yao

Partial pressure (also fugacity, activity) O_2—Baranov, Baranova, Beurlen, Bortnikov, Chen, Durisova, Ferkous, Frietsch, Gebre-Mariam, Háber, Halter, Hezarkhani, Jendrzejewski, Kilias, Kogarko, Kovalenker, Melcher, Nikogosian, Nogueira, Ogasawara, René, Sasaki, Simakov, So, Takagi, Thiersch, Tomilenko, Wang, Wood, Yao, Zhao

Partial pressure (also fugacity, activity) S_2, H_2S, etc.—Baranova, Beurlen, Bortnikov, Chen, Cheng, DeSchutter, Durisova, Háber, Hezarkhani, Kovalenker, Nogueira, So, Wood, Zvágina, Zhang

Partitioning between phases. *See also* Isotopes, general; Analysis, REE—Adam, Bennett, Berndt, Bodnar, Chevychelov, Dixon, Kent, Litasov, London, Matsumoto, Nikogosian, Rebbert, Schafer, Schreyer, Sheppard, Stalder, Taylor, Veksler, Webster, Zhang, Zimmermann

Petrography of inclusions; artifacts, sample preparation—Fan, Nakashima, Poole, Prokof'ev, Smelik, Smirnov

Reviews, introductions, and bibliographies. *See also* Books—Bodnar, Cabri, Candela, de Ronde, Duan, Durisova, Fan, Fritz, Hedenquist, Liu, Mél'nikov, Roedder, Ronchi, Shen, Valyashko, Wilkins, Zhou

Rock-water interaction (alteration, exchange rates, etc.)—Abart, Baker, Conrad, Garrido, Gunter, Ilchik, Komninou, Levasseur, Liu, Lodemann, Losh, Menuge, Ryzhenko

Silicate melt inclusions, homogenization, data, and techniques—Ahamdach, Andreeva, Belkin, Breiter, Chabiron, Chupin, Danyushevsky, Della-Pasqua, de Vivo, Franz, Han, Johnson, Li, Lowenstern, Potter, Prokof'ev, Mangas, Marianelli, Panina, Reyf, Rub, Sharygin, Student, Thomas, Titov, Tolstykh, Varela

Silicate melt inclusions, Interpretation—Cesare, Danyushevsky, Della-Pasqua, Hoà, Li, Malíkova, Marianelli, Rapien, Solovóva, Student, Thomas, Veksler, Webb, Williamson

Solubility of metals—Eichhorn, Fein, Gammons, Hezarkhani, Huff, Odling, Prokofyev, Rapien, Seward, Suk, Thomas, Webb

Structural geology, use of inclusions in. *See also* Inclusions in rocks, metamorphic, P-T paths; Origin of Inclusions, chronology; Fluid, flow—Andre, Bell, Brauer, Dinter, Durisová, Ferkous, Garcia, Giesecke, Henry, Jang, Jenkin, Lee, Lespinasse, Mapani, Montomoli, Muchez, Mullis, Mutemeri, Ohtani, Pettke, Ramboz, Rodger, Sachan, Sakaguchi, Selverstone, Singh, Smit, Voltaggio, Wawrzyniec, Wyder, Zeeh, Zheng

Synthetic inclusions; inclusions in synthetic materials—Arcos, Audétat, Frost, Gibert, Günther, Henn, Ishiyama, Kawakami, Krol, Ménez, Peretti, Sawaki, Schafer, Schmetzer, Smelik, Smirnov, Stasiuk, Tomilenko, Veksler, Webster, Zhang

Water (and OH) in magmas and minerals—Azimov, Belkin, Boudreau, Calvache, Danyushevsky, Dingwell, Freda, Harms, Kamenetsky, Lowenstern, Nabelek, Prokof'ev, Reyf, Roggensack, Seltmann, Solovóva, Thomas, Webster

Water (liquid and salts) in silicate melt inclusions—Chang, de Vivo, Han, Lowenstern, Naumov, Papale, Sharygin, Shimizu, Student, Thomas, Tomilenko, Webster

Xenoliths. *See also* Inclusions in rocks, peridotite—Carpenter, Cesare, Chazot, Chupin, Draper, Franz, Freda, Frezzotti, Fulignati, Golovin, Hurai, Kogarko, Mangas, Matsumoto, Neumann, Rehkämper, Saal, Schiano, Tomilenko, Varela, Wiechert, Wu, Yaxley, Zinchuk

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.

A
Aar granodiorite Massif, France—Ayt Ougougdal, Mullis
Aar Massif, Switzerland—Wyder
Abagaitui fluorite, Transbaikalia, Russia—Alëshin
Abitibi Au, Canada—Boullier, Schandl
Acupan Cu-Au, Philippines—Cooke
Adirondack garnet, New York—Darling
Adirondack Highlands, New York—Castleberry, Selleck
Afghanistani emerald—Giuliani
Ailaoshan pegmatite, Yunnan, PRC—Li
Akchatau greisens, CIS—Kozlov
Aketao corundum, Xinjiang, PRC—Wang
Akwatia diamonds, Ghana—Stachel
Alban Hills, Italy—Freda
Alberta Basin oil, Canada—Mountjoy
Aldan lamproites, Siberia, CIS—Panina
Algoma-type banded iron Au, NWT—DeSchutter
Alid volcanic center, Eritrea—Lowenstern
Alleghany Au, Ca—Goldfarb
Alpine fissures, France—Poty
Altay pegmatite, Xinjiang, NW China—Lu
Alto Jauru Greenstone VMS Au, Brazil—Pinho
Amantaitau Au, Western Uzbekistan—Askerova
Amesmessa Au, Hoggar, Algeria—Ferkous
Anatolia Sb, Hg, Au, Turkey—Ozgür
Andong Cu, Gyeongsang Basin, Korea—So
Andranondambo sapphire, Madagascar—Gübelin
Ankaramite Vanuatu, Rinjani volcano, Lombok—Della-Pasqua
Anle Sn-Cu, Inner Mongolia—Wang
Apollo polymetallic, Siegerland, FRG—Wagner
Appalachian basin—Elliott
Appalachian fold-and-thrust belt—Evans
Apuseni Mts. Au-Ag, Romania—Alderton, Cioflica
Arcturus Au, Zimbabwe—Mutemeri
Asama Volcano, Japan—Yamaguchi
Ashanti Au belt, Ghana—Oberthür, Schmidt, Schmidt-Mumm
Ashele Cu-Zn VHMS, Xinjiang—Chang, Ye
Atsagin-Dush Volcano xenoliths, Mongolia—Wiechert
Au quartz, northeastern Brazil—Beurlen
Au-Pb deposit, China—He
Austrian Alps Au—Kucha
Avila-Béjar episyenites, Spain—Recio
Aznalcóllar VHMS, Spain—Toscano
Azov Sea Au, CIS—Voznyak

B
Badenian evaporites Poland, Ukraine—Galamay, Petrichenko
Badenian halite, Bochnia—Kovalevich
Badenian salts, Carpathians—Galamay
Baguamiao Au, Fengxian, Shannxi, PRC—Zhong
Baia Mare Au-Cu-Zn-Sb, Romania—Leroy
Baiguoyuan Ag-V, Hubei, PRC—Chen
Bald Mountain VHMS, Maine—Foley
Ballinglen W-Sn, SE Ireland—O'Reilly
Balmat-Edwards District, New York—Hill
Bamble granulite, Norway—Lidwin
Bandama volcanic complex, Gran Canaria, Spain—Mangas
Bandelier Tuff Fm, Los Alamos, New Mexico—Newman
Bankuan Au, PRC—Chen
Banská-Stiavnica Au-Ag-Pb-Zn, CSSR—Haber, Kovalenker
Barberton belt Fe, South Africa—Channer
Barberton greenstone belt, South Africa—Channer, de Ronde
Barrandian basin, Czech Republic—Dobes, Durisová, Suchy
Barro Alto complexes, Goias, Brazil—Török
Bathurst VHMS, New Brunswick, Canada—Goodfellow, Scott
Bayan Obo REE, Inner Mongolia, PRC—Cao
Beaconsfield Au, Tasmania—Russell
Beddiane MVT Pb-Zn, northeastern Morocco—Bouabdellah
Belingwe komatiite, Zimbabwe—Shimizu
Bell porph-Cu—Hedenquist
Bendigo Au, Australia—Xia
Berbes fluorite, Spain—Arcos
Bereznjakovskoje Au, Chelyabinsk CIS—Lehmann
Berëzovskoe Au, Urals, Russia—Baksheev, Bortnikov, Zvágina
Bernardan U, Marche, France—Patrier
Betic Cordillera graphite, Spain—Barrenechea
Betxi Hg, Spain—Tritlla
Biella pluton, Italy—Philippot
Big Gossan Cu-Au, Ertsberg, Irian Jaya—Meinert
Biggenden skarn, Southeast Queensland, Australia—Edraki
Bingham Canyon porphyry Cu, Utah—Anderson, Bodnar, Hedenquist, Shepherd
Birimian pegmatites, southeastern Ghana—Chalokwu
Bismark skarn, Mexico—Melchor
Björkal Au, Sweden—Billström
Black Angel massive sulfide, W. Greenland—Konnerup-Madsen
Black Hills pegmatite, South Dakota—Sirbescu
Blanco Trough, Juan de Fuca Ridge—Manac
Bleiberg Pb-Zn, Austria—Rantitsch
Blond granite Au-W, NW French Massif Central—Vallance
BM&S No. 12 VHMS, New Brunswick, Canada—Lusk
Bo-Va Au, North Vietnam—Hoa
Bohemia granulites—Durisová
Bohemian Massif, Czech Republic— Dobes, Durisová
Bolton Syncline schists, Connecticut—Bell
Bolton Syncline, Connecticut—Bell
Borralha W, northern Portugal—Noronha
Bou Azzer Co-As-Ag-Au, Anti-Atlas, Morocco—En-Naciri, Essarraj
Brawley geothermal, California—Wright
Brazilian emerald—Giuliani
Brennta Cu, Austria—Kling
Brewery Creek OD, Yukon and Alaska—Lang
Brilon Reef Complex, Germany—Grobe

Broadlands-Ohaaki geothermal, New Zealand—Normans, Simmons
Broken Hill, New South Wales—Williams
Brusson Au, NW Alps—Pettke
Brusson Massif Au, Italy—Boiron
Bugdaya Mo, Eastern Transbaikalia, CIS—Krylóva
Bukok hydrothermal clay, Korea—Koh
Burguillos del Cerro complex, Spain—Bachiller
Butiya Uplift granulites, Canadian Shield—Tomilenko
Butte porphyry Cu, Montana—Bodnar, Maeda

C
Cabaçal Au, Brazil—Pinho
Cabeza Lijar W-Mo, Spanish Central System—Noronha, Quílez
Cabeza Mediana W, Spain—Noronha
Cabrera pegmatites, Spanish Central System—Lozano
Cadjebut Zn-Pb, Western Australia—Arne
Caledonian Appinite Au, Scotland—Crummy
Caledonian basin oil, Sweden—Samuelsson
Calliachar Au-Urlar Burn, Scotland—Ixer
Cambrian carbonate platform, Canada—Yao
Cambrian salt, Siberia—Grishina
Cameroon Line xenoliths, Tanzania—Rehkämper
Canary Islands xenoliths—Neumann
Candelaria Au, Argentina—Gonzalez
Cangxian Uplift oil, PRC—Ou
Cannington Pb-Zn-Ag, Cloncurry District, NW Queensland—Dong, Williams
Capitan Mtns. U-Th-REE, New Mexico—Shepherd
Capodimonte 1D geothermal, Latium, Italy—Tecc
Carlés Cu-Au, NW Spain—Arcos
Carlin NV, Au—Cameron, Tüysüz
Carlin type Au, Jiangxi, PRC—Cheng
Carlin-type Au—Ilchik
Carneros epithermal, Almería, SE Spain—Demoustier
Carnic Alps, Southern Austria—Rantitsch
Carnmenellis granite—Hussain
Carolina Fe-Au slate belt, U.S.A.—Foley
Carpathian oil and evaporites—Bodnar, Dudok, Kovalevich, Peryt
Carreña de Cabrales Cu-Co-Ni, Spain—Garcia Iglesias
Castleward lead (Cu-Ag), Ireland—Moles
Catalina Schist, California—Bebout
Central Alps, Switzerland—Yardley
Central Iberian Au, Spain-Portugal—Murphy
Central Mátra Mts. epithermal, Hungary—Gatter
Central Pyrenees, France—Banks
Central Tennessee zinc district—Sturchio
Cero Vanguardia Au-Ag, Patagonia, Argentina—Schalamuk
Cerro Negro volcano, Nicaragua—Roggensack
Cerro Rico Ag, Bolivia—Steele
Cerro Vanguardia Au-Ag, Patagonia, Argentina—Schalamuk
Cesano 1 geothermal, Latium, Italy—Tecce
Cevenole Zn-Pb, France—Ramboz
Chamba Thrust, Himachal Himalaya, India—Singh
Changbai Mountains volcanics, PRC—Wu
Changcheng Au-Ag, Guangdong, PRC—Zhang
Changkeng Au, Guangdong, PRC—Liang
Charmitan Au, CIS—Bortnikov
Chebach'e Ural pyrite, CIS—Baranov
Chelyabinsk epithermal Au, southern Urals, Russia—Lehmann
Chertomlyk greenstone Au, CIS—Shibetskiy
Chhendapathar W, Bankura District, West Bengal, India—Guha
China Ni-Mo sulfide beds—Lott
Chinese Pb-Zn-polymetallic skarn deposits—Zhao
Chinmienshan Pb-Zn, Taiwan—Chu
Chinyika shear zone, Zimbabwe—Mutemeri
Chipilapa-Ahuachapan geothermal area, El Salvador—González Partida
Chogar complex, Stanovoi Range, Russia—Tomilenko
Cieszyn magma province, Poland—Wlodyka
CIS pegmatites—Kozlov
Cloncurry Cu-Au-Co, NW Queensland, Australia—Blake, Borrok, Dong, Williams, Wood
Cloncurry polymetallic OD, Australia—Dong
Co. Galway fluorite, Ireland—Menuge
Cobalt, Ontario—En-Naciri
Colombian emeralds—Giuliani, Zimmermann
Connemara base-metal, Ireland—Jenkin
Cooper oil Basin, Australia—Rezaee, Toupin
Cordilleran Au—Goldfarb
Cornwall, UK—Dominy, Gleeson, Williamson
Creede mining district, Colorado—Hayba
Cretaceous carbonates, Iran—Ghazban
Crete metamorphic rocks—Küster
Croagh Patrick Au, Ireland—Wilkinson
Crofoot-Lewis gold-silver, Australia—Ebert
Cruachan Cruinn Au, Scotland—Crummy
Cu-pyrite OD, Urals, Russia—Kostina
Cuddapah Basin barite, Andhra Pradesh, India—Mukherjee
Cumbria anhydrite, Northern Pennines, UK—Crowley
Curraghinalt Au, Northern Ireland—Boyce, Wilkinson
Cusiana oil field, Colombia—Warren

D
Da'anzhai oil, Sichuan, PRC—Zheng
Dabaoshan Pb-Zn-polymetallic, Quangdong, PRC—Li
Dabie Mtns. eclogites, China—Han
Dabie Shan metamorphics, China—Baker
Dachang Sb, Guizhou, China—Zhuang
Darasun OD, Transbaikalia—Prokofiev
Dartmoor Sn, UK—Shepherd
Daugiztau Au, Russia—Askerova
Dead Sea halite—Shepherd
Death Valley waters, Ca—Yang
Death Valley, Ca—Roberts
Deer Trail Mtn.-Alunite Ridge, Marysvale, Utah—Cunningham
Denggezhuang Au, Mouping, Shandong, PRC—Zhang
Deputatskoe Sn, Yakutia, CIS—Borisenko
Deseado epithermal Au-Ag, Patagonia, Argentina—Schalamuk
DESMOS caldera,Manus back-arc basin, Papua New Guinea—Gamo
Devil Peak rhyolite, Nevada—Knupp
Diaoquan Ag-Au, Shanxi, PRC—Zhou
Dixie Comstock Au, Nevada—Lutz
Dixie Valley fault geothermal, Nevada—Hedderly-Smith, Lutz
Djugdjur Massif, Siberia—Berdnikov

Donalda Au, Abitibi, Canada—Boullier
Dongchuan Cu, Yunnan Province, SW China—Qiu
Dongping Au, Hebei, PRC—Mo
Dongyang talc, Korea—Park
Dovyren Complex PGE, East Siberia—Konnikov
Dugald River Zn-Pb-Ag, Mount Isa, Australia—Xu
Duluth complex, Minnesota—Hauck
Durajoki Rapakivi granite, Finland—Haapala

E
East Antarctica granulites—Cartwright, Rao
East China oil—Xie
East European platform evaporites—Khmelevska
East Kemptville Sn, Nova Scotia—Halter, Kontak
East Pacific Rise geothermal—Von Damm
East Rift Zone, Kilauea Volcano, Hawaii—Conrad
East Slovakian basin, Slovakia—Galamay
East Texas basin oil—Zeigler
Eastern Alps siderite, Austria—Prochaska
Eastern and Southern Alps—Zeeh
Eastern Ghats granulite belt, India—Bhowmik
Eastern Goldfields Province, Western Australia—Wang
Eastern Ladakh eclogites, Himalayas, India—Sachan
Egyptian Au—Taylor
Ehrenfriedersdorf Sn-W, Erzgebirge, SE Germany—Webster
El Estepar W-Mo, Spanish Central System—Quílez
El Faldeo Au-Zn, Chilean Patagonia—Palacios
El Hamman Sn skarns—Volfinger
El Hoyazo xenoliths, SE Spain—Cesare
El Juncalon Sb, Central Iberian Zone—Ortega
El Laco Fe, Chile—Rhodes, Sheets
El Salvador porph-Cu—Hedenquist
El Soldado Cu, Chile—Holmgren, Klohn, Zentilli
"El Valle" Cu-Au, Asturias, Spain—Cepedal
Eldjurtu granite, near Elbrus, Caucasus—Sobolev
Elk Point Basin, Saskatchewan, Canada—Koehler
Eloise Cu-Au deposit, Australia—Dong
Ely porph-Cu—Hedenquist
Emirli Sb, Hg, western Turkey—Akçay
Emperor epithermal Au, Fiji—Begg
Epithermal/porphyry, Kassiteres, Thrace, Greece—Voudouris
EPR 9-10° thermal system—Berndt
Eromanga oil basin, Australia—Toupin
Erro-Tobbio peridotite, Western Alps—Scambelluri
Erzgebirge Sn-W, Germany—Seltmann, Thomas
Eslida Hg, Spain—Tritlla
Espadán Ranges Hg, Eastern Spain—Tritlla

F
Fankou Pb-Zn-polymetallic, Quangdong, PRC—Li
Fantale volcano, Ethiopia—Taylor
Far Southeast porph-Cu—Hedenquist
Fasolnoe Ag-Pb-Zn, East-Sikhote-Alin, Russia—Pakhomova
Fawakhir Au, El Six, Egypt—Loizenbauer
Fazenda Canto Au, Brazil—Silva
Fazenda Maria Preta Au, Brazil—Silva
Felbertal W, Austria—Eichhorn
Fennoscandia Cu-Au—Frietsch
Fichtelgebirge, Germany—Thomas
Fohnsdorf coal basin, Austria—Zimmermann
Fort Knox Au deposits, Tombstone-Tungsten magmatic belt, Yukon-Alaska—Baker, Lang
Franqueira gemstones, NW Spain—Marcos-Pascual
Fulmar oil field, central North Sea—Macaulay
Fuping gneiss, Taihang Mountains, PRC—Liu
Furtei Au, Sardinia, Italy—Ruggieri
Fuxian diamonds, China—Liu

G
Gakehe Cu-Ag-As, Qinghai Province, PRC—Li
Galeras Volcano—Calvache
Galicia Central pegmatites, Spain—Fuertes- Fuente
Gallinas Mtns. REE-fluorite, New Mexico, USA—Samson, Williams-Jones
Galway Granite, Connemara, Ireland—O'Reilly
Ganesh Himal ruby/sapphire, Nepal—Smith
Gaolong Au, Guanxi, PRC—Shi
Gardar rift, S. Greenland—Konnerup-Madsen
Gardiner complex, East Greenland—Nielsen
Garganta de los Montes W-Mo, Spanish Central System—Quílez
Garsonui polymetallic, Transbaikalia, Russia—Alëshin
Gays River MVT, Canada—Chi
Gidginbung epithermal Au, Australia—Lawrie
Gjeving-Complex, Aust Agder, Norway—Fossum
Golden Kilometre Au, Australia—Gebre-Mariam
Golden Sunlight Au-Ag-Te, Whitehall, Montana—Paredes, Spry
Göpfersgrün talc, Bavaria, Germany—Loth
Gore Mountain granulite, New York—Darling
Gore Mountain, New York—Darling
Gotthard Massif, Switzerland—Wyder
Granny Smith Au, Australia—Ridley
Great Bahama Bank—Westphal
Great Kuwae eruption, Vanuatu—Witter
Greece vein-quartz—Arvanitidis
Griffins Find Au, Australia—Brown
GSJ Hirabayashi bore, Japan—Ohtani
Guangxi strata-bound deposits, S. China—Rao
Guli carbonatites—Veksler
Gumbeyskoe U, Middle Urals, Russia—Baksheev
Gyeongsang Basin Cu, Korea—So

H
Haast Schists, New Zealand—Yardley
Haha Jima Island porph Cu—Armstrong
Hakurutale granulites, Sri Lanka—Bolder-Schrijver
Haoshi Ag, Zhejiang Province—Chen
Harney Peak Granite, Black Hills, South Dakota, USA—Nabelek, Sirbescu
Hassi Bir Rekaiz oil, Algeria—Franks
Hatchobaru geothermal, Japan—Hayashi
Haushi Group sandstones, Oman— Juhász-Bodnár, Ramseyer
Hawaii basalts—Dixon
Hellyer massive sulfide, Australia—Khin, Solomon
Hemmerlein Skarn-Greisen Sn, Erzgebirge, Germany—Malyshev
Hensbarrow granite, St. Austell, Cornwall, England—Williamson
Hessian Depression xenoliths, Germany—Carpenter
Hetai Au, South China—Wang
High-P metamorphic, Tianshan, Xinjiang, China—Bin
Hijori geothermal, Japan—Ohtani
Himalaya eclogites, India—Sachan

Hokuroko basin, Japan—Solomon
Homestake Au, Lead, South Dakota—Cooper
Homrat Akarem rare metal, Egypt—Solovóva
Hualilan Au, Argentina—Bengochea
Huanghua Depression, PRC—Ou
Huangshan Au, PRC—Chen
Huayuan Pb-Zn, Hunan, PRC—Liu
Hunan MVT, PRC—Boni
Hunjiang Au (Carlin type), Jilin, PRC—Yang
Hunsur migmatites, Karnataka, India—Srikantappa

I
Iceland mantle—Gurenko
Igarape Bahia Au, Brazil—Lindenmayer
Iglesiente-Sulcis district, Sardinia—Parente
Il-Ky CaF_2 district—Brannon
Indonesia ankaramite, Rinjani volcano, Lombok—Della-Pasqua
Inyo Obsidian Dome, California—Navon
Irecê Basin Zn-Pb-Ag, Bahia, Brazil—Kyle
Irish Midlands OD—Eyre
Iron Quadrangle quartz veins, Brazil—Boiron
Isle of Skye, Scotland—Gilliam
Itajubatiba Au skarn, NE Brazil—Souza Neto
Iultin area, CIS—Erokhin
Ivigtut, Greenland—Pauly
Iwozawa geothermal, Nagano, Japan—Sasaki

J
Jabiru oil field, Vulcan sub-basin—George
Jade hydrothermal field, Central Okinawa Trough, Japan—Lüders
Japan pegmatites—Sawaki
Jeanne d'Arc Basin, Newfoundland—Huang
Jiadong Peninsula Au, PRC—Xu
Jianfengling pegmatite, PRC—Chang
Jiaodong Peninsula Au, PRC—Xu
Jiguanzui skarn Au, Hubei, PRC—Zhao
Jilau Au, Tajikistan—Cole
Jilingshan skarn Au, Hubei, PRC—Zhao
Jilove Au-polymetallic, Czech Republic—Zacharias
Jima Island porph Cu, Arizona—Armstrong
Jinya Au, Guangxi, PRC—Wang
Jokoku mine, Japan—Ishiyama
Juan Pablo mine, Zimapán, Mexico—Dubois
Jurassic oil, Norway—Williams
Jwaneng diamonds, Botswana—Deines

K
Kaiserstuhl complex, Germany—Sokolov
Kakkonda geothermal, Japan—Sawaki
Kalgoorlie Au, Western Australia—Witt
Kamsdorf siderite-sulphide-barite, Thuringia, Germany—Kling
Kanamaru pegmatite, Niigatu Pref, Japan—Nanbu
Kanggur Tag Au, Tianshan Mountains, PRC—Ji
Kanowna Belle, Eastern Goldfields Province, Western Australia—Wang
Kapan basanites, Armenia—Nikogosian
Kaperské Hory, Bohemian Massif—Durisová
Kariiskoe Au,Eastern Transbaikalia—Prokof'ev
Kashi Depression, PRC—Li
Kasperské Hory Au, Bohemia—Durisová
Kassiteres epithermal porphyry-type Au, Thrace, Greece—Voudouris
Kaybob South oil, west-central Alberta—Green
Kazakhstan pegmatites, CIS—Kozlov
Kazakstan VHMS—Parilov
Keketuchai pegmatite, Xinjiang, PRC—Li
Keketuohai No. 3 pegmatite, Xinjiang, PRC—Lu
Kempirsai chromite, Kazakhstan, Urals—Melcher
Keno Hill Pb-Zn-Ag, Tombstone-Tungsten magmatic belt, Yukon-Alaska—Baker
Kentstown Granite Co., Meath, Ireland—O'Reilly
Kerala Khondalite Belt,South India—Rajesh
Khatatba oil reservoir, Egypt—Marfil
Khibiny alkalic complex, Russia—Potter
Khobna W, Maharashtra, India—Narasimhan
Kidd Creek VMS, Canada—Schandl
Kidston Au-Cu, North Queensland, Australia—Ryan
Kilauea volcano, Hawaii—Johnson
Kirishima geothermal, Japan—Etoh, Noto, Sawaki
Kiruna iron, Sweden—Blake
Kiruna-type OD, Slovakia—Hurai
Kitakami Mtns., Japan—Sasaki
Kochbulak Au-Te, Uzbekistan—Kovalenker
Kola granulite, Russia—Fonarev
Kola Peninsula hydrocarbons, Russia—Potter
Kola Superdeep Borehole, Russia—Smithson
Konder Massif PGE, Aldan Shield, CIS—Ukhanov
Korean granites—Jang
Kovdor akalic complex, Russia—Potter, Veksler
KTB deep drill hole, Germany—Durisová, Grawinkel, Lodemann, Moeller, René
Kücük Menderes Sb-Hg-Au, Anatolia, Turkey—Ozgür
Kudryavyi volcano, Iturup Island, S. Kuril Arc—Tsaryeva
Kukhi-Lal pegmatites, CIS—Bushev
Kukkurt pegmatites, CIS—Bushev
Kurihashi contact zone, Kitakami Mtns., Japan—Sasaki

L
La Clarté orbicular granite, France—Decitre
La Fossa caldera, Vulcano Island, Italy—Voltaggio
La Gardette Au, French Alps—Marignac
La Gomera, Canary Islands—Frezzotti
La Guitarra Ag-Au, Temascaltepec, Mexico—Camprubí
La Voluntad porhyry copper, Neuquén Province, Argentina—Mirta
Laacher See Volcano, Germany—Harms
Laerma Au, West Qinling, PRC—Liu
Lago di Cignana, Piemontese Zone, Western Alps—van der Klauw
Laisvall, Sweden—Bjørlykke
Lala Cu, Huili, Sichuan, PRC—Jin
Langshan Huogeqi Cu, Inner Mongolia—Sun
Lannigou Au, Guizhou, China—Zhuang
Lapponian Pahtohavare—Frietsch
Larafella Au, Burkina Faso—Klemd
Larderello geothermal, Italy—Villa
Larentiére Pb-Zn-Ag, Ardèche, France—Chi
Largentiere Zn-Pb—Volfinger
Las Animas mine, Zimapán, Mexico—Dubois
Lau Basin, France—Dubois
Leicestershire igneous rocks, England—Pearson

Leinster granite, SE Ireland—Moran
Lepanto epithermal Au, Philippines—Arribas
Leucite Hills lamproite, Wyoming—Sharygin
Levoca oil basin, Slovakia—Sotak
Liaoning diamond deposit, China—Gorshkov
Lihir Islands, Papua New Guinea—Eiler
Limpopo belt Au, Zimbabwe—Chupin, Schmidt-Mumm, Smit, Stevens
Limpopo belt quartzite zircon, S.A.—Chupin
Limpopo belt zircon, S.A.—Chupin
Lindsley Ni-Cu-PGE, Sudbury, Canada—Molnár
Liulong Au, Jiangxi, PRC—Wang
Llallagua Sn, Bolivia—Dietrich
Llanfair Pb-Zn-Cu, North Wales—Haggerty
Llanrwst Pb-Zn, North Wales—Haggerty
Lodève basin U, Herault, France—Ahamdach
Lofotep granulites, Norway—Markl
Loihi seamount, Hawaii—Burnard, Honda, Kent
Lomo de Toro mine, Zimapán, Mexico—Dubois
Long Quan Au, China—Wu
Long Valley Caldera, California—McConnell
Longshui Au, PRC—Wang
Lorraine basin, France—Fanlo
Los Azufres geothermal, Mexico—Izquierdo
Los Frailes VHMS, Spain—Toscano
Los Humeros geothermal, Mexico—Barragan
Loscos polymetallic, Iberian Mountains—Spain
Lovozero alkalic complex, Russia—Potter
Lower Silesian metasomatites, Czech Republic—Kozlowski
Lower Silesian scheelite, Bohemia—Kozlowski

M
Macedonia CaF_2, Ba, polymetal, Greece—Michalidis
Madagascar granulites—Moine
Magan carbonatites—Veksler
Magdala Au, Australia—Mapani
Maikhura Sn-W, Tadjikistan—Voinkov
Maimecha-Kotui ultramafic alkaline complex, Siberia—Kogarko
Main Divide Au, Southern Alps, New Zealand—Cox
Malanjkhand Cu-Mo, India—Panigrahi
Manantial Espejo Au-Ag, Patagonia, Argentina—Etcheverry, Schalamuk
Mangaia lavas, Austral Islands—Saal
Manhattan Prong, New York—Henry
Maotang Au, Henan—Feng
Mardjanbulak Au, Russia—Askerova
Mar W-Sn-Cu skarns, Yukon, Alaska—Baker
Mari Rosa Sb, Central Iberian Zone—Ortega
Mariktikan W, west Transbaikalia—Reyf
Maritimes basin MVT, Canada—Chi
"Marmarosh diamonds", Romania—Banerjee, Dudok, Voznyak
Marun-Keu complex (Polar Ural), Russia—Azimov
Marvel Loch Au, Australia—Brown
Mauna Loa volcano, Hawaii—Johnson, Nikogosian
May Au, Karelia, Russia—Poritskiy
Medvezh'ya Caldera, Kuril Islands—Tolstykh
Meguma Terrane Au, Nova Scotia—Kontak
Mendip Hills, UK—Wogelius
Messinian halite, Red Sea—Kovalevich
Metaggitsi W, Chalkidiki Peninsula, N. Greece—Kilias
Metaliferi Mtn. porph. Cu, Romania—Pintea
Mexican epithermal OD—Norman
Mianning REE deposit, Sichuan, China—Niu
Mid-Atlantic Ridge hydrothermal—Bortnikov, Jendrzejewski
Milldam Mine, S. Pennines, UK—Rodger
Mina Nova Au, Crixás greenstone belt, Brazil—Fortes
Minastira granite, Puno, Peru—Kontak
Miocene halite, Poland—Veigas
Mir kimberlite pipe, Yakutia, Russia—Kasimova, Novgorodov, Sobolev, Tomilenko
Mississippi Valley-type Pb-Zn—Zhou
Mitterberg Au, Austria—Kucha
Mogzon volcanic belt, Russia—Kuzmin
Mojiang Au, Yunnan, PRC—Bi
Moldanubian Zone, Western Bohemia—Durisová
Mole Granite Sn-W, Western Australia—Audétat, Günther
Molinello Mn, Northern Apennine, Italy—Marescotti
Mong Hsu (Myanmar) rubies—Peretti
Mont Blanc granite Massif, France—Ayt Ougougdal, Boiron, Guerci, Marshall
Mont Blanc Massif, Switzerland—Marshall
Mont Chemin Au, Switzerland—Marshall
Montagne de Pormenaz polymetallic, France—Polliand
Montana Clara xenoliths, Fernando de Noronha Island—Kogarko
Monteferro-El Rosal shear zone, Spain—Hébert
MORB popping rock, mid-Atlantic Ridge—Moreira
Morenci porph Cu, Arizona—Armstrong
Mori geothermal, Hokkaido, Japan—Muramatsu
Morro do Ouro Au, Minas Gerais-Brazil—Freitas-Silva
Mount Chalmers VMS, Queensland, Australia—Hunns
Mount Etna, Italy—Allard, D'Alessandro
Mount Isa fold belt, Australia—Williams, Wood, Xu
Mount Pleasant Sn-W-Mo, New Brunswick—Seltmann
Mt. Chalmers VHMS, Australia—Khin
Mt. Erebus, Antarctica—Esser
Mt. Somma-Vesuvius, Italy—de Vivo
Mufushan pegmatite, Hunan, PRC—Li
Muiane Li-pegmatite, Mozambique—Boiron
Muruntau Au, Uzbekistan—Askerova, Berger, Graupner
Mushugai-Khuduk carbonatitic complex, Mongolia—Andreeva
Muteh Au, Iran—Moritz
Muya block, Transbaikalia—Tomilenko

N
Nanga Parbat geothermal, Pakistan—Craw
Nanortalik Au, South Greenland—Petersen
Naozhi Au, Jilin, PRC—Huang
Navan Pb-Zn, Ireland—Everett, Rizzi
Navia Au belt, Spain—Arias
Nepal corundum—Smith
Neves-Corvo VHMS, Portugal—Moura
New South Wales diamonds, Australia—Meyer
Newer Volcanics, Australia—Matsumoto
Newtownards Pb-Zn-Cu, Northern Ireland—Moles
Nezdice wollastonite marble, Czech Republic—Zák
Nezhdaninskoye Au, CIS—Bortnikov
Ngatamariki diorite geothermal, New Zealand—Christenson
Nigeria beryl—Banko
Niquelandia complexes, Goias, Brazil—Török
Niuxinshan Au, Hebei, NE China—Yao

Norseman Au, Western Australia—Witt
North Anatolian Fault Zone, Turkey—Janssen
North Arch volcanic field, Hawaii—Dixon
North China craton Au, PRC—Nie
North Fiji basin basalt—Nishio
North Irish Sea oil—Parnell
North Sea oil, Norway—MacLeod, Williams
Northeastern Brazil Au—Beurlen
Northern Greece vein-quartz—Arvanitidis
Northern Internal Rif polymetallic, North Morocco—Fkihech
Northern Muya Block eclogites, East Siberia—Tomilenko
Northern Pennines barite anhydrite, UK—Crowley
Nunarssuit syenite, Greenland—Hodson
Nunivak Island lherzolites, Alaska—Chazot

O
Oberpfalz, Germany—Thomas
Oka Complex, Canada—Sokolov
Oki-Dogo Island, Japan—Kashima
Oklo, Gabon—Mathieu, Rigali, Savary
Olary Block pegmatites, south Australia—Lu
Oldoinyo Lengai volcano, Tanzania—Mitchell, Nielsen, Sokolov
Olimpiada Au, Sb, W, Yenisei Range, Russia—Baranova
Olympic Dam, South Australia—Blake
Oman ophiolite chromites—Schiano
Onikobe geothermal, Japan—Sawaki
Ordos Basin geothermal, China—Ren
Ordos Basin oil, PRC—Liu
Osborne Cu-Au, Cloncurry District, NW Queensland, Australia—Blake, Dong, Xu, Zhou
Ostal Alps crystallines, Switzerland—Kaindl
Ouenza siderite, Algeria—Bouzenoune

P
Palea Kavala Au, Greece—Vavelidis
Pamir pegmatites, CIS—Bushev
Panasqueira W, northern Portugal—Noronha
Pannonian oil basin, Hungary—Toth
Papoose Flat Pluton, Eastern California—Brauer
Papua New Guinea oil-gas—Krieger
Paris basin, France—Ayt Ougougda, Worden
Patagonia xenoliths, Argentina—Varela
Pb-Zn Stribo epithermal, Czech Republic—Dobes
Pb-Zn-polymetallic skarn, China—Li, Zhao
Pea Ridge, Missouri—Borrok
Pearl River Mouth oil, PRC—Zhou
Pedrosa del Rey As-Sb-Au, Spain—Paniagua
Pegmatite, Altay, Xinjiang, NW China—Lu
Penggou Au, Lushan County, Henan, PRC—Zhang
Permian Castile, JX-NM—Leslie
Phalaborwa Igneous Complex, S. Africa—Meier, Palmer
Piaotang Sn-W, South China—Ivanova
Pinatubo geothermal, Philippines—Reyes
Pine Creek, Leduc Fm., west-central Alberta—Green
Pipe Bele, Khakassia, Russia—Golovin
Podlesí granite, Czech Republic—Breiter, Seltmann
Pollone Pb-Zn-Ag, Tuscany, Italy—Costagliola
Pontides Au, NE Turkey—Tüysüz
Porgera Au, Papua New Guinea—Cameron, Richards
Port Coldwell Pb-Zn-Ag—McCuaig
Porthleven Pb-Zn, South Cornwall, UK—Gleeson
Porto Nacional Province Au, Brazil—Mesquita
Potosi region Sb, Bolivia—Dill
Pozo Escondido oil field, Argentina—Cesaretti
PRC pegmatites—Li
Profitis Ilias Au, Milos Island, Greece—Kilias
Prognóz Ag-Pb-Zn, Yakutia, CIS—Bórtnikov
Promontorio del Franco polymetallic, Isola del Giglio, Italy—Maineri
Putang Au, Henan—Feng

Q
Qinshui Basin geothermal, China—Ren
Qiong Dongnan oil, PRC—Guo
Qiongmo Au, West Qinling, PRC—Liu
Qixiashan Pb-Zn-Ag-Mn polymetallic, Nanjing, China—Xie
Qixiashan polymetallic, Jiangsu, PRC—Xie
Queensland, Australia—Dong
Questa Cu-Mo porph, NM—Shepherd

R
Raft River metamorphic complex, Utah—Dinter
Ramnes cauldron, Norway—Sato
Rampura Agucha Zn-Pb-(Ag), India—Höller
Rauer Group, East Antarctica—Cartwright
Red Mountain porphyry Cu, Arizona—Bodnar
Red Sea halite Atlantis II Deep, Red Sea—Kovalevich
Reelfoot Rift MVT, south-central U.S.—Leach
Renco Au, Zimbabwe—Schmidt-Mumm
Renison Bell Sn, Australia—Adabi
Rhine Graben, France—Cathelineau
Rhön peridotite xenoliths, Germany—Franz
Rinjani volcano ankaramite, Lombok—Della-Pasqua
Rio Itapicuru greenstone Au, Brazil—Silva
Romania Au—Berbeleac
Ronda peridotite, southern Spain—Garrido
Round Mountain Au-Ag, NV—Henry
Rundvågshetta, Lützow-Bay, Antarctica—Kerkhof
Rushan Au, Shandong, PRC—Zhai
Rybalka pluton (Gorny Altai), CIS—Titov
Rzhávtsy Ural pyrite, CIS—Baranov

S
Saidu Au, Habahe, Xinjiang, PRC—Cheng
Salam oil field, Egypt—Marfil
Salamon Au, Spain—Paniagua
Salton Sea geothermal, California—Williams, Wright
Samhwanghak Au, Youngdong, Republic of Korea—So
Samoa basalt—Burnard
San Andreas fault, Ca—Kennedy
San Bartolomé Ag, Central Ecuador—Mulshaw
San Rafael Sn, SE Peru—Kontak
San Rafael W(Sn), Spanish Central System—Garcia, Noronha
Sandawana emerald, Zimbabwe—Zwaan
Sandmata granulite, India—Dasgupta
Sangequan Au, East Junggr, PRC—Gao
Santa Coloma W, Spain—Espinola
Santa Rita porph-Cu—Hedenquist
Sapphire, Czech Republic—Malíkova
Savannah River nuclear site, South Carolina—Huner
Saxon Granulite Massif, Germany—Anderson, Mayanovic
Schwäbische Alb melilitites, Germany—Kozlowski

Scotia Au mine, Western Australia—Kent
Scourian granulites, NW Scotland—Andersen, Boullier
Seta epithermal Au, Japan—Yajima
Setesdalen pegmatites, Norway—Larsen
Shandong corundum, PRC—Li
Shap granite, England—Lee
Shasta Au-Ag, British Columbia, Canada—Thiersch
Shawmere anorthosite, Ontario, Canada—Lamb
Shevaroy Hills Massif, India—Harlov
Shibangou Au, Xixia, Henan, PRC—Zhang
Shimanto complex, SW Japan—Sakaguchi
Shimen As, Hunan Provinc, PRC—Xiong
Shuiquangou Au-Te, PRC—Zhang
Shuiximiao pegmatite, PRC—Zhou
Shunga district, Karelia, Russia—Buseck
Shungites, Karelia, Russia—Buseck
Sierra Morena Cu, Spain—Asensio
Sierras Pampeanas gems, Argentina—Gomez
Sierrita Au, Pernambuco, Brazil—Beurlen
Sifnos Island Au, Greece—Vavelidis
Sikanni gas field, British Columbia, Canada—White
Silesian-Cracow Zn-Pb, Poland—Kozlowski, Leach, Viets
Simberi Islands, Papua New Guinea—Eiler
Simplon Line, Central Alps, Switzerland—Wawrzyniec
Singelele paragneiss zircon, S.A.—Chupin
Slovak Republic Au—Háber, Kovalenker
Smackover Formation, Mississippi Salt Basin—Barker
Smoky Butte lamproites, Montana—Sharygin
Snake Range, NV—Losh
Snake River basalts, Idaho—Tobin
Snow Goose Grid Au, NWT—DeSchutter
Somma-Vesiuvius volcano, Italy—Belkin, Raia
Songxi Ag-Sb, Guangdong, PRC—Xiao
Sopron area, Eastern Alps, W.Hungary—Török
Soultz deep drilling, France—Cathelineau
Soultz-sous-Forêts granite, France—Savary
South China Sea oil—Wu
South Crofty mine, Cornwall, UK—Dominy
South Pennine orefield, UK—Rodger
South Platte District pegmatites, Colorado—Levasseur
South Wales Coalfield, Alderton
Southeast Cu-Au porphyry, Philippines—Arribas, Shinohara
Southeastern Piedmont—Evans
Southern Alps Au, New Zealand—Cox
Southern Alps geothermal, New Zealand—Craw
Southern Apuseni Mountains Au-Ag-Te, Romania—Alderton
Southern China W-Sn polymetallic—Cao
Southern Leicestershire diorites, England—Pearson
Southern Uplands OD, Scotland—Lowry
Southern Urals VHMS, CIS, Sushchevskaya
Spanish Central System barren quartz—Martin, Crespo
Spanish Central System W-Mo-Sn—Quílez
Sputnik kimberlite pipe, Yakutia, CIS—Sobolev
St. Austell, Cornwall, England—Williamson
St. Lawrence rift system, Canada—Carignan
St. Peter Sandstone, Illinois Basin—Pitman
St. Sylvestre granite, France—Andre
Starra Au-Cu, Cloncurry, Australia—Blake, Dong, Rotherham
Stavelot-Venn Massif sulfides, Belgium—Zhang
Stawell Au, Australia—Mapani
Stël'tsovskoe Mo-U, Transbaikalia, Russia—Alëshin
Stillwater Complex, Montana—Boudreau
Strange Lake peralkaline granite, Quebec/Labrador—Salvi
Streltsovka Mo-U, Transbaikalia, Russia—Chabiron
Stribo, Western Bohemia—Dobes, Durisová
Subiza potash deposit, Navarra, Spain—Cendón
Sungun porphyry Cu, Iran—Calagari, Hezarkhani
Sura greenstone Au, CIS—Shibetskiy
Sushikeng Pb-Zn, Guangdong, PRC—Lu
Sutherland epithermal Au, Scotland—Crummy
Svetloe Sn-W, Chukot Peninsula, CIS—Erokhin
Swan Hills Simonette oil, Alberta, Canada—Duggan, Green
Syrymbet Sn, CIS (?)—Velfchkin
Szeleng OD, Chinmienshan, Taiwan—Yui

T

Taconic slate belt, New York—Giesecke
Talcuna Cu, Chile—Ortega
Talganskoe Ural pyrite, CIS—Baranov
Tallawang Fe skarn, Gulgong, NSW—Ayshford
Talysh zone, Azerbaijan—Panina
Tampico-Misantla oil Basin, Mexico—Pottorf
Tanzania xenoliths—Rehkämper
Tauern window, Austria—Hasenberger
Tavetsch Kakirites, Swiss Alps—Wyder
Taylorsville Basin, Virginia—Yi
Tellian Atlas oil, northern Algeria—Messelles
Tendaho geothermal, Ethiopia—Ruggieri
Tengiz oil field, Kazakhstan—Baskin, Hallager
Terra Nova oil, Jeanne d'Arc Basin, Newfoundland—Huang
Tervussky granite Massif, Priladozhie, CIS—Glebovitsky
The Geysers geothermal, California—Norman
Thomas Range topaz, Utah—Holzhey
Three Mile Hill Au, Australia—Brown
Timmins VMS, Canada—Schandl
Timna igneous complex, southern Israel—Vapnik
Tishinskoe WHMS, Rudnyi Altai, Russia—Vikentyev
Tiwi geothermal, Philippines—Moore, Norman
Tombstone-Tungsten Au-W-Sn-Cu, Yukon-Alaska—Baker, Lang
Tongan boninite—Danyushevsky
Toro Sandstone oil, Papua, New Nuinea—George
Touissit-Bou Beker MVT district, northeastern Morocco—Bouabdellah
Transcarpathian evaporites, Ukraine—Shaidetska
Transdanubian calcite dikes, Hungary—Demény
Triassic oil, Alberta—Kirste
Triassic oil, British Colombia—Kirste
Triassic salt domes, Tunisia—Charef
Triberg granite-Sn-Be, Schwarzwald, Germany—Markl
Troodos ophiolite, Cyprus—Danyushevsky, Petko, Portnyagin
Turon CaF_2, Southern Spain—Morales-Ruano
Tuscan nappe, Northern Apennines, Italy—Montomoli
Tuscarora Au-Ag, Nevada—Boden

U

Udachnaya kimberlite pipe, CIS—Kasimova, Tomilenko
Ukrainian evaporites—Petrichenko
Ukrainian Folded Carpathians—Bodnar
Ukrainian shield pegmatites—Matviyenko
Ulakan Formation ankaramite, Bali—Della-Pasqua
Ural pyrite, CIS—Baranov

Uzel'ginskoe Ural pyrite, CIS—Baranov

V
Valu Fa Ridge, Lau Basin—Kamenetsky
Vanuatu ankaramite, Rinjani volcano, Lombok—Della-Pasqua
Variscan granites, Germany—Thomas
Veintiuno Cu, Northern Chile—Sierra
Verbano zone granulites, northern Italy—Harlov
Vergenoeg CaF_2-Fe, Bushveld Complex, South Africa—Borrok
Verkhneurálsky VHMS, CIS—Baranov, Naumov, Sushchevskaya
Vesuvius, Italy—Belkin, Fulignati, Marianelli
Viburnum Trend MVT Mo—Chi
Viet Nam lamproite—Hòa
Villa Senni volcano—Freda
Viola Formation, Kansas—Newell
Virginia City Au, Madison County, Montana—Lockwood
Vitim Plateau basanite, Siberia—Litasov
Vitkov II U, Czech Republic—René
Vivero fault, NW Spain—Canals
Vizcachitas porphyry Cu, Chile—Willard
Volyn pegmatites, Kazakhstan, CIS—Kozlov
Vulcano Island geothermal, Aeolian Islands, Italy—Bolognesi, Capasso, Voltaggio
Vyhne-Klokoc Fe skarn, Western Carpathians, Slovakia—Kodera

W
W. Australia lamproite—Sharygin
W. Kimberley lamproite,Wyoming—Sharygin
W. San Martin W, Argentina—Gomez
Wadi Allaqi Au, Egypt—El Kazzaz
Waisoi porphyry Cu, Namosi, Fiji—Ellis
Warrabarty Zn-Pb, W. Australia—Smith
Watersville limestone, Maine—Bickle
Wawa Au, Ontario—Samson
WD-1a borehole, Kakonda geothermal, Japan—Ohtani, Sawaki
Weissecks CaF_2, Salzburg, Austria—Koss
Wendeng Au, Shandong, PRC—Xu
Wenyu Au, PRC—Jiang
West Asturian Leonese Au, Spain—Tornos
West Greenland komatiite—Appel
West Kungnat syenites, Greenland—Hodson
West Ozërnyi Ural pyrite, CIS—Baranov
West Qinling Au, PRC—He, Liu
Western Azov Sea Au, Russia—Voznyak
Western Carpathians greenschist—Hurai
Western Victoria xenoliths, Australia—Yaxley
Westonia Au, Australia—Cassidy
White Island, New Zealand—Rapien
Wiluna Au, Australia—Brown
Windermere Supergroup, Canadian Cordillera—Nesbitt
Witwatersrand Au, S. Africa—Chupin, Coetzee, Frimmel
Witwatersrand zircon, S.A.—Chupin
Woodcutters' Pb-Zn-Ag, Northern Territory, Australia—Giles
Woodlawn VHMS, NSW Australia—Lusk
Wutai Mountain Au, PRC—Liu
Wuxi Au-Sb-W, Hunan, China—Hu

X
Xianghualing Nb-Ta, PRC—Qiu
Xiaoqinling Mtns. Au, PRC—Xu
Xiazhuang U, PRC—Liu
Xifanping porphyry Cu, Sichuan, PRC—Chen, Xu
Xihuashan-Dangping W-Be, south China—Liu
Xikeng pegmatite, Fujian, PRC—Li
Xinqiao skarn Au, Anhui, PRC—Zhao
Xinzhou Au, Guangdong, PRC—Yao

Y
Yakutian kimberlites diamonds, Russia—Barashkov, Bratus', Tomilenko
Yamagata Prefecture, Japan—Ohtani
Yangbin Sn porphyry, Zhejiang, PRC—Chen
Yangtze Permian reef, PRC—Shen
Yanyuan Co., Sichuan, PRC—Chen
Yauli Dome polymetallic, Peru—Lavado
Yellowstone National Park geothermal, Wyoming—Lewis
Yemen spinel lherzolites—Chazot
Yerington porph-Cu—Hedenquist
Yishui polymetallic, Guangdong, PRC—Liu
Yunnan stratabound Pb-Zn-(F-Ba), PRC—Zhang

Z
Zabargad Island (Red Sea rift, Egypt)—Boullier, Trieloff
Zacatecas polymetallics, Mexico—Norman
Zaghouan CaF_2-polymetallic, PRC—Souissi
Zaghouan fluorite, Tunisia—Souissi
Zechstein evaporites, Germany—Prohl
Zentnev granulites/eclogites, Pamir, Russia—Chupin
Zgounder Ag, Anti-Atlas, Morocco—Essarraj
Zhangquan Zhuang Au, Hebei, PRC—Li, Shi
Zhejiang Au-Ag, PRC—Chen, Pirajno
Zhilingtou Au-Ag, PRC—Chen, Xu
Zimapán Pb-Zn-Ag, Mexico—Dubois
Zimipán As, Hidalgo, Mexico—Moran

Index of Non-first Authors

First authors are found alphabetically in Abstracts and Citations. Note: see caveats about the spelling of authors' names on page 1.

A
ABART, R. 90, 95
ABBES, Ali 35
ACHTERBERGH, E. van 166
ADSHEAD, N.D. 226
AFANAS'EVA, Z.B. 13, 14
AGAR, S.M. 147, 148
AI, Tianjie 113
AI, Xia 58
AILERU, O.O. 152
AISSA, M. 204
AKÄAY, Migrac 200
AKBÁROV, Kh.A. 130
AKINFIEV, N.N. 13, 191
AL-AASM, I.S. 210
ALBINSON, Tawn 145
ALDERTON, D.H.M. 147
ALECHINE, Alexei 34
ALIOTTA, Guida 71
ALLÉGRE, C.J. 136
ALMINAS, H. 79
ALMODÓVAR, G.R. 198
ALTHAUS, Egon 84, 93
AMANOR, J.A. 147
AMBATS, G. 92
AMETRANO, S. 56
ANDERSON, A.J. 98, 128
ANDERSON, I.K. 42
ANDRESEN, Bjørg 139
ANDREWS, J.N. 155
ANGELL, C.A. 157
ANH, T.T. 83
ANÍKINA, E.Yu. 23
ANOVITZ, L.M. 19
ANSDELL, K. 99
ANTONIO, M.R. 189
APLÁTOV, V.V. 23
APLIN, A.C. 121
APODACA, L.E. 110
ARANYOSSY, J.-F. 171
ARBOLEDA, C. 68, 226
ARCOS, D. 55
AREHART, G.B. 38
ARELLANO, V.M. 14, 87
ARGOUARC'H, Yann 124
ARGUNOV, K. 146
ARGUNOV, K.P. 26
ARISKINA, Oksana 73
ARRIBAS, A. 8, 81
ASHIKHMINA, N.A. 165
ASHLEY, Paul 54
AUDETAT, Andreas 75
AUMÂITRE, Roland 153
AUZENDE, J.-M. 64
AXEN, G.J. 177, 208
AYERS, J.C. 109
AYORA, C. 6, 32, 57, 179, 190
AYT OUGOUGDAL, Mohammed 32, 74, 124, 144
AYUSO, R.A. 44, 59

B
BABÁNSKY, A.D. 185
BABICH, V 22
BACHILLER, N. 119
BAGAS, Leon 155
BAILLY, Laurent 111
BAKER, M.B. 83
BAKER, T. 108
BAKKER, R. 204
BAKUMENKO, I.T. 183
BALLHAUS, C. 128
BALLURKAR, Ashok 138
BANKS, D. 126, 204
BANKS, David 9, 32, 55, 74, 124
BANTIGNIES, J.-L. 155
BARANOV, E.N. 190
BARANOV, Eduard 141
BARBANSON, L. 55, 136
BARBIERI, M. 205
BARFOD, Dan 161
BARNES, S.J. 79
BARRES, Odile 156
BARSUKOV, V.L. 166
BARTHOLOMEW, M.J. 57
BARTLEY, J.M. 47
BARTON, Erika 38
BARTON, Jay 38
BARTON, M.D. 87
BAS, Bulent 168
BASKIN, D.K. 77
BASSETT, A.M. 183
BASSETT, W.A. 175
BAU, M. 88
BEAUCAIRE, C. 171
BEAUFORT, Daniel 153
BECHSTÄDT, Thilo 22
BEHRENS, H. 47
BEILI, Zhang 174
BELKIN, H.E. 44, 159, 191, 192
BELL, K. 169
BENOIT, Dick 120
BENVENUTI, M. 40
BENVENUTI, Marco 166
BENY, Claire 165
BERGSTRÖM, S.M. 85
BERNHARDT, H.-J. 174
BERSHOV, L.V. 72
BETHKE, P.M. 42
BETZ, Heidi 181
BEVINS, R.E. 3
BEZÁK, Vladimír 86
BI, Chengsi 224
BI, Xiangwu 84
BIAN, Qiantao 190
BJERG, E.A. 201
BJØRLYKKE, Knut 211
BLACK, Stuart 44
BLAZHKO, V.I. 60
BLAZHKO, Vladimir 109
BLEEKER, Wouter 173
BLENCOE, J.G. 6, 175, 176
BLENKINSOP, T.G. 175
BODINIER, J.-L. 65
BODNAR, R.J. 26, 43, 81, 82, 106, 121, 160, 165, 167, 174, 178, 188
BOER, Rudolf 23
BOGDANOV, Yu.A. 24
BOIRON, M.-C. 5, 9, 32, 55, 63, 64, 65, 74, 112, 124, 126, 134, 135, 137, 144, 145, 155, 200, 204, 159,
BOLAND, M. 210
BONHOMME, Michel 153
BONI, Maria 152
BORIC, Ricardo 222
BORISENKO, A.S. 23
BOROVIKOV, A. 22
BÓRTNIKOV, N.S. 228
BOSAK, Pavel 189
BOTH, R.A. 93
BOTKUNOV, A.I. 185
BOTTAZZI, P. 160
BOTTINGA, Y. 173
BOTTRELL, S.H. 41, 77
BOUDIER, Françoise 25
BOY, A.E. 41
BOYCE, A 210
BOYCE, A.J. 29, 118, 120
BOYCE, Adrian 21, 22, 69, 187
BOYD, S.R. 31
BRAITHWAITE, C.J.R. 164
BRANCA, M. 205
BRANDSTÄTTER 12
BRANNON, J.C. 189
BRAUN, J.J. 149
BRAY, A.M. 205
BRAY, C.J. 43, 72, 163
BREITER, K. 177
BREITHAUPT, Angela 93
BREY, G.P. 187
BRIL, H. 159
BRIL, Hubert 153
BROMAN, C. 18
BROMAN, Curt 114
BROWN, A.C. 24
BROWNE, P.R.L. 182
BRUTON, C.J. 136
BUCHANAN, D.L. 139
BUCHER, Kurt 125
BUICK, I.S. 31
BÜKER, Carsten 90
BUKIN, G.V. 183
BUKOWSKI, Krzysztof 64
BURKE, E.A.J. 4
BURNARD, P. 84
BURNARD, P.G. 29
BUSLAEVA, E.Yu. 28
BUSSELL, M.A. 48
BUSSY, F. 125
BUTTERMORE, L.G. 205
BUYKO, A.K. 157

C
CABENA, L. 54
CABY, R. 58

CALDANARO, A.J., Jr. 52
CAMPBELL, A.R. 143
CAMPBELL, I.H. 67, 150, 207
CANALS, Àngels 30
CANALS, Martin 50, 144, 156
CAO, Jianjing 220
CARDELLACH, E. 30, 199
CARDELLACH, E. 30
CAREY, P. 210
CAREY, Paul 26
CARR, G.L. 75
CARROLL, M.R. 42
CARTER, J.L. 109
CASQUET, C. 10, 11, 119
CASSIDY, K.F. 132
CASTOR, S.B. 82
CASTORINA, F. 205
CASTROVIEJO, Ricardo 46
CATHELINEAU, M. 64, 65, 126, 159, 204
CATHELINEAU, Michel 5, 9, 10, 32, 55, 74, 88, 112, 124, 135, 137, 144, 200
CAVARRETTA, G. 191, 192
CENDÓN, D. 190
CENDON, Dioni 179
CHADWICK, T.H. 187
CHALAIN, J.-P. 78
CHAMBERLAIN, C.P. 41
CHAMPAGNON, B. 35
CHANG, H. W. 97
CHANG, Hailiang 159
CHANG, Sihe 116
CHANG, Xiangyang 158
CHANG, Xu 115
CHANNER, D.M. DeR. 43, 163
CHAPMAN, H.J. 18
CHAPMAN, L.H. 212
CHARLOU, J.-L. 64
CHARLOU, J.L. 88
CHAROY, B. 68
CHASHCHUKHIN, I.S. 100
CHATZIKIRKOU, A. 132
CHAUSSIDON, Marc 76, 174
CHEBOTAREV, Mihail 8
CHEILLETZ, A. 68, 226
CHEKHMIR, A. 120, 142
CHELIOTIS, I. 94
CHEN, G.-H. 223
CHEN, Jun 206
CHEN, Xiaoming 36
CHEN, Ziliao 178
CHENERY, Simon 179
CHENG, Jingping 113, 133
CHENG, Keming 207
CHENG, Zhongmei 225
CHEPUROV, A.I. 194
CHEPUROV, Anatoly 196
CHEREVICHNAYA, L.F. 72
CHERNYSHEV, I.V. 101
CHEVALIER, P. 131
CHEVALLIER, P. 131
CHEVYCHELOVA, T.K. 37
CHIBA, Hitoshi 64
CHOÏ, C.G. 204
CHOI, S.-H 184
CHOMIAK, Beverly 145
CHOU, I.-M. 43, 175
CHRYSSOULIS, S.L. 147
CHU, H.-T 221
CHU, Xuelei 115
CHUCHLA, R.J. 157
CHUN, M.-K. 192
CHUPIN, V.P. 38
CHUPIN, Vladimir 39, 108
CIONI, R. 124
CLAGUE, D.A. 47
CLARK, A.H. 99
CLARK, J.R. 192
CLINE, J.S. 211
CLOCCHIATTI, R. 123, 201
CLOCCHIATTI, Robert 174
CLYNNE, M.A. 118
COGET, P. 68
COLWELL, Frederick 193
CONKRIGHT, M.E. 167
CONSTANDINIDOU, E. 94
COOK, N.J. 206
COOKE, D.R. 15, 55
CORRETGE, L.G. 7
COVENEY, R.M., Jr. 118
CRAW, Dave 41
CRAWFORD, A.J. 55, 91
CROSSING, J. 94
CUESTA, A. 7
CUIGNET, M. 3
CUNEY, M. 126
CUNEY, Michel 34, 102, 134
CZABO, Csaba 160

D
D'ALESSANDRO, Walter 3
da SILVA, M.R.R. 17
DAHLBERG, E.H. 79
DALE, Jason 191
DANDURAND, J.L. 186
DANYUSHEVSKY, L.V. 157
DARDENNE, M.A. 61
DARLING, R.S. 82
DAWSON, J.B. 161
DE CAPITANI, Christian 138
de DONATO, Philippe 156
de PARSEVAL, Philippe 134
de RONDE, C.E.J. 34
de VIVO, Benedetto 15, 152, 159, 198
Del ROCIO TELLO, M. 14
DELOULE, Etienne 174
DEMICCO, R.V. 220
DEMIKHOV, Yu.N. 60, 180
DEMIKHOV, Yuriy 109
DEMIN, Sergey 183
DENG, Jian 37
DePAOLO, D.J. 92
DESROCHER, S. 95
DESSÌ, Roberto 166
DIAMOND, L.W. 154
DINGWELL, D.B. 172
DISNAR, J.R. 149
DOBES, P. 52, 53, 189, 222
DOMINGUEZ, E. 33
DOMINGUEZ, Eduardo 65
DORA, O.Ö 149
DÓRIA, Armanda 74, 145
DOROFEEVA, V. 142
dos SANTOS, R.B. 17
DOSTAL, J. 99
DOWLING, S.M. 85
DRAKOPOULOS, M. 155
DU Shaohua 159
DU, Jiafeng 81
DUBESSY, J. 126
DUBESSY, Jean 20, 32, 87, 134, 156, 158, 192
DUBOIS, M. 170
DUFFIELD, W.A. 118
DUGGAN, James 137
DULSKI, P. 177
DUMAS, Paul 75
DURISOVÁ, J. 47
DZHILI, Khi 130

E
EADINGTON, P.J. 66, 105, 198
EARLS, G. 26, 210
EBIHARA, M. 169
ECHEVESTE, H. 56
EFIMOVA, E.S. 185
EGGINS, Stephen 91
EHL, Jürgen 43
EICHELBERGER, J.C. 128
EISENBERG, L.I. 66
EL BOUKHARI, Abdelmajid 55
ELEFTHERIADIS, G. 201
ELIE, Marcel 10
ELLIS, P. 109
ELLWOOD, A. 92
ELSON, H.B. 82
EMSBO, Poul 203
ENKIN, R. 96
ERNST, W.G. 114
ESSENE, Eric 23
EVANS, W.C. 92
EWERS, G.R. 132

F
FABRE, Cécile 20, 134
FALLICK, A.E. 18, 29, 41, 118, 120, 147, 161
FALLICK, Anthony 21, 22
FALLICK, T. 210
FALLICK, Tony 26, 69, 88, 187
FALLOON, T.J. 42, 221
FALSTER, A.U. 208
FAN, Guang 149
FAN, Hongrui 216
FAURE, K. 133
FAURE, Kevin 43
FAUZI, H. 185
FAVARA, Rocco 31
FEDESEJEV, V. 111
FEDOROV, I.I. 186
FEELY, M. 131, 146, 147
FEELY, Martin 88, 136
FENG, Qiao 116, 117
FENOLL HACH-ALÍ, P. 58, 136, 150
FÉRAUD, G. 155
FERNANDEZ, N.C. 117
FERNANDEZ, R.R. 172
FERRY, J.M. 18
FINK, J. 142
FIRDAOUS, Karima 25
FITCHEN, W.M. 157

FITTON, J.G. 161
FLEHOC, Christine 3
FLEXSER, Steven 40
FLOHR, M.J.K. 59
FOLEY, S.F. 187
FOMIN, Yu.A. 180
FOMIN, Yuriy 109
FONTAN, F. 68
FOORD, E.E. 34, 79, 208
FORD, Derek 50
FORNARI, D.J. 205
FÖRSTER, H.-J. 209
FORSYTHE, L.M. 187
FORTUNÉ, J.P. 186
FOSTER, D.A. 15
FOSTER, F. 187
FOSTOUKOS, D. 132
FOUILLAC, A.M. 153
FRANCE-LANORD, C. 68
FRANZ, Gerhard 227
FRANZ, L. 78
FRASER, D.G. 213
FREDERICKSON, Christian 93
FREI, Robert 155
FREZZOTTI, M.L. 123
FRICKE, K. 128
FRICOVA, Alexandra 222
FRIEDMAN, G.M. 93
FRIMMEL, H.E. 140
FRISCHKNECHT, R. 9
FRISCHKNECHT, Rolf 75
FRITZ, Bertrand 170
FRITZ, Peter 117
FROGNER, Paul 114
FRYDA, J. 177
FRYDA, Jirí 27
FU, Dexin 216
FU, Jiamo 216, 226
FU, Shigu 37
FU, Xijie 221
FUERTES, M. 33
FUJIMOTO, K. 147, 148, 170
FURMAN, F.C. 93
FYFE, W.S. 132, 155

G
GAETA, M. 61
GAILLOT, Philippe 43
GALABURDA, Yu.A. 205
GALDOBINA, L.P. 28
GALINDO, C. 10, 11
GALLAGHER, V. 146
GALLASTEGUI, G. 7
GALLEGO, M. 149
GALLOWAY, Simon 208
GAMO, T. 144, 218
GAMYÁNIN, G.N. 23
GANCHIN. Y.V. 184
GANDHI, S.M. 84
GARBER, R.A. 14, 77
GARCIA, Eugenia 145
GARCÍA-VEIGAS, J. 190
GARIÉPY, C. 31
GARLICKI, Aleksander 201
GAROFALO, Paolo 166
GARTZ, V.H. 62
GASQUET, Dominique 44
GATTER, István 46, 135
GAUTHIER-LAFAYE, F. 126
GEMMELL, Bruce 55
GEMMELL, J.B. 93
GENINI, A. 172
GEUKENS, F. 224
GHAZBAN, Fereydoun 136
GHAZI, A.M. 54
GHAZI, M.A. 34
GHIURCA, Virgil 12
GIAMMANCO, S. 42
GIARD, D. 68
GIBERT, F. 131
GIONCADA, Anna 63
GIRNIS, A.V. 199
GIULIANI, G, 226
GIULIANI, Gaston 60
GNILUSHA, V.A. 158
GOFF, S. 44
GOKO, Kazunori 171
Gold Research Team 156
GOLDBERG, S.G. 194
GOLDHABER, M.B. 26, 156
GOLDSTEIN, Arthur 68
GOLDSTEIN, Robert 210
GOLIÁS, V. 53
GÓLUBEV, V.N. 3
GOLUBEV, Viatcheslav 34
GORBATY, Yu.E. 21
GORYAINOV, S. 146
GOTTSCHALK, Matthias 227
GÖTZINGER, M.A. 100
GRAHAM, C.M. 54
GRAHAM, D.W. 28
GRAHAM, James 221
GRANDE, Tor 157
GRAVES, M.C. 222
GRAY, D.R. 15
GRAY, G.G. 157
GREEN, D.H. 147, 221
GREEN, Darryl 137
GREEN, T.H. 1, 49
GREENWOOD, P.F. 66
GRICHUK, D.V. 200
GRIFFIN, W.L. 185
GRIME, G.W. 213
GROSSMAN, E.L. 111
GROVE, M. 92
GROVES, D.I. 66
GRUM, W. 129, 130
GU, Xuexiang 115
GÜBELIN, E.J. 183
GUGGENHEIM, R. 153
GUHA, Dipayan 43
GUIBINGA, A. 51
GUILLAUME, Damien 67
GUNTHER, D. 172
GÜNTHER, D. 9
GUO, Hongzhong 113
GUO, Hui 225
GURNEY, J.J. 45
GURURAJAN, N.S. 160
GUTIÉRREZ, A.G. 71

H
HAGEMANN, S.G. 27, 31
HAJIKAZEMI, E. 67
HALBACH, P. 149
HALBACH, Peter 119
HALL, A.J. 41, 42
HALLAGER, W.S. 14
HALLIDAY, A.N. 161
HALLS, C. 48
HALLS, Chris 40
HALTER, W. 99
HAMANO, Koji 141
HAMEG, Ahmed 61
HAMILTON, P.J. 66
HAN, S.-J. 223
HAN, Xiuli 112
HANSEN, B.T. 117
HANSEN, E.C. 79
HAO, Yanli 36
HARAYAMA, S. 170
HARLEY, S.L. 31
HARRIS, J.W. 31, 45, 187
HARRIS, P.M. 14, 77
HARRISON, T.M. 92
HART, R.J. 42
HART, S.R. 167
HARTE, B. 147
HARTMAN, B.H. 160
HARTMANN, L.A. 132
HARWOOD, G.M. 112
HASZELDINE, R.S. 42, 120
HAURI, H. 167
HAYASHI, M. 191
HAYNES, J.T. 54
HE, Mingyue 207
HEDENQUIST, J.W. 7, 180
HEFTON, K.K. 129
HEIN, U.F. 223
HEINHORST, J. 111
HEINRICH, C.A. 9, 29, 75, 166
HEINRICH, Wilhelm 227
HEIZLER, M.T. 56, 82, 136
HELGESON, H.C. 4, 156, 190
HEMLEY, R.J. 90
HENDERSON, I. 12
HENRY, C.D. 19
HERRINGTON, Richard 69
HERVIG, R.L. 165, 211
HERVIG, Richard 102
HEUMANN, Rebecca 32
HICKEY, K.A. 16
HICKMAN, A.H. 155
HICKMAN, S.H. 15
HIGUCHI, T. 147, 148
HIGUCHI, Takayuki 147
HILLAIRE-MARCEL, C. 31
HIRAI, Hidekazu 141
HIROSE, Kei 180
HIYAGON, H. 144, 169
HLADIKOVA, Jana 189
HODGES, Kip 106
HOFSTRA, A. H. 110, 203
HOINKES, G. 90
HOLDSTOCK, M.P. 146
HÖLL, R. 118
HÖLL, Rudolf 54
HOLLOWAY, J.R. 92
HOLM, P.E. 168
HOLMGREN, C. 95
HOLTZ, F. 47
HOLTZ, François 174
HONDA, M. 127
HOPPE, Peter 160

HORITA, J. 6
HORN, I. 187
HORN, Ingo 4
HORSTAD, Idar 191
HOYNE, B. 95
HU, Kai 222
HU, Ruizhong 17
HUANG, H.-L. 78
HUANG, Huilan 34, 91
HUANG, X. 85
HUILAN, Huang 77
HUMBERT, Franck 126
HUNNS, S.R. 93
HUNZIKER, J.C. 126
HURAIOVÁ, Monika 86
HUSTON, D.L. 132
HUTCHEON, I. 95
HUTCHEON, I.D. 92
HUTTON, D. 210
HUTTON, Donnie 26, 210
HYODO, M. 172

I
IGNATIKOV, Evgeny 8
IHINGER, Phil 227
IKEUCHI, Jun 91
INGUAGGIATO, Salvatore 31
IRVING, E. 96
ISHIBASHI, Junichiro 64
ISHIHARA, Shunso 141
ISLAM, R. 167
ISTRATE, George 93
ITO, H. 147, 148
ITO, Y. 218
IVANOV, Boris 128
IVANOV, D.A. 210
IVANOV, M.V. 182
IVANOVA, G.F. 13, 14
IVANOVICH, Miro 117
IZAWA, E. 56, 80, 81

J
JACKOVA, Ivana 189
JACKSON, S.E. 191
JACKSON, Simon 4
JACQUOT, Emmanuel 170
JAGOUTZ, Emil 54
JAMES, R. 44
JAMIESON, D.N. 166
JANARDHAN, A.S. 79
JANICKE, J. 198, 199
JARMERSTED, C.S.-V. 149
JARMOLOWICZ-SZULC, K. 102, 103
JAVOY, M. 31
JAVOY, Marc 88
JEAN-BAPTISTE, Philippe 3
JEFFREY, C.A. 153
JELEN, Stanislav 76, 100
JENKIN, G.R.T. 147
JESSBERGER, E.K. 198, 199
JI, J.-F. 206
JIN, Chiyao 37
JIN, Guangfu 36
JIN, Kuili 113
JOCHUM, Johannes 160
JOHNSTON, D. 210
JOHNSTON, Dave 26, 57
JONES, A.G. 76
JONES, Martin 191
JONES, P.C. 135
JONSSON, E. 18
JUDE, R. 39
JUHASZ, Attila 198
JUTEAU, T. 122
JUVE, Gunnar 109

K
KAINDL, R.A. 95
KALTOFT, Kristian 154
KALYUZHNYI, V.A. 51
KAMENETSKY, V.S. 157
KAMENETSKY, Vadim 221
KAMINSKY, F.V. 185
KANDUTSCH, Georg 79
KANIS, Jan 229
KANISAWA, S. 170
KAPPLER, Paul 222
KAROLI, Stanislav 52, 64
KARPHUKHINA, Valentina 141
KARPUKHINA, V.S. 12, 190
KARSAKOV, L.P. 16
KÁZMER, Miklós 46
KEMP, A.J. 112
KEMPE, U. 72
KENDALL, A.C. 112
KENNAN, P.S. 136
KENNEWELL, P. 132
KENT, A.J. 15
KEPPENS, E. 138
KEPPLER, Hans 178, 202
KERRICH, Robert 99
KESLER, Stephen 23
KHARAKA, Y.K. 92
KHIN Zaw 86, 166, 185
KHOLMOGOROV, A.I. 22
KIEFERT, Lore 78, 174
KIHLE, Jan 139
KILIAS, S.P. 8
KIMURA, J. 87
KIMURA, Shigeo 91
KING, H.E., Jr. 182
KINZLER, R.J. 209
KIRCHNER, E.Ch. 79
KIRSCHNER, D. 125
KISELËVA, G.D. 202
KISLOV, E.V. 98
KISSIN, S.A. 129
KLEMD, Reiner 129
KLEMM, W. 193
KLING, M. 118
KLUG, B. 84
KNIGHT, J.T. 213
KNYAZEVA, S.N. 166
KO, H.K. 110
KOEBERL, Christian 16
KOGISO, Tetsu 191
KOISHIKAWA, A. 141
KOLATA, D.R. 85
KOLPAKOVA, N.N. 13
KOMATSU, Ryo 139
KOMIYA, Tsuyoshi 180
KOMNINOU, Ali 74
KONECNY, Patrik 86, 87
KONNERUP-MADSEN, J. 94
KONONKOVA, N.N. 5, 194, 199
KONTAK, D.J. 78
KONTOROVICH, Alexei 73
KOOI, Eline 93
KOONS, P.O. 41
KOTEL'NIKOV, A.R. 100
KOTELNIKOVA, Z.A. 60
KOTOV, N.V. 157
KOTULOVA, Julia 186
KOUZMANOV, Kalin 21
KOVALENKER, V.A. 76, 94
KOVALENKO, N.I. 167
KOVALENKO, V.I. 5, 142, 199
KOVALEVA, V.F. 158
KOVALEVICH, V.M. 154
KOVALEVSKI, V.V. 28
KOZAR, M.G. 157
KOZLOWSKI, A. 213
KOZLOWSKI, Andrzej 110, 203
KRAMERS, J.D. 155
KRAVCHENKO, G.L. 205
KREMENETSKY, A.A. 72
KRIEGER, F.W. 66
KRIEGSMAN, Leo 20
KRINOV, D.I. 24
KRISHNA, R.N. 141
KROGER, Yves 160
KROUSE, H.R. 120, 164, 218
KRSTIC, Dragan 93
KRUK, N.N. 193
KRYLÓVA, T.L. 3, 24, 202, 203
KUHLEMANN, Joachim 222
KUHS, W.F. 35
KULCHYTSKA, Anna 205
KULIS, J. 193
KUN, Shen 18
KUNZ, J. 136
KURAT, G. 97, 198, 199, 201
KUROVSKAYA, N.A. 122
KUSAKABE, Minoru 146
KUZ'MIN, V.I. 28
KUZ'MINA, T.M. 158
KUZMIN, Dmitri 39
KYLE, P.R. 56
KYSER, T.K. 96

L
LABUDIA, C.H. 201
LACOUR, J.-L. 134
LAHSEN, A. 150
LAMB, W.M. 111
LANDIS, G.P. 110
LANG, J.R. 11
LAPINA, M.I. 72
LAPLACE-BUILHE, Corinne 156
LAPORTE, Didier 67
LARDEAUX, J.-M. 155
LARESE, R.E. 77
LARGE, R.R. 93
LARGHI, Laurence 50
LARTER, S.R. 16, 121
LARTER, Steve 191
LASARENKO, H.E. 60
LATTANZI, P. 40
LATTANZI, Pierfranco 121, 166
LAW, R.D. 26, 167
LAWRIE, K.C. 132
LEACH, D. 53
LEACH, D. L. 26, 104

LEACH, David 48
LeBOUTILLIER, N. 48
LÉCOLLE, P 26
LECUYER, C. 122
LEDÉSERT, B, 170
LEE, H. 192
LEE, Insung 152
LEES, B.K. 95
LEGG, I. 210
LEGG, Iain 26
LEGRAND, F. 131
LEGRAND, J.M. 186
LEHMANN, B. 46
LEITE, J.A.D. 79
LEMON, N.M. 163
LEMPP, Christof 84
LENTZ, David 72
LEOST, I. 159
LEROY, J.L. 5, 170
LEROY, Jacques 112
LESPINASSE, Marc 5, 170
LEWIS, Stephanie 84
LEXA, Jaroslav 96
LI, Anren 225
LI, Chunfang 214
LI, Cunyou 179
LI, Lizhu 217
LI, Mingbi 215
LI, Tongjin 223
LI, Wen 113
LI, Wenhou 116, 117
LI, Xueli 116
LI, Yuanlin 116
LI, Yuansheng 119
LI, Zhaonai 214, 224
LIANG, Huaying 133
LIANG, Long 61
LIE, Lihong 113
LILLEY, M.D. 205
LIN, Maoqing 144
LIN, Qianlong 224
LIN, Wenwei 224
LIN, Yuping 217
LIN, Zhuoran 57
LIOU, J.G. 147
LISENBEE, A.L. 40
LISK, Mark 66
LITASOV, Y.D. 114
LITOVCHENKO, Anatolyj 205
LIU, Bin 179
LIU, Changshi 36
LIU, Deliang 224
LIU, Jiajun 115
LIU, Jianming 115
LIU, Jinxuan 112
LIU, Jinzhong 226
LIU, Keming 58
LIU, R. 78
LIU, Ruoxin 57
LIU, Wei 115, 223
LIU, Wenjun 22, 225
LIVINGSTON, Eric 26
LOBZIN, E.V. 28
LOGAN, M.A. 42
LOGVENCHEV, Peter 149
LONDON, David 87
LONGERICH, H.P. 191
LÓPEZ, J.A. 64, 65, 126
LÓPEZ, José 145
LORAND, J.-P. 174
LOREDO, J. 150
LOREDO, Jorge 65
LOTTERMOSER, B.G. 119
LOUCKS, R.R. 15, 150
LOUVAT, D. 171
LOWRY, David 36
LOZANO, R.P. 123
LU, Fengxiang 225
LU, H.-Z. 18
LU, Jialan 226
LU, Jianjun 217, 222
LU, Junming 178
LU, Qi 115
LU, R. 90
LU, Wanjun 64
LU, Xinbiao 207
LUEDERS, V. 88
LUNAR, R. 181
LUNAR, Rosario 149
LUO, Yaonan 217
LUPULESCU, M. 39
LUQUE, F.J. 14
LUSTENHOUWER, W.J. 62
LUXORO, S.S. 166

M
MA, D.-S. 149
MA, Liyan 119
MACDONALD, Ray 44
MACHEL, H.G. 74
MAEDA, S. 191
MAEKAWA, T. 170
MAGYAR, Julius 186
MAINERI, Cinzia 63
MAKHMUDOV, S.A. 151
MAKINO, Kuniaki 170
MAMEDOV, M.N. 151
MANANDHAR, M.N. 183
MANDEVILLE, C.W. 209
MANGAS, Jose 63
MAO, H.-k. 90
MAO, Yanhua 113
MARCOUX, Eric 111
MARIGNAC, C. 50
MARIGNAC, Christian 44, 200
MARIN, Yu.B. 103
MARINER, R.H. 92
MARSHALL, B. 68
MARSHINTSEV, V. 146
MARTELAT, J.-E. 155
MARTIN, R.F. 99
MARTIN-IZARD, A. 33
MARTIN-IZARD, Agustín 63
MARTINEZ, Estela 70
MARTINEZ, F.J. 30
MARTINEZ, Luis 149
MARTINEZ, S.R. 51
MARTINSSON, Olof 62
MARTY, Bernard 155
MARUYAMA, S. 114, 180
MAS, G.R. 71
MAS, Graciela 16
MASSARE, D. 123
MASSARE, Dominique 174
MAT'O, L'uboslav 76
MATEL, N.L. 158
MATHEZ, E.A. 209
MATSUMOTO, Taizo 218
MATSUNAGA, Isao 148
MATTER, Albert 90, 160
MATTEY, D. 11
MATTEY, David 36
MATTHEWS, Alan 11
MAUCHIEN, Patrick 134
MAYANOVIC, R.A. 4
MAYES, David 129
MAYEWSKI, Paul 111
McBIRNEY, A.R. 120
McCAIG, A.M. 12
McCARTHY, M.D.B. 41
McCUAIG, T.C. 92
McDERMOTT, F. 79
McDONALD, A. 44
McDOUGALL, I. 84, 127
McGEEHIN, J.P. 44
McINNES, B.I.A. 54
McINTOSH, W.C. 56, 82
McKIBBEN, M.A. 214
McKNIGHT, S.B. 165
McLEAN, Chris 208
McMILLAN, P.F. 157
McNAUGHTON, N.J. 66, 79
MEISSER, N. 125
MELFOS, V. 201
MÉNEZ, B. 155
MENZIES, Martin 36
MERNAGH, T.P. 93, 109
METCALF, R.V. 96
METZ, P. 104, 105
MEYER, H.O. 42
MEYERS, W.J. 119
MICHEL, G.W. 88
MICHELOT, J.-L. 171
MIKUCKI, E.J. 213
MIKULSKI, S.Z. 104
MILESI, J.-P. 111
MILLEDGE, H.J. 132
MIRONOVA, O.F. 13, 122
MIRONOVA, O.V. 24
MISHRA, Biswajit 75
MISI, Aroldo 108
MISRA, K.C. 189
MIURA, Hiroyuki 43
MIZUTA, T. 87
MOCHALOV, A.G. 200
MOISSETTE, Alain 20, 179
MOLES, N. 210
MOLES, Norman 26, 210
MOOKHERJEE, A. 151
MOON, C.J. 2
MOORE, J.N. 120, 145
MORALES-RUANO, S. 58, 159
MORAVEK, Petr 222
MOREIRAS, D.B. 123
MORGUNOV, K.G. 98
MORIN, Paul 198
MORITZ, Robert 156
MORRISON, Jean 108
MORSE, J.W. 111
MORTENSEN, J.K. 11, 108
MORTON, P. 79
MOTOMURA, Yoshinobu 80
MOTORINA, I.V. 151
MOUAWAD, F. 153

MOUNTJOY, E.W. 52, 73
MROCZEK, E.K. 38
MUCHEZ, P. 223
MUCHEZ, Ph. 182, 224
MUEHLE, K. 88
MUEHLENBACHS, Karlis 142
MUELLER, B. 212
MÜHE, Richard 91
MUKHOPADHYAY, P.K. 222
MULLIS, Josef 153, 215
MUNIZAGA, Francisco 222
MUNOZ, Margot 43
MURAO, S. 85
MURZIN, V.V. 242
MUSASHI, Masaaki 125
MUSSI, Mario 67
MYSTOWSKA-MAZUR, M. 105

N
NAAR, Joaquin 207
NABELEK, P.I. 182
NADEN, J. 94
NAGY, Bartholomew 164
NAKAJIMA, K. 169, 170
NAKAMURA, Eizo 89
NAKANO, Satoshi 97
NAKASHIMA, S. 218
NAKAYAMA, K. 133
NAKAYAMA, Ken 218
NATAU, Otfried 84
NAUMOV, V.B. 5, 24, 76, 101, 102, 122, 194
NAUMOV, Vladimir 102, 143
NAVON, O. 120
NEGRETTI, Laura 172
NEHLIG, Pierre 111
NERUCHEV, S.S. 98
NESBITT, B.E. 69
NEUMANN, E.-R. 62
NEUMANN, M. 111
NEUMAYR 117
NEWBERRY, R.J. 69
NEWMAN, Sally 102
NEWTON, R.C. 6, 79
NI, P. 157
NI, Pei 36, 179, 217
NIEDERMAYR, G 12
NIEZGODA, Halina 77
NÍKONOV, B.S. 202
NIMFOPOULOS, M.K. 132
NIVIN, V. 157
NOGUEIRA, Pedro 144
NOLTE, Eckehart 117
NORMAN, D.I. 136, 143
NORMAN, M.D. 92
NORONHA, Fernando 74, 137, 144
NÓSIK, L.P. 23, 24, 228
NOVGORODOVA, M.I. 28
NTAFLOS, T. 97

O
O'KEEFE, W.G. 146
O'REILLY, C. 131
O'REILLY, Cian 88, 135
O'REILLY, S.Y. 127
OBERTHÜR, T. 175
OFFIELD, T.W. 59
OFFLER, Robin 9
OHNSTON, Dave 210
OHTANI, T. 141
OJALA, V.J. 164
OKABE, Takashi 172
OKAJIMA, Atsushi 91
OKAMURA, Kei 64
OLIVO, G. 212
OLIVO, G.R. 169
ONSTOTT, T.C. 193
OOSTING, S.E. 205
ORESKES, N. 163, 178
ORSOEV, D.A. 98
ORTEGA, L. 181
ORTOLEVA, Peter 161
OSCARSON, R.L. 14
OSORGIN, N.Yu. 186
OTT, S. 95
OYARZUN, R. 181
OYARZUN, Roberto 149
OZKAN, H.M. 2

P
PAGEL, Maurice 2, 170
PAGLIARULO, Pietro 135
PAL'YANOV, Yu. N. 194, 195
PAL'YANOVA, G.A. 98
PALESSKII, S.V. 193
PALIN, J.M. 67
PALLADINO, D.M. 61
PALMER, James 136
PALMER, M.R. 112
PAN, Yuanming 59
PANCHAPAKESAN, V. 141
PANCZER, G. 35
PAONE, Angelo 44
PARADA, M.A. 150
PARAT, Abdukadir 207
PARELLO, F 3, 42
PARISI, Bianca 3
PARK, K.-H 152
PARNELL, J. 26, 135, 210
PARSONS, Ian 110
PASTERIS, J.D. 14
PATTRICK, R.A.D. 29, 87, 164
PAUER, F. 35
PEATE, D.W. 79
PEKDEGER, A. 149
PEN'KOV, V.F. 28
PENG, Songbai 159
PERDAHL, J.-A. 62
PERETTI, A. 74
PÉREZ-TORRADO, F.J. 123
PERKINS, E.H. 75
PERMANYER, A. 123
PERSON, Mark 198
PERTOLD, Z. 47
PERYT, T.M. 102, 154
PETER, J.M. 72
PETERSEN, O.V. 153
PETRICHENKO, O.I. 51, 52, 103
PETRONILHO, L.A. 66
PETROV, V.G. 83
PETSCH, E.J. 229
PEVIDA, L.R. 33
PFEIFER, H.-R. 126
PHILIPPOT, P. 131
PHILIPPOT, Pascal 172
PHUÓNG, N.T. 83
PICCARDO, G.B. 160, 172
PICHAVANT, Michel 174
PILLINGER, C.T. 133
PINEAU, Françoise 88
PIRONON, J. 126
PIRONON, Jacques 32, 55, 73, 87
PISOTSKII, B.I. 72
PITONAK, Pavel 186
PLOTNIKOV, A.M. 76
POBEREGSKI, A.V. 51, 52, 102, 154
POITRASSON, Franck 109
POKHILENKO, L.N. 194, 195
POLLARD, P.J. 49
POLOZOV, Alexandr 73
POLVE, Mireille 109
POLYA, D.A. 29
POLYKOVSKY, V.S. 130
POPOV, Vladimir 149
POPULUS, P. 131
POREDA, Robert 47
PORITSKAYA, L.G. 157
PORTUGAL, E. 14
POSPELOVA, L.N. 39, 193
POTY, B. 3
POTY, Bernard 9, 34, 74, 124
POWELL, J.W. 110
POWELL, T.S. 136
PRACEJUS, Bernhard 119
PRASOLOV, E.M. 98
PRESSL, M. 95
PRIETO, M. 150
PROCHASKA, W. 107
PROKOFIEV, Vsevolod 12
PROL-LEDESMA, R.M. 30
PRZYBYLO, Jerzy 64
PUDILOVÁ, M. 53
PUEYO, J.-J. 32
PUEYO, J.J. 190
PUIG, Carlos 139
PULHAM, A.J. 207

Q
QI, Jianzhong 216
QI, Shihua 206
QIAO, Junyi 218
QING, H. 85
QU, X.-M. 206
QUEZADA, R.A. 66
QUILEZ, E. 10, 11

R
RAKOTONDRAZAFY, Michel 134
RAMAMBAZAFY, A. 134
RAMBOZ, C. 58, 204
RAMSEYER, Karl 90
RANKIN, A.H. 96, 157
RED'KO, L.R. 227
REED, M.H. 121
REINECKE, T. 201
REJMER, J.J.G. 210
REN, S.K. 207
RENAC, C. 159
RENAC, Christophe 149
REPETSKI, J.E. 110
RHÉAUME, Pierre 37

RHEDE, Dieter 209
RHODES, A.L. 178
RIBERA, Fidel 197
RICE, C.M. 22, 187
RICE, J.M. 161
RICHARDSON, Mark 157
RICHMOND, Julie 212
RIERA KILIBARDA, C. 47
RINGELBERG, D.B. 143
ROBBIANO, Andrea 172
ROBERT, François 25
ROBERTS, S. 7, 140
RODAS, Magdalena 14
RODGERS, Andrew 135
RODRÍGUEZ, V T. 71
RODRIGUEZ-PEVIDA, L.S. 150
ROLANDI, Giuseppe 44
RONCHI, L.H. 114
ROSSEL, Laura 201
ROSSI, C. 123
ROSSMAN, G.R. 114
ROWAN, E.L. 110
ROWLEY, D. 11
ROYER, J.-J. 170
ROZHKOVA, N.N. 28
ROZKOSNY, Ivan 189
RUBIN, Meyer 44
RUCK, Régine 10
RUDINEC, Rudolf 186
RUFFET, R. 155
RUGE, H. 95
RUGGIERI, Giovanni 67, 135
RUI, Xingjian 37
RUMBLE III, D. 18
RUSINOV, V.L. 101, 102
RUSSEGGER, Barbara 160
RUTHERFORD, M.J. 209
RYÁBCHIKOV, I.D. 72, 185, 215
RYAN, C.G. 1, 49, 93, 185
RYE, D.M. 57
RYE, R.O. 42, 53
RYZHENKO, B.N. 105

S
SACHS, P.M. 79
SACHSENHOFER, R.F. 160
SÁEZ, R 198
SAFONOV, Yu.G 24, 101, 102
SAHU, K.C. 141
SAKHNO, Bogdan 128
SALAZKIN, A.N. 122
SALVIOLI MARIANI, E. 33
SAMORUKOVA, L.M. 69
SAMSON, I.M. 212
SANGSTER, D.F. 24
SANO, Y. 144, 218
SANTACROCE, R. 124
SANTOSH, M. 159
SANTOYO, Edgar 203
SAPARIN, G. 146
SARU, Denisa 39
SASADA, M. 148, 171
SASADA, Masakatsu 148, 172
SASAKI, Munetake 140, 172
SASAKI, S. 144
SASSANI, D.C. 181
SATO, H. 87
SATO, T. 170
SAVARD, M.M. 37
SAVARY, V. 51
SAVEL'EVA, N.I. 122
SAWAKI, T. 147, 148, 191
SAZÓNOV, V.N. 24, 228
SBRANA, Alessandro 63
SCAILLET, Bruno 174
SCHALAMUK, I. 56
SCHÄRER, Urs 54
SCHLATTER, Denis 154
SCHMINCKE, H.-U. 79
SCHMITZ, J. 84
SCHOCH, A.E. 39
SCHOONEN, M.A.A. 119
SCHOUTEN, Jan 93
SCHRIJVER, Kees 37
SCHROLL, Erich 160
SCHROVEN, K. 224
SCHUMACHER, J.C. 125
SCRIVENER, R.C. 48, 179
SEAL, R.R., II 59
SECCOMBE, P.K. 9
SEDLÁCKOVÁ, Vladimíra 48
SEDOVA, I.S. 69
SEGGIE, R.J. 163
SEITZ, J.C. 19
SELF, S. 213
SELLECK, Bruce 68
SELLSCHOP, J.P.F. 42
SELTMANN, Reimar 27, 209
SELVERSTONE, J. 208
SELVERSTONE, Jane 47
SENGUPTA, Pulak 43
SERENKO, Tom 40
SEVERSON, M.J. 79
SEWARD, T.M. 190
SEYFRIED, Jr., W.E. 17
SHAN, Qiang 113, 144
SHANG, Ruxiang 214
SHANKS, W.C., III 205
SHARMA, Rajesh 160, 182
SHARYGIN, V.V. 70
SHATSKY, Vladislav 196
SHAW, Harry 69
SHEBANIN, A.P. 22, 194, 195
SHEBANIN, Anatoly 196, 197
SHEETS, S. 163
SHELLEY, J.M.G. 150
SHELTON, K.L. 184
SHEN, Kun 115
SHEN, Shiliang 217
SHEN, Su 89
SHEN, Weizhou 36, 217
SHENG, Guoying 216
SHEPHERD, T.J. 94, 197
SHEPPARD, S.M.F. 35, 155
SHI, Jixi 226
SHI, Lida 112
SHI, Weijun 116
SHIBETSKY, Yu.A. 60
SHIBETSKY, Yuriy 109
SHIMIZU, N. 167
SHIMIZU, Nobumichi 180
SHINOHARA, H. 81
Shipboard Scientific Party
of the ManusFlux Cruise 64
SHIRONOSOVA, G.P. 98
SHITASHIMA, Kiminori 64
SHMULOVICH, K.I. 228
SHOCK, E.L. 190
SHTUKA, Arben 51
SHUN, Qing 217
SHVAROV, Yu.V. 167
SIE, S.H. 1
SIEMANN, M.G. 158
SIERRA, Josefina 8, 149
SILLITOE, R.H. 108
SILVA, D. 66
SIMMONS, Stuart 160
SIMMONS, W.B. 208
SIMON, Grigore 129
SIMON, Klaus 86
SIMOS, I. 94
SINTUBIN, M. 138
SIVTSOV, A.V. 72
SKIRROW, R.G. 132
SLACK, J.F. 59
SLOBODNIK, M. 138
SMAGUNOV, N.V. 191
SMIRNOV, S.Z. 70, 114
SMITH, J.G. 118
SMITH, Martin 221
SMITH, Sean 137
SNEE, L.W. 53
SNIGIREV, A. 155
SNOWDON, L.R. 187, 222
SOBOLEV, A. 144
SOBOLEV, N.V. 196
SODERHOLM, L. 189
SOKOLOV, S.V. 202
SOLER, A. 6, 55
SOLOVOVA, I.P. 143
SOLYANIK, Valentina 149
SONG, Zhijie 113
SÖNMEZ, N. 149
SONNET, Ph. 186
SPENCE, B. 95
SPENCER, R.J. 164, 218
SPERB, R. 1
SPIRIDONOV, A.M. 158
SPIRIDONOV, Ernst 12
SPIRO, B.F. 197
SPIRO, Baruch 2, 139
SPISIAK, Jan 186
SPIVACK, A.J. 25
SPOONER, E.T.C. 34, 43, 72, 163
STAHL, E. 84
STAHL, I. 200
STANISOVÁ, Nikol 48
STANLEY, C.J. 87, 212, 213
STANLEY, Chris 57
STASIUK, D.L. 85
STEIN, H.J. 53
STEPHENS, W.E. 118, 161
STEWART, M.A. 25
STICHLER, W. 149
STIEVENARD, M. 88
STIGLER, A. 118
STÖCKERT, Bernhard 73
STÖCKHERT, B. 107
STOECKHERT Bernhard 175
STOECKHERT, B. 201
STOLPER, E.M. 54, 83, 92
STRAND, L. 53
STUART, Fin 69

STUMPFL, E.F. 107, 129, 130
STURCHIO, N.C. 112
SUAREZ, O. 7
SUCHY, Václav 48
SUISINOV, Kubentay 14, 77
SULLIVAN, G.E. 14
SUMMA, L.L. 9
SUN, Dazhong 158
SUN, Duzhong 158
SUN, Guiying 223
SUN, Shihua 115
SUN, Zhanxue 116
SUSHCHEVSKAYA, T.M. 12
SUTHERLAND, F.L. 132
SUTTON, S. 189
SVERJENSKY, D.A. 181
SVOREN', I.M. 26
SYLVESTER, P.J. 67
SZABO, Cs. 167
SZABO, Csaba 178
SZARAN, Janina 77

T
TADDEUCCI, A. 205
TADOKORO, Sakiko 218
TAGUCHI, S. 56, 191
TAKAHASHI, M. 170
TAKEHARA, Lucy 79
TALNIKOVA, S.Y. 14
TANAKA, H. 147, 148
TANAKA, Ryoji 141
TANELLI, G. 40
TANELLI, Giuseppe 166
TANG, Yaolin 226
TASIRAN, Ian 129
TATSUMI, Yoshiyuki 97
TAYLOR, C.D. 26
TAYLOR, R.P. 125, 177
TECCE, F. 205
TELLO, E. 14
TERNES, Kim 141
THALHAMMER, O.A.R. 129, 130
THALHAMMER, Tatiana 129
THANH, H.H. 83
THOMAS, D.M. 40
THOMAS, R. 177
THOMAS, Rainer 4, 27, 209
THOMAS, Victor 183
THOMPSON, J.F.H. 108
THORDSEN, J. 92
TIMOFEEV, A.V. 107, 203
TKACHENKO, Anatoly 183
TOMIDA, Naoto 147
TOMILENKO, A.A. 183
TOMITA, N. 148
TORNOS, F. 7
TOROK, Kalman 44
TOURAY, J.-C. 55, 136
TOURET, J.L.R. 39, 60, 62, 140, 196
TOURET, Jacques 20
TRACY, R.J. 81, 82
TRAXEL, K. 46
TRELOAR, P.J. 157
TRIGILA, R. 61
TRITLLA, J. 12
TROUILLER, Alain 10
TRUCKENBRODT, J. 128
TRUCKLE, J.S. 187
TRULL, T.W. 88
TSANG, B. 95
TSARYEVA, Galina 102
TSUKIMURA, Katsuhiro 172, 191
TSUNOGAE, T. 91
TUCCIMEI, P. 205
TUISKU, Pekka 62
TURI, B. 205
TURKIN, A.I. 196
TURNER, G. 84
TURNER, Grenville 28
TURNER, S.P. 79

U
UCHIDA, T. 172, 191
UGIDOS, J.M. 161
URABE, Tetsuro 64
USTINOV, V.I. 200
USTINOV, Vladimir 12

V
VALENZA, M. 42
VALLEY, J.W. 28, 54, 68, 128
van CALSTEREN, P. 79
van MOORT, J.C. 1, 166, 217
van REENEN, D.D. 183
VANKO, D.A. 85
VANNUCCI, R. 160
VARNE, Rick 46
VASCONCELLOS, M.A.Z. 79
VASSEUR, Guy 149
VAZQUEZ, Rodrigo 93
VEEKEN, P.C.H. 227
VEKSLER, I.V. 143
VEKSLER, Ilya 185
VÉLICHKIN, V.I. 3, 34
VENNEMANN, T.W. 40, 93
VENTURELLI, G. 33
VENUGOPAL, L. 187
VESICA, P. 205
VETTER, U. 175
VIAENE, W. 138, 182, 223
VIETS, J.G. 104
VIETS, John 48
VIKÉNT'EV, I.V. 24, 228
VILLA, I.M. 155
VILLA, L. 7
VILLASEÑOR-CABRAL, M.G. 51
VINDEL, E. 64, 65, 126, 149
VINDEL, Elena 145
VITI, Cecilia 62
VITYK, M.O. 20, 87
VLASOV, B.P. 203
VOLCHENKO, Yr.A. 100
VOLOSOV, A.G. 122
VOZNYAK, D.K. 51
VRÁNA, Stanislav 222

W
WALGENWITZ, Frédéric 156
WALKER, K.R. 194
WALL, G.R.T. 213
WALL, V.J. 29
WALLACE, Paul 47
WALLIANOS, A. 46
WALSHE, J.L. 29
WALTER, Uwe 222
WAMBACH-SOMMERHOFF, K.R. 200
WANG, Anjian 117
WANG, Hongmei 216
WANG, J. 16
WANG, Liankui 223
WANG, P. 217
WANG, Ping 113
WANG, Pu 207
WANG, Rucheng 36, 217. 225
WANG, Shulai 58
WANG, Wenxue 218
WANG, Xiuzhang 113, 133
WANG, Yinglan 57, 216
WANG, Yunshuen 38, 221
WANG, Zhonggang 119
WARD, J. 41
WARNER, D. 198
WARNER, J.L. 14, 77
WATANABE, K. 56
WATANABE, M. 218
WATKINSON, D.H. 135
WATSON, M.D. 39
WAWRZYNIEC, T. 177
WEBER, H.W. 198, 199
WEBSTER, J.D. 15, 44, 159, 191
WEDEPOHL, K.H. 210
WEI, Chunsheng 225
WEISBROD, Alain 51
WEISER, T. 147
WEISSER, D.J. 111
WELLENS, M. 84
WENNER, D.B. 54
WERDING, G. 175
WHITE, C. 164
WHITE, N.C. 7, 81
WHITEHOUSE, M.J. 4
WIECHERT, Uwe 86
WIECK, J.M. 198
WILCOCK, I.C. 78
WILKINSON, J.J. 57, 212, 213
WILKINSON, Jamie 26, 40, 57, 69
WILLIAMS, G.P. 75
WILLIAMS, P.J. 19, 49
WILLIAMS, S.N. 29, 165
WILLIAMS-JONES, A.E. 58, 64, 78, 82, 99, 150, 168, 169, 192
WILLIAMSON, M.A. 85
WILLIS, Marc 181
WILSON, M.A. 66
WILSON, N.S.F. 222
WILTSCHKO, D.V. 111
WIN, T.T. 185
WIRTH, Richard 61
WIWCHAR, B. 75
WOLF, M. 149
WOLF, Manfred 117
WOOD, B.J. 63
WOOD, C.P. 38, 160
WOOD, S.A. 87
WRIGHT, Paul 208
WU, Shunbao 216
WULFF-PEDERSEN, E. 142
WYBORN, L.A.I. 132
WYLIE, P.J. 110

X
XAVIER, R.P. 181
XIA, Ping 113
XIE, Fapeng 36
XIE, Yanguang 119
XIE, Yihan 57
XIE, Yuling 217
XIONG, Xiaolin 225
XU, Butai 36
XU, Guizhong 190
XU, Hong 117
XU, Honglin 223
XU, Jiuhua 81
XU, Kunhua 119
XU, Ping 57
XU, Shijin 36
XUE, Chunji 89
XUE, F. 11

Y
YAGI, Masahiko 172
YAMAGUCHI, Yoshiaki 170
YAMASAKI, A. 192
YANAN, Bao 72
YANG, C. 85
YANG, Kaihui 175
YANG, Mingshou 37
YANG, Nong 217
YANG, Rongyong 113
YANG, Wenbo 164
YANG, Xiaoyong 224
YANG, Xingke 89
YANG, Yu 207
YANG, Zhenlin 81
YANG, Zhenqiang 36
YAO, S 217
YARDLEY, B.W.D. 88, 98, 170
YARDLEY, Bruce 20, 32
YATSEVICH, Igor 127
YAZEVA, R.G. 94
YE, Zaojun 225
YEFIMOVA, E.S. 185
YEH, T.-H 221
YIN, Hongfu 216
YOKOYAMA, Takushi 80
YOSHIOKA, Ken 218
YOUNG, B. 41
YU, B.-S. 38
YU, Xiaofeng 207
YU, Xiaoguo 76
YU, Yunmei 64
YUN, S.-T. 184
YUREWICZ, D.A. 157
YUSTE, O.A. 117

Z
ZACHARIÁ, Jiøí 121
ZAIDENBERG, A.Z. 28
ZÁK, K. 53
ZÁK, Karel 48
ZANKO, L. 79
ZEITLER, P.K. 41
ZEMAN, Antonín 189
ZENG, N. 133
ZENG, Yishan 116
ZENG, Zhangren 89
ZHAI, Lina 115
ZHAI, Wei 113
ZHAN, Wenhuai 214
ZHANG, Baomin 64
ZHANG, Bin 115
ZHANG, C. 217
ZHANG, Chuanling 207
ZHANG, Guoheng 113
ZHANG, Guowei 225
ZHANG, Hanwen 113
ZHANG, Hu 113
ZHANG, Huizhi 216
ZHANG, Jianhong 207
ZHANG, Jing 207
ZHANG, R.Y. 147
ZHANG, Ronghua 84
ZHANG, Wangseng 64
ZHANG, Wenhuai 206, 216
ZHANG, Wenhuai 224
ZHANG, Xiaohua 221
ZHANG, Yinan 224
ZHANG, Z.-M 78
ZHANG, Zeming 78
ZHAO, Taiping 37
ZHAO, Zhongyuan 161
ZHENG, Minghua 115
ZHENG, Rongcai 22, 116
ZHENG, Shu 115
ZHENG, Youye 207
ZHIMULEV, E.I. 186
ZHOU, Su 159
ZHOU, Xiugao 216
ZHOU, Xiugro 216
ZHOU, Yufeng 115
ZHU, Bingquan 158
ZHU, Jinchu 225
ZHU, S.-H. 30
ZHU, Weilin 215
ZHU, Yungfeng 185
ZHURAVLEV, D.Z. 193
ZIEGENBEIN, D. 128
ZIMMERMANN, Heide 179
ZIMMERMANN, J.L. 68
ZINCHUK, I.N. 72
ZINCHUK, N. 146
ZINCHUK, N.N. 26
ZORINA, L.D. 158
ZOTOV, A.V. 191
ZUBIA, M. 172
ZUPPETTA, Agustino 198
ZVYAGINA, O.V. 24

ERRATA

Volume	Page	Line/Paragraph	Line	Change
28	127	4R	5	Add: "A related abstract in FIR v. 28, p. 61"
28	168	2L	6	Add: "See FIR v. 28, p. 131"
29	262	3	4	Change to "(and omissions) is welcomed."
29	xi	11	1	Change "AFU" to AGU"
29	xii	2	–	Add "MVP magmatic volatile phase."
29	xiv	-9	–	Change to "Laser ablation..."
29	xv	-6	–	Change to "Time-of-flight - Secondary..."
29	xv	–	–	Add "LS ICP MS" Laser sampling..."
29	xv	–	–	Add "TOF MS Time-of-flight mass spectrometry"
29	33 L	5		Delete paragraph from "composite" through to "remnants."
29	125L	3	7	Change "No. 2" to "No. 3"
29	172 L	3		Move "LU, Xiancai" to 4th author position
29	231 R	–		Alphabetical order of items incorrect
29	232 L	–		Alphabetical order of items incorrect
29	245 L	–		Alphabetical order of items incorrect
29	263 L	–		Add "Moiseyenko, Moore" to "Methane."
29	263 L	–		Under "Nitrogen," change "Jadhar to "Jadhav."
29	266 L	4		Delete "Metamorphic P-T paths"
29	268 L			Under "Peridotite" change to "Varfalvy."
29	268 L	-6		Change to "Guilhaumou."
29	273 L			Under "Dabie" change to "Touret."
29	273 L	-10		Change to Antarctica
29	275 R	4		Change to Mount St. Helens
29	275R	-1		Change to Porger