THE GEOCHEMICAL NEWS

Newsletter of The Geochemical Society

in cooperation with The European Association of Geochemistry

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2002 V. M. Goldschmidt Conference - *From Stars to Life*

Davos, Switzerland E-Abstract Deadline: 1 May 2002

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- Geochemistry at University of London

The Geochemical Society

The **Geochemical Society** is a nonprofit scientific society founded to encourage the application of chemistry to the solution of geological and cosmological problems. Membership is international and diverse in background, encompassing such fields as organic geochemistry, high- and low-temperature geochemistry, petrology, meteoritics, fluid-rock interaction, and isotope geochemistry. The Society produces a ***Special Publications Series***, ***The Geochemical News*** (this quarterly newsletter), the ***Reviews in Mineralogy and Geochemistry Series*** (jointly with the Mineralogical Society of America), the journal ***Geochimica et Cosmochimica Acta*** (jointly with the Meteoritical Society), and co-publishes the electronic journal ***G^3*** (jointly with the American Geophysical Union: AGU); grants the ***V.M. Goldschmidt***, ***F.W. Clarke*** and ***Clair C. Patterson Awards***, and, jointly with the European Association of Geochemistry (EAG), the Geochemistry Fellows title; sponsors the V.M. Goldschmidt Conference, held in North America in odd years and elsewhere in even years, jointly with the EAG; and co-sponsors the Geological Society of America annual meeting and the AGU spring meeting. The Society honors our first President, F. Earl Ingerson, and our first Goldschmidt Medalist, Paul W. Gast, with the ***Ingerson*** and ***Gast Lectures***, held annually at the GSA Meeting and the V.M. Goldschmidt Conference, respectively. The Geochemical Society is affiliated with the American Association for the Advancement of Science and the International Union of Geological Sciences.

Members of the Organic Geochemistry Division are individuals with interests in studies on the origin, nature, geochemical significance, and behavior during diagenesis and catagenesis of naturally occurring organic substances in the Earth, and of extraterrestrial organic matter. GS members may choose to be affiliated with the OGD without any additional dues. The OGD presents the **Alfred E. Treibs Award** for major achievements in organic geochemistry, and **Best Paper** awards (student and professional) in organic geochemistry.

The Geochemical News
April 2002

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From the President...

The 2002 Goldschmidt Conference

Spring arrived early this year in the Swiss lowlands, but, high up in the Alps, snow still covers the wintry landscape. As has often been said before, there is a time and a season for everything. Thus, down here in the lowlands, we have put winter behind us and are looking forward to the major geochemical event of the coming summer, the 12th Annual Goldschmidt Conference to be held in Davos, Switzerland from 18 to 23 August 2002. The Organizing Committee, headed by local conveners Alex Halliday, Rainer Wieler, and Jan Kramers, has worked hard to put the final touches on the web-based second circular and is now preparing to receive an onslaught of abstracts and registrations. If you have not, as yet, checked the web site, please take a look at http://www.goldschmidt-conference.com/2002/gold2002/. In particular, scroll through the symposia list to get an overall view of the wide variety of geochemical topics "from stars to life" that will be covered at this year's meeting, as well as a preview of the invited keynote speakers. I am sure you will agree that it will be an exciting program, one that you will not want to miss. In addition to the scientific program, you will have the opportunity to enjoy the Swiss alpine environment through a number of scheduled field trips and social events. And, while you are looking at the web site, browse through the links to Davos and learn why this alpine town, the highest one in Europe, is also known as a Summer Paradise. Begin now to plan your summer holidays in combination with the 2002 Goldschmidt Conference.

And, please mark the following fast approaching deadline in your calendar: 1 May 2002 for electronic submission of abstracts and grant applications.

Congratulations to the 2002 Medallists and Fellows

During my first months as President of The Geochemical Society, my greatest pleasure has undoubtedly been to contact and personally congratulate the newly elected 2002 Medallists and Fellows. I am sure I was as thrilled to break the news to the various individuals, as they were to receive it. I was deeply impressed by the gracious responses that I received from everyone. But, not to hold you in suspense any longer, I wish to inform you of the following news: John Hayes, Woods Hole Oceanographic Institution, USA, will be awarded the 2002 V.M. Goldschmidt Medal, the highest honour of the Geochemical Society. Archie Douglas of The University, Newcastle-upon-Tyne, UK, will receive the 2002 Alfred Treibs Medal for major achievements in organic geochemistry. Harry Elderfield, University of Cambridge, UK, will be given the 2002 C.C. Patterson Medal for his innovative breakthroughs in environmental geochemistry. For her outstanding early career contributions, Ruth Blake, Yale University, USA, will be honoured with the 2002 F.W. Clarke Medal. In recognition of his exceptional service to the Society, Denis Shaw, McMaster University, Canada, will receive the first Geochemical Society Distinguished Service Award. Finally, the list of new GS/EAG Fellow for 2002 includes 7 prominent geochemists: David Des Marais, NASA-Ames Research Centre, Mike Drake, University of Arizona, Irving Friedman, Emeritus at U.S. Geological Survey, Cristopher Martens, University North Carolina, Phil Meyers, University of Michigan, Garrison Sposito, University of California (Berkeley) and John Wasson, University of California (Los Angeles). You will learn more about these individuals and have the opportunity to personally congratulate most of them in Davos this summer, where they will be honoured during the Awards Ceremony at the Goldschmidt Conference.

Additionally, I would like to take this opportunity to thank the members of the various award committees who have contributed their time to this important task of nominating fellow geochemists to be honoured by The Geochemical Society. I would particularly like to acknowledge the terrific job done by the committee chairs and heartily thank the following persons for their service to the Society: Peggy Delaney (Clarke Committee), Harry Elderfield (Geochemistry Fellows Committee), Bob Berner (Goldschmidt Committee), and Lynn Walter (Patterson Committee).

Service to the Society

You may have noted that Seth Davis, GS Business Manger, added an additional item on your dues statement this year, inquiring if you would be interested to serve The Geochemical Society as an officer or as a member (chair) of one of the committees. I am happy to report that many of you responded positively. Each spring, the Vice President of The Geochemical Society compiles an updated list of volunteers to serve on the various GS committees. As a result of Seth's initiative, this year's process of finding volunteers to serve as new committee members was made easier for our current V.P. Tim Drever. As many of you have already experienced, serving on GS committees offers one the opportunity to influence the activities of The Geochemical Society through participation on the Joint Publications, Nominations and Program committees. Furthermore, participation on the Clarke, Goldschmidt, Patterson and Geochemical Fellows committees affords one the chance to participate in the nomination of new awardees and fellows to be honoured each year by the Society. If you wish to be more involved, remember to express your interest on next year's dues statement. Committee members serve for 3 years with new terms beginning on the 1st of July of each year. We will be posting the new list of committee members in the next issue of The Geochemical News.

The 2002 Board of Directors Meeting

The annual business meeting of The Geochemical Society's Board of Directors is always held in conjunction with the Goldschmidt Conference. This year's meeting will be convened in Davos on Saturday 17 August. The meeting provides the possibility for the BoD members to discuss face-to-face the important business and developments within the Society. Although there are many issues that can be handled routinely by e-mail exchange, the bigger issues require extended discussion to reach decisions. This will be my first BoD meeting as President, as well as the first meeting for our new Secretary, Jeremy Fein. We look forward to representing the interests of the Society members at the BoD and communicating to you the issues and actions of the BoD. Let us know if you feel that there are burning issues that we should add to this year's agenda. To keep abreast of what transpires, it is possible for you, as a Society member, to follow the proceedings of the BoD meetings through the extended minutes published in The Geochemical Newsletter and archived on The Geochemical Society's web site (http://gs.wustl.edu).

Finally, in my next letter, I will provide you with an up-to-date report on the progress of the 12th Annual Goldschmidt Conference from the prospective of a local. Until then, I wish you a productive springtime and look forward to meeting you in Davos.

With best wishes,

Judith A. McKenzie
GS President

Editor's Corner...

Inspired by the theme of this year's V. M. Goldschmidt Conference - "From Stars to Life" - we present for this issue a cover photo from the Hubble Space Telescope of a stellar nursery in the neighboring galaxy of M33. These are exciting times for the astrobiologist. On November 27th, 2001 David Charbonneau (CalTech) and Timothy Brown (NCAR) announced the spectroscopic detection of sodium in the atmosphere of a Jovian planet orbiting HD 209458, a sunlike star 150 light years away. This is a milestone in planetology. For the first time we have direct evidence of the atmospheric composition of an extrasolar world. As this new technique is refined, and ultimately augmented with space-based interferometric instruments, we can expect to assay distant worlds for telltale biogenic gases. Our first glimpse of life elsewhere in the universe may be an absorption spectrum.

Our examination of the theme "From Stars to Life" brings you, in this issue, an interview with internationally recognized astrobiologist Christopher Chyba. Dr. Chyba sat down with Associate Editor Mitch Schulte and shared his views about the emergence of life and the search for biotic systems elsewhere in the cosmos.

Remember, the 2002 Goldschmidt abstract deadline is 1 May 2002. Don't forget to submit your contribution! Until next issue...

Regards,

Johnson R. Haas
Carla Koretsky
Editors

COVER: STELLAR NURSERY IN GALAXY M33

This is a Hubble Space Telescope image of a vast nebula called NGC 604, which lies in the neighboring spiral galaxy M33, located 2.7 million light-years away in the constellation Triangulum. This is a site where new stars are being born in a spiral arm of the galaxy. Though such nebulae are common in galaxies, this one is particularly large, nearly 1,500 light-years across.

At the heart of NGC 604 are over 200 hot stars, much more massive than our Sun (15 to 60 solar masses). They heat the gaseous walls of the nebula making the gas flouresce. Their light also highlights the nebula's three-dimensional shape, like a lantern in a cavern. By studying the physical structure of a giant nebula, astronomers may determine how clusters of massive stars affect the evolution of the interstellar medium of the galaxy. The nebula also yields clues to its star formation history and will improve understanding of the starburst process when a galaxy undergoes a "firestorm" of star formation.

The image was taken on January 17, 1995 with Hubble's Wide Field and Planetary Camera 2. Separate exposures were taken in different colors of light to study the physical properties of the hot gas (10,000 Kelvin). Credit: Hui Yang (University of Illinois), Jeff J. Hester (University of Arizona) and NASA.

Special Session Announcement

Minerals, Solutions, and Microbial Life

AGU Spring meeting
May 28-June 1, 2002
Washington, D.C.

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Call for Nominations ACS Geochemistry Division Medal

To be awarded for outstanding contributions in any area of the field of Geochemistry.

The Division of Geochemistry of the American Chemical Society is currently soliciting nominations for the second awarding of the Geochemistry Division Medal. The GEOC medal is awarded biennially to an individual for outstan ding accomplishment in any area of Geochemistry.

The award consists of a bronze medallion plus $2000. The awardee will receive an allowance for travel to the award ceremony, as well as registration costs for the ACS meeting at which the award will be conferred. The second Geochemistry Division Medal will be presented at the 225th ACS National meeting to be held in New Orleans, LA March 23-28, 2003.

Letters of Nomination and supporting materials should be sent to the Chair of the GEOC Medal Committee, Dr Robert H. Byrne, at the address given below, by June 1, 2002.

Nominations should include a detailed description of the nominee's outstanding accomplishments, relevant citations and, at the discretion of the nominator, any other supporting information. Two letters from individuals other than the primary nominator are requested, but not required, by the committee. Nominators should confirm, prior to submission of the nomination, that the nominee is willing to be considered for the award. Nominees will be considered for two years.

Additional details of the award can be found at the Divisional web site at:http://membership.acs.org/g/geoc/medal/medal.html

Please address inquiries to Dr Robert H. Byrne

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Geochemical Society Business Office News

Membership

Many thanks to new and renewing members for making the 2002 renewal drive so successful. Society membership is on par with the progress we've made in 2001, and is certain to jump ahead of last year's totals as we prepare for the Goldschmidt Conference in August.

A lot of potential members find out about the GS through word of mouth, so please continue to promote your society.

Subscription

For those of you subscribing to GCA, you should have received your reader key information to log on to the Elsevier Science website and view GCA electronically. If you haven't been able to, please let me know and I will help.

Elsevier Science has also solved its problems with back issues. If you are still missing issues from your 2001 or 2002 subscriptions, please contact the GS business office.

Publication

By the time this issue of GN reaches you the new Geochemical Society Special Publication Volume 7: A Tribute to David A Crerar should be in stock and available for purchase. Ordering information is available on an order form appearing elsewhere in this issue.

In other related news, on 7 March 2002, the remaining stock of special publications were relocated from Maryland to the business office in St. Louis. Special Thanks to Bob Osburn and Robbie Valentine for helping me unload the shipment.

Website

Do not forget to check back with the GS website regularly for announcements, conference listings, membership directory, and more. We are still working to have a secure on-line system in place for membership and publications, and hope to have that running in the near future.

Conferences

Information about Goldschmidt 2002 can be found from the conference website (http://www.goldschmidt-conference.com/2002/gold2002/), which will be regularly updated as the conference approaches. If would like to receive circulars (informing you of abstract deadlines, arrangements for registration, etc...) please send your email address to Cambridge Publications (goldschmidt2002@the-conference.com) who will ensure that your name is added to the mailing list.

Conference listings are regularly updated on our website (http://gs.wustl.edu/conferences/), if you know of a relevant conference that you'd like to add, please email me, and I will get it listed.

Cheers,

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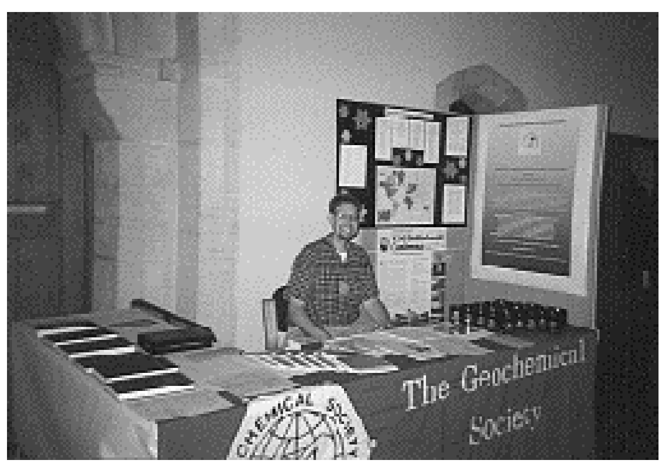

AAAS Annual Meeting Boston, February 14th-19th

The AAAS meeting was very exciting and interdisciplinary making it difficult to summarize "areas of interest" to the Geochemical Society. The two major seminars at the meeting, the "2002 Nanotechnology Seminar: From Computer Electronics to Medicine" and the "2002 Genome Seminar: Genomes Around Us: What are We Learning?" were well organized and well attended by scientists, funding agencies, policy-makers, and the media. These seminars provided excellent introductions to recent advances in each topic for general scientific audiences. Many other seminars touched upon topics of interest to the geochemical community:

- Low Dose Radiation: Science, Ethics and Communication Shaping Public Policy The Farm Crisis: How the Heck Did We Get Here?
- The New Biology of Rocks
- Human Population and Freshwater Resources: Science, Policy and Public Outreach
- Climate Change: Integrating Science, Economics and Policy
- The Challenges and Promise of Global Environmental Monitoring
- The Big Climate Impact of Tiny Particles
- Deciphering Complex Changes to Global Ice and Snow

The idea for each seminar is first proposed by the AAAS Sections and the Section affiliates. Most of them run for half a day and consist of five to six invited speakers. We are currently affiliated with the Chemistry Section and the Geology and Geography Section. In Boston, the Geology/ Geography and Chemistry Sections co-sponsored the following symposia:

- Images of a Dynamic Earth
- Recent Innovations in the Science of Underground Development
- Visualizing the Sea Floor: Mapping Submarine Landscapes
- Revisiting Nuclear Power for the Energy Crisis

Alan Leshner, the new Chief Executive Officer of the AAAS, outlined priorities of the AAAS for the next few years:

(1) adjusting the AAAS goals, objectives, and strategies to the reality of the 21st century,
(2) expanding AAAS leadership role – defining the society's niche in the U.S. and globally,
(3) increasing the AAAS focus on public understanding of science and on the role of science in policy decisions,
(4) expanding the AAAS membership to better serve the needs of science and technology,

Leshner is interested in hearing from affiliate societies: How can the AAAS better serve the affiliate societies? How can the AAAS be "value added" on top of what affiliate organizations offer to members? The idea of lowering the AAAS membership fee for members of affiliate organizations is being evaluated. We will keep you posted!

The new FY 2003 budgeted proposed the week of February 5th was reviewed at both the AAAS Council and Affiliates meetings. The total discretionary U.S. budget proposed for FY 2003 is approximately $767 billion, that is, $49 billion more than for FY 2002. This increase is divided between DOD (+$44.9), NIH (+$3.7), Education (+$0.5), and all other agencies (e.g., NSF, EPA, Parks) are held flat ($0.0). Over the past three years, the R&D budgets for NIH, NASA, and NSF have increased by 17.4%, 5.3%, and 3.6%, respectively. The R&D budgets for DOE and DOD have decreased by –8% and –2%, respectively. In "constant" dollars (adjusted to account for inflation) the NIH increase is larger than the entire NSF budget. In the last 12 years, NIH is the only non-defense R&D budget that has increased over time (Fig. 1).

The research emphasis has changed over time from space (1960-1975) to energy (1975-1990) to health (1990 – present). Federal R&D accounts for only 1/3 of the spending on R&D in the United States today. A preliminary analysis of the federal budget can be found on-line at www.aaas.org/spp.

Don Kennedy, editor of *Science* Magazine, discussed the status of the journal at the AAAS Council meeting. Over 8000 papers are submitted per year, it takes about 120 days between submission and publication, about 1 in 9 papers submitted are published, and the average length of the papers has increased from 3.2 pages to 3.7 pages, largely to be able to accommodate more graphics. The editorial staff of *Science* Magazine has been making a conscious effort over the last five years to increase the number of disciplines represented in the journal, thereby increasing its usefulness to the scientific community and increasing the journal's readership.

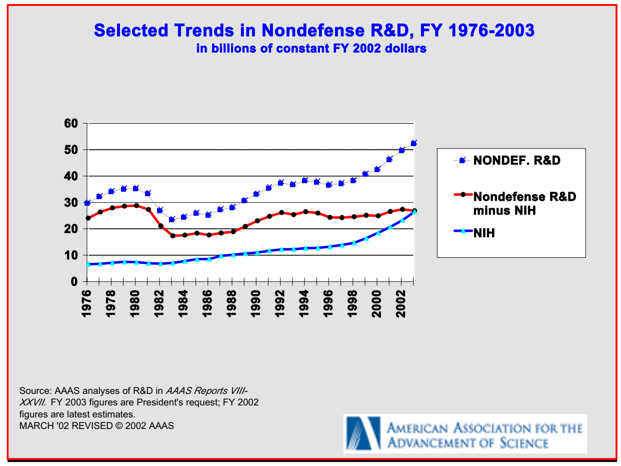

Figure 1. Source: AAAS Analyses of R&D in AAAS Reports VXI-XXVI (www.aaas.org/spp/dspp/rd/fy03.htm)

Science On-line (http://www.scienceonline.org/) was heavily promoted at the meeting and rightfully so. *Science* issues from Oct. 1995 – present can be accessed using Science On-line. JSTOR can be used to search *Science* (1895-1996) and other scientific journals. Also discussed was the Electronic Information For Libraries project (EIFL, www.eifl.net), which is an infrastructure program for libraries in developing countries (44 developing countries), provided through "High Wire", the publishers of Science On-line.

Two of our members were elected to the status of Fellow by the AAAS Council in September 2001: W. D. Carlson of the University of Texas, Austin for seminal contributions to metamorphic petrology, mineral thermobarometry, and especially x-ray computational tomography of minerals, chemical zoning, and subsolidus diffusion in the crust, and J. M. Ferry of Johns Hopkins University, for the discovery that chemically reactive fluid flow controls the mineralogy of many metamorphic rocks and for development of models to estimate flow direction and amount. Congratulations to both of you!

The overall theme for the next AAAS Annual Meeting from Feb. 13-18th, 2003 to be held in Denver, Colorado, is "Science as a Way of Life". The AAAS Council has proposed several sub-themes for this meeting including:

- Science and Human Culture
- Life of Science
- Science and Technology of Life
- Science and Uncertainty
- Evolution of Evolutionary Ideas
- Challenging and Changing Nature
- Public Health and Public Risk
- How the World Works
- Science Calamity and Conflict
- Beyond the Human Genome – What Next?

Proposals for the 2003 meeting are due to AAAS by March 18, 2002. The theme for the 2004 meeting in Seattle will be determined in September. Proposals for symposia are due during the second week of March each year. If you have any suggestions for AAAS symposia for the 2004 meeting, or other suggestions about what AAAS can do for the Geochemical Society, please contact either Louise or Robyn.

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MEETING REPORT
Third Biennial Geochemistry SIMS Workshop
October 12th-14th, Tempe, Arizona

The third Biennial Geochemistry SIMS Workshop was held on 12-14 October, 2001 in Tempe, Arizona. SIMS (Secondary Ion Mass Spectrometry, also known as the ion microprobe) is a microanalytical technique that allows the quantitative determination of element abundance (from H to U) in selected spots a few to dozens of microns in diameter. It can deliver isotope ratio analyses as well as generate qualitative (quantitative in some cases) maps of elements (or isotope ratios) on sample surfaces. The purpose of this series of meetings (supported by NSF Division of Earth Sciences - Instrumentation and Facilities Program) is to provide a means for US and other SIMS labs to exchange information about analytical techniques, facilities operation, maintenance tips, new instrumentation, and recent scientific results. This venue provides a unique opportunity for SIMS labs to discuss the science of the technique as well as scientific discoveries.

The highlight of this year's meeting was an invited talk by Professor Emeritus Georges Slodzian (Univ. Paris, Sud) on the problem of making isotope ratio measurements using electron multiplier counting with sub-per mil precision. Professor Slodzian was a graduate student of Professor R. Castaing, the inventor of the electron microprobe. Professor Slodzian has designed three generations of SIMS instruments successfully marketed by Cameca Instruments.

Presentations from three US labs funded as national or regional facilities indicated that demand for SIMS analyses was great enough to keep additional instruments busy. Other labs not funded as facilities but with open-door policies for outside users also noted that demand was high.

Frank Stadermann and Christine Floss (Washington University, St. Louis) presented results from the recently installed Cameca NanoSIMS applied to the analysis of interstellar SiC grains extracted from the Murchison meteorite. This new SIMS specializes in the analysis of small particles (<1 μm). Because most interstellar particles are on the order of 0.1 μm in diameter and earlier analyses by older SIMS were restricted to larger particles, there has been a question as to whether smaller particles would show different chemical characteristics. Initial isotope ratio measurements of Si and C by the NanoSIMS matched analyses of larger grains from the same meteorite, giving confidence that this SIMS is working well. In general, when smaller areas are analyzed, analysts discover larger variations and more complexity in nature than had been known.

Michael Pellin from Argonne National Laboratory described upgrades to his Time-of-Flight Resonance Ionization Mass Spectrometer (ToF-RIMS) and Andrew Davis (University of Chicago) presented results of the analysis of interstellar grains using this approach. RIMS works through the ablation of material from a sample (using a pulsed laser or ion beam) and selective ionization of the ablated atoms by firing a laser tuned to the resonant energy of the element of interest through the cloud of atoms. Ideally, only one element will be ionized, and the signal detected in the ToF mass spectrometer can be directly converted to isotope ratios of that element. The main upgrades are related to the availability of lasers capable of ionizing elements with a single pulse instead of requiring multiple pulses. The analysis of interstellar grains provides a test of nucleosynthesis models in the stars where the grains formed.

Albert Fahey (NIST) described the potential for using Time-of-Flight SIMS (ToF-SIMS) for isotope ratio measurements in geo- and cosmochemical samples.

Michael Wiedenbeck (GeoForschungZentrum, Potsdam, Germany) provided a list of useful accessories to a SIMS lab, including quieter cooling fans for the electronics racks, and an adapter to the optical microscope allowing visitors to match photomicrographs obtained in their lab to the images on the SIMS microscope, enhancing the ease of navigation around the sample. Mostafa Fayek (Oak Ridge National Laboratory) described the status of research on sedimentary and igneous rocks in earth science and archaeological applications.

New science results at the workshop included study of sulfur (Peter Weber, UC Berkeley with Kevin McKeegan, UCLA) and strontium (P. Weber with Joe Wooden and Charlie Bacon, USGS) isotope ratios in salmon otoliths. These results allow hatchery fish to be distinguished from wild salmon, critical information in studying changing natural habitats. The sulfur isotope analyses (performed on the UCLA Cameca 1270 SIMS) were challenging because S isotope microanalyses on insulating carbonate (containing low levels of sulfur) had never been attempted before. The strontium isotope measurements were obtained on the reverse-geometry SHRIMP ion microprobe at the Stanford University/US Geological Survey laboratory. The developing ability to obtain strontium isotope ratios *in situ* represents an exciting new direction for earth science research.

New analyses of trapped melt inclusions in olivine phenocrysts for Pb isotopes by Graham Layne and coworkers at Woods Hole Oceanographic Institute (Cameca 1270) showed that the extreme heterogeneity observed in earlier studies of melt inclusions (*Science* 282 (1998) 1481) is not an isolated occurrence. When glass inclusions from the same hand sample have such a wide range in Pb isotopic ratios the interpretation of earlier bulk analyses becomes more challenging.

In contrast, analyses of melt inclusions and other glassy samples by Erik Hauri (Carnegie Institute of Washington's Department of Terrestrial Magnetism) emphasized the opposite end of the periodic table; studies of H, C, halogens and sulfur were presented, with an emphasis on hydrogen and D/H ratios.

Mary Reid from UCLA described her efforts to push the SIMS technique for U-Pb age determinations in zircon by analyzing very young samples of this mineral. Such studies of relatively recent eruptions are showing zircon residence times in magma chambers to be tens of thousands of years.

The presentation by the Canadian Geological Survey (Richard Stern) involved characterization of a homogeneous zircon and the factors that increase uncertainties in the U-Pb age. Much discussion about the role of different instrument parameters followed this talk.

Contributions from the host institution included microanalyses of oxygen isotopes in the rims of high-temperature calcium-aluminum inclusions from meteorites (recording early post-condensation processes in the solar nebula) by Laurie Leshin, analysis of Si, N, and C isotope ratios in interstellar SiC grains by Gary Huss, and measurements of the useful ion yield in SIMS as a function of mass spectrometer potential (R. Hervig). The latter measurement showed that doubling the voltage on the secondary ion column doubled the transmission of ions through the instrument.

The meeting was also attended by one manufacturer of SIMS (Cameca Instruments) who presented a description of their newest instruments.

The resounding conclusion of the attendees was that another meeting in two years time was an absolute necessity for learning about new developments in this fascinating technique.

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Congratulations to Alexandra Navrotsky!

FRANKLIN INSTITUTE COMMITTEE ON SCIENCE AND THE ARTS ANNOUNCES 2002 BENJAMIN FRANKLIN MEDAL LAUREATES

The Geochemical Society congratulates and honors **Alexandra Navrotsky** upon her award of the prestigious Benjamin Franklin Medal by the Franklin Institute Committee on Science and the Arts. On January 28, 2002, President and CEO Dennis M. Wint of the Franklin Institute announced the names of the 2002 recipients of this highly prized award for scientific achievement and preeminence. Professor Navrotsky is recognized for her spectrum of accomplishments in crystal chemistry that have established convincingly the identity of materials at hundreds of kilometers of depth in the Earth, systems that otherwise are inaccessible to direct observation.

Widely regarded as the American Nobel Prizes, and among the oldest comprehensive science and technology awards programs in the world, The Franklin Institute Awards have recognized preeminent accomplishment in science and technology since 1824, in the spirit of discovery embodied by Benjamin Franklin. Indeed, 98 Franklin Institute laureates have received Nobel Prizes in their respective fields – 14 in the last five years alone, resulting in a mounting distinction for the awards as a bellweather for the Nobels. A virtual who's who of 19^{th} and 20^{th} century scientific achievement, the list of venerable honorees includes Albert Einstein, Thomas Edison, Orville Wright, Marie and Pierre Curie, Jacques Cousteau and Stephen Hawking. Recognized for their seminal contributions to scientific thought and progress, this year's elite group of 2002 Franklin Institute Award laureates, including three women for the first time, are paving the way for future innovation and discovery in the generations to come.

Stated Wint, "These exceptional scientists are taking up the torch of a 177-year-old legacy – the recognition of extraordinary achievement in science and technology, in order to inspire appreciation for the power of science to broaden our understanding of the universe, improve our lives, and encourage and inspire new generations. We are proud to honor them as they have honored us, with their commitment and dedication to science."

The Franklin Institute
Email: www.fi.edu
Telephone: 215-448-1176

Geochemical Society / Mineralogical Society of America Short Course Announcement

Application of Synchrotron Radiation in Low-Temperature Geochemistry and Environmental Science

Monterey, California, December 4-5, 2002

The powerful applications of synchrotron radiation in geochemistry and environmental science began to be realized about two decades ago. With the advent of third-generation synchrotron radiation sources in Europe, North America, and Japan, significant progress has been achieved in the development and application of synchrotron methods to geological and environmental materials. There has been exponential growth in the number of synchrotron users from the earth and environmental science communities. This Short Course is designed to fill the need for a comprehensive, in-depth review of the underlying theory and application of various synchrotron radiation methods as they pertain specifically to geochemical and environmental science applications.

Registration is $200 ($100 for students) before October 15, 2002. For more info see the conference website:

http://cars.uchicago.edu/shortcourse2002/

Conveners
Paul Fenter, Argonne National Laboratory
Mark Rivers, University of Chicago
Neil Sturchio, University of Illinois at Chicago
Steve Sutton, University of Chicago
Michael J. Bedzyk, Northwestern University

Speakers:
Mark Rivers, University of Chicago
Gordon E. Brown, Jr., Stanford University
Paul Fenter, Argonne National Laboratory
Glenn A. Waychunas, Lawrence Berkeley National Lab
Carol Hirschmugl, University of Wisconsin at Milwaukee
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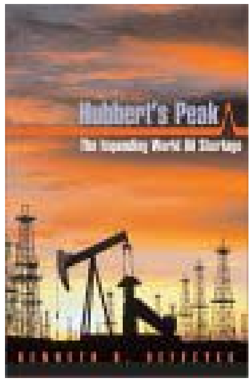
BOOK REVIEW



The Spice Must Flow: A Review of *Hubbert's Peak* by Kenneth Deffeyes

Review by Johnson R. Haas

In Frank Herbert's novel *Dune*, galactic empires rose and fell by the flow of *spice*, an odd substance vital to the technology of interstellar transport. The problem was that spice came only from one politically and ecologically dubious planet, and so the lives of billions hinged on an irreplaceable resource mined from a dangerous and volatile place that the powerful cared about for no other reason. At face value it's an interesting allegory of our own dependence on crude oil, largely from the Middle East. However, despite internecine wars, post-colonial politics, and transnational terrorism, the flow of cheap petroleum continues unabated. For how much longer can we expect the spice to flow?

Not for much longer, according to Kenneth Deffeyes. In his latest book *Hubbert's Peak*, Deffeyes, a lifelong oilman, pulls no punches. His beginning two sentences define his thesis and our dilemma: "Global oil production will probably reach a peak sometime during this decade. After the peak, the world's production of crude oil will fall, never to rise again." The rigs won't run dry, Deffeyes warns, but our days of cheap crude and SUV leviathans are essentially finished. As production crests and begins to decline, the widening gap between increasing demand and decreasing supply will trigger the dawn of a permanent geopolitical bidding war for the remaining ground reserves.

Essentially Deffeyes is reiterating with modern data an argument and a forecast made decades ago, originally by geologist M. K. Hubbert. By analyzing the production versus time curves of major oil fields and integrated oil-producing regions, Hubbert realized that the cumulative volume of petroleum drawn from a given reservoir follows a normal distribution. A new field is drilled, and soon begins a steep rise in productivity. Production accelerates as new exploration and drilling quantify the extent of the reservoir and maximize the economic yield. A finite geologic deposit, the field – or at least the economically viable and physically extractable part of it – eventually begins to play out, and production drops accordingly. As the dregs sour, deepen, or thicken, drilling costs rise above the price of the product, and production ends. Using data available at the time, Hubbert predicted in 1956 that US petroleum production would peak around 1970 and diminish ever afterwards. US petroleum production peaked in 1970, and has since drifted steadily downward.

Using similar data for world petroleum yield through time, many authors issued predictions in the 1990s that global crude production would peak around 2004-2008. After that the crude would continue to flow, but at decreasing rates that would never rebound. Largely ignored, these were merely the latest of a long string of dire predictions (starting in the 1930s) that oil exhaustion was just around the corner. So far so good, right? Maybe not. Those recent papers [Hatfield (1997) *Nature* 387:121; Kerr (1998) *Science* 281:1128; Campbell and Laherrerre (1998) *Scientific American*, March:78] re-examined Hubbert's empirical approach and concluded that, just as US production would maximize predictively, world annual oil production would soon also reach an upper limit. Deffeyes expands on these works to some extent, but his primary goal is to call attention to their overall predictions and to how unlikely it is that these estimates of a world oil production peak in the first decade of the 21st century are wrong.

As a writer Deffeyes is prosaic and matter-of-fact, if sometimes clunky. He likes to embellish his narrative with quirky stories from his lifetime in the oil business. For the most part this works, but in some cases the effort falls flat. Deffeyes doesn't rage against the machine; he's part of it and proud of it. He makes it clear from the beginning that oil is his life's work, and that while petroleum may not be with us for much longer as a primary energy source, its rich concoction of complex hydrocarbons - irreplaceable as petrochemical feedstocks - will only grow in value as ground reserves disappear.

Hubbert's Peak would be very useful as a secondary text or an assigned reference for a course in petroleum geology or energy resources. For most of the book Deffeyes draws on his experience to educate the reader about where petroleum comes from, how it forms, how we explore for it, and how it is physically extracted. A chapter is devoted to drilling methods, including such topical issues as directional drilling (a major concern in the US Great Lakes region) and secondary recovery methods. Another chapter summarizes the major oil-producing regions of the world, and discusses why it is unrealistic to expect that future petroleum demand could be accommodated by some as-yet undiscovered deposit.

Deffeyes' message is clear: no new discoveries, no new drilling methods or miraculous technologies, no geochemical revolutions to come have any realistic likelihood of significantly expanding currently known reserves or staving off the coming oil shortage beyond the end of this decade. Deffeyes provides some recommendations of what exactly to do about this in the last two chapters. He argues briefly that conservation and renewable energy solutions would have been far more effective in preventing the coming crisis if implemented a decade ago. Now, less than half a decade from the coming shortage, we are in a much more precarious position. If we start now with serious conservation and renewable-energy infrastructural developments, we will arrive at a more sustainable future, but not before the shortage arrives. As Deffeyes notes: "Running out of energy in the long run is not the problem. The bind comes during the next 10 years: getting over our dependence on crude oil."

In outlining which renewable energy options are most promising, Deffeyes stumbles. He spends too much time on the limits of geothermal energy, leaving little space to more productive and more realistic choices, such as nuclear (if we're willing), solar photovoltaic, solar thermal, and wind. To be fair, his aim in this book is not to talk about renewable energy. His message is specifically geologic, and he does a nice job of summarizing at an introductory level the current state of knowledge about petroleum formation, deposition, extraction, and sustainability. Every geology or environmental science undergraduate should learn about these issues. They will all deal with them sooner than they think.

To Seek Out New Life...
An Interview with Christopher Chyba

by Mitch Schulte

Christopher Chyba is the Carl Sagan Chair for the Study of Life in the Universe and directs the Center of the same name at the SETI Institute in Mountain View, CA. He is also an Associate Professor (Research) in the Department of Geological and Environmental Sciences at Stanford University, and co-director of the Stanford Center for International Security and Cooperation (CISAC).

He earned his Ph.D. from Cornell University in 1991 working with the late Carl Sagan. He received a White House Fellowship in 1993 and served on the national security staff of the White House from 1993 to 1995. In 1994, while Director for International Environmental Affairs on the staff of the National Security Council, Dr. Chyba was named one of Time magazine's "Fifty for the Future." In 1996, he received the Presidential Early Career Award for Scientists and Engineers. As a contractor since leaving the White House, he drafted the President's Decision Directive on responding to emerging infectious diseases, and completed a report for the Office of Science and Technology Policy in 1998 on preparing for biological terrorism. In October 2001 he was named a MacArthur Fellow. He chaired the Science Definition Team for NASA's Europa Orbiter mission, a mission to search for an ocean beneath the icy crust of Jupiter's moon Europa. He is also a previous member of the executive committee of NASA's Space Science Advisory Committee (SSAC), and past chair of that committee's Solar System Exploration Subcommittee (SSES), which recommends priorities for solar system exploration. At CISAC, his research includes issues of biological terrorism and emerging diseases, nuclear weapons material security, and nonproliferation.

GN Associate Editor Mitch Schulte met with Dr. Chyba at his SETI office on March 7, 2002 to discuss his views on astrobiology and the origins of life.

MS: First of all, as you [have] pointed out, you're not a geochemist, and many people in the geochemistry community might not really know you very well, even though you've been active in a field, origin of life or astrobiology, that certainly involves geochemistry, and has sort of become an all-encompasing kind of field, and geochemistry, and geology, plays a very important part of that..

CC: Absolutely.

MS: So for those readers who might not be familiar with you, perhaps a little background might be in order. For example, [in] what [subjects] are your degrees?

CC: Ok, my first degree was in physics from Swarthmore College, a small liberal arts school [in Pennsylvania]. My minors there were mathematics and philosophy. I did my senior thesis in political science. So I took advantage of the fact that it was a small, liberal arts school. I took it at its word.

MS: So you've been well-rounded from the beginning.

CC: Well, we could argue about that, but... and I have an M. Phil. in history and philosophy of science and I guess a second B.A. in mathematics from [Cambridge] University. And then I switched; I was really doing mathematical physics there, but I switched out of that because I decided I was really most interested in origins of life and what's now called astrobiology... it was clear the way for me to approach that topic was from a physical or planetary science background, because that would take advantage of my physics, and then I could try to learn some biology and chemistry. [The] person in the States who was doing that was Carl Sagan. So I wrote Carl and that worked out. I wound up going to Cornell to do my Ph.D. at Cornell in the astronomy department. Cornell has four groups in their astronomy department, and one of those is the planetary sciences group. That's unusual; usually planetary groups are in departments of Earth and planetary science, so they're more geologically oriented than Cornell's program was, which is more physics oriented. [Although] with Carl, you know you sort of had everything [laughs], including an unusual amount of biology. Carl was one of the very few people in the country who was really an exobiologist at that time.

MS: What time frame was this?

CC: That was [late] '85. There was some skepticism on the part of some members of the department about whether it made sense to pursue exobiology. In retrospect that's sort of ironic since now everybody's an astrobiologist. [Almost] no matter what you're doing, people describe themselves that way now.

MS: You have to use the right words, I suppose. So what was it that attracted you to origin of life research?

CC: I'd taken some biology as an undergraduate, and chemistry, and fit it in around the edges where I could. And I gave some thought to switching out of physics and going to graduate school in biology. [That] would mean that I would have a lot of biology to get under my belt, but that I could get away with it if I wanted to. But I didn't pursue that; I went to Cambridge and was doing mathematical physics. I guess it became clear to me... I was likely to do a Ph.D. in something called Kaluza-Klein theory, which is one of these 11 dimensional unified field theories. I had a couple publications in general relativity. And it seemed likely that I was going to spend the next three or four years of my life behind a desk doing one thing, and there was all this other science I had always cared about. And also I had always been interested in foreign policy issues. There was, except for the fact that scientists come from all over the world, there wasn't really much connection to those issues in mathematical physics. And then in the bookstore, I noticed I was spending all my time in the rather thin origin of life section, and decided that that was telling me something. So I looked into planetary science programs, and I applied to three programs in the States, but also wrote a letter to Carl Sagan. [I] didn't have a phone in my Cambridge flat, but one day I received a telegram that said "Chris, call Carl Sagan collect at 617-555-1234, Dad." So Carl encouraged me to come to Cornell, and I went. [It] was, professionally one of the best decisions I'd ever made. It was fantastic.

MS: What was the topic of your thesis, specifically, with Carl [Sagan]?

CC: I did a whole lot of different kinds of work while I was a grad student there. I did a couple papers in theoretical mechanics—tidal evolution in the Neptune-Triton system. But most of my work was involved, in one way or another, with planetary science relevant to the origins of life. I had several papers on cometary spectroscopy, interpreting the mid-infrared features of Comet Halley in light of laboratory results that were being done in Carl's lab. There are features indicative of organics in the mid-infrared in a variety of comet spectra now, but we were seeing them for the first time in Comet Halley in 1986. It was brand new data, [they were] new results, there was already a lab program in place having to do with irradiation of carbon-bearing ices, which was germane to those results. So I put some of that together. [The] thesis has a couple chapters on that topic, trying to elucidate the nature of cometary organics, and then most of it dealt with the role that comet and asteroid impacts may have played in the origin of life on Earth, whether it was depositing volatiles, water, or so-called biogenic elements, [e.g. carbon and nitrogen] and how one could constrain those. Speculation had been around for decades, but it struck me that one could use the cratering record in the inner solar system to try to put some constraints on the role that comets in particular might have played. Then we wound up getting into numerical hydrodynamic simulations of comet impacts to investigate the question of survivability of organics, such as amino acids, in comet impacts. Comet impacts on a big planet like the Earth can certainly deliver biologically relevant elements, such as carbon, but can they actually deliver their organics intact? You wouldn't expect that because the energies [involved in the impacts] are so large. So we did one big paper in Science about that as part of my thesis, and then in the late nineties with Elisabetta Pierazzo, who was then at the University of Arizona, I returned to that problem, both because you could do much better computer simulations now and because there are more lab data available than there were at the time of my thesis. And it looks as though the answer is that even with kilometer-sized impacts you can deliver ten percent or so of the organic complement of the comet intact. So depending on your model for the early Earth, and what you think the nature of the early atmosphere was, which turns in part on geochemical [and geophysical] understanding, because it has to do with the timing of core formation [in] the Earth's history, and whether you sequester the iron quickly into the core. [You're] probably driven to a carbon dioxide early atmosphere, although there is still controversy over that. In that kind of atmosphere, Miller-Urey synthesis is less efficient by many orders of magnitude. So the cometary influx is potentially germane. [There is] this whole vision of origins of life, where what you need to think about is how [to] stock the primordial soup. What's exciting about the geochemical work that's been in the literature for the last decade, and the vent hypothesis, is that it goes right at that 50-year-old assumption. [It says] you [don't] want to think in terms of getting the compounds stockpiled in the soup, that instead [you should] think about metabolism,[and] approach it from [a] metabolism [angle]. That actually is one of the most exciting things going on in the field.

MS: You're anticipating my questions here!

CC: Well, it's true. The one thing we do know how to do in origins of life is produce organic monomers; you either make them in the Miller-Urey atmosphere, or you make them through ice irradiation in the interstellar medium or in comets and you deliver them. [That's] the one part of the puzzle that we have multiple pathways towards understanding. And it may well be time to move on to some other part [laughs].

MS: After 50 years. Well, then this of course brings up the question of once you deliver these molecules to the Earth, then what happens to them? I guess that's the big unknown here, and this then sort of begs the question: Can life begin in an environment that we consider to be extreme? What are your thoughts on various hypotheses about where life might have originated, whether these are applicable to other bodies in the solar system?

CC: Well, you know as well as I do how subjective that word "extreme" is.

MS: Sure. I *actually disagree with it in many cases, because we are living in a 20% oxygen atmosphere, which is pretty extreme if you ask me.*

CC: Exactly. My fear is that it's going to turn out... the short answer is we don't know, ok? [Laughs]. The longer answer is that my fear it that it's going to turn out that you're going to need to have different parts of the puzzle take place in different environments, which suggest that you need a kind of complicated system for this to work out. That's no more than a fear... I hope it turns out to be simpler than that. But I can imagine a case in which you do get a kind of initial background of organics that [is] simply available in the environment through production in the atmosphere, and exogenous delivery, and so on, but then the critical first polymerization step takes place on some mineral surface that may or may not reside in a hydrothermal system. Now it may be that you synthesize the monomers you need directly in that system; that may also be the case.

MS: In which case the delivery of volatiles is the important component from a planetary aspect.

CC: Then the only important component is coming up with the biogenic elements and the water to begin with. On the other hand, Art Weber, who is a SETI Institute PI, thinks that we need to pay much more attention to the role of sugars in the origin of life, because that way, if you start with sugars, then you're starting off with an energy-rich compound. And Art is very skeptical about hydrothermal systems from the point of view of sugars since sugars are so fragile. So you know, we still only have different pieces of the puzzle and you can make some progress in one direction or another in these environments. Maybe that means... that what happened was that different pieces of the puzzle came together from different environments. Or maybe, just as likely, I think, that means that we haven't done near enough work yet. One thing that does disturb me about the deep origin hypothesis, [which is] obviously intriguing from the point of view of the phylogenetic record, [although] I don't think that's a *requirement* of the phylogenetic record because of the impact environment, but one thing that does disturb me about it, although it is also a case where a lot more work ought to be done, is that... what's important about planetary science in the origins of life context is that it gives you access to actual natural systems, where spatial and temporal scales are much bigger than the scales you can address in the laboratory. [There] are several of those in the solar system. When we get to Titan's atmosphere in 2004, that'll be one example.
[Editor's Note: The Cassini spacecraft is scheduled to arrive at Saturn in 2004, and will deliver a probe to Titan's surface.] And it's not just in the solar system. A second example from my point of view is the chemistry of the interstellar medium. There's been this many decades, really a century old speculation, about whether you could have life

based on something other than carbon, and silicon is everyone's choice because it's right underneath carbon on the periodic table. Theoretically, silicon almost never makes double bonds, and that's because it's a bigger atom and it's harder for it to do the kind of double bonding carbon can.

CC: So it... likes to make mineral grains instead of a suite of interesting molecules. Ok, so we know that theoretically, but if you look at the ISM, you see this whole suite of carbon compounds, more than 70 of them. You don't see [an] analogous suite of rich, silicon-based chemistry. So even though we weren't exploring the ISM in order to address some hypothesis about silicon-based life, it nevertheless, through our exploration, I think, gives us information that's germane to this long-standing question. And I think similarly, the exploration of Titan might help us address some questions like that. Is it possible on a global scale to develop chirality, even if we so far can't give a good mechanism for what the drive is, nonbiologically, for chirality. We're about to go to a world that's been organically prebiotic for 4 billion years, so we think. If there were some chiral excess on Titan, that would be damned exciting. And on the flip side is, if there's not...

MS: Well, so what?

CC: Yeah, probably so what? Probably people will say "No surprise," but if there were, that would be very exciting. Another long-term speculation is what about life based on the solvent [being] something other than water? There are good reasons for it to be water... it's one of the three or so most polar liquids known, and probably geochemically the most plausible to have present in large abundances. Liquid ammonia is probably plausible, although it would have to be much colder if liquid ammonia were the solvent. It too is a polar molecule, though not as polar as water; since chemistry depends exponentially on temperature, life in liquid ammonia would presumably progress much, much more slowly, but I don't think that's a show-stopper because what matters it that you can catalyze reactions faster than are taking place in the environment.

MS: Which is the [way] life [works].

CC: Yeah, so everybody would be in that environment moving much more slowly. But then the radical suggestion is, what about life based on a non-polar solvent? I don't think you can go much farther than just state that, because our understanding is so limited. It would be in some sense opposite of the way we think about the problem now.

MS: Well, since life depends on disequilibrium to make its way, is that a viable [proposal] even to consider?

CC: I think you could have types of disequilibria.

MS: Based on non-polar solvents?

CC: Yeah, that's what you'd have to gesture towards. You would still need to be able to dissolve [compounds] and then bring [them] together to liberate energy in a non-polar solvent.

MS: Cells that we know of now have to have proton pumps and transport ions across a gradient, or a membrane.

CC: Everything would have to be different, so there's very little to say at this point. My only point here is we're going to go into Titan, which may be a world that has a meteorological cycle based on a non-polar solvent... methane and ethane potentially, because ethane is such an important photochemical product of methane in the atmosphere. It may be that if there's a liquid on the surface, the dominant liquid turns out to be ethane. We'll find out. But once again, through exploration we're going to get some insight into these long-standing but very exotic speculations. Let me talk to you about some of the less exotic ones.

MS: Well, if we could stick with the exotic for just one more minute. How would we know? Let's say we go to Titan and there's life there that's based on a non-polar solvent.

CC: At 90 Kelvin.

MS: At 90 Kelvin, how are we going to know that that's alive?

CC: Well, that's a fine question. My personal prejudice is that if one wants to start asking questions about how we're going to recognize unusual life, a good starting point is the Viking experience of 25 years ago. It's the only time we've gone seriously to look for life elsewhere. I think in retrospect, it was premature, although I think we should be proud of it. In retrospect, sending humans to the moon was premature because we did it without developing the infrastructure first

MS: The scientific infrastructure?

CC: The scientific infrastructure and also the infrastructure that would allow a human presence on the moon to be sustained. Nevertheless, I think we should be proud that the human race did this as soon as it could. It was a wonderful thing. In the case of Viking, we didn't have the geological and chemical context that we needed before we started looking for life there. And we wouldn't have sent the set of biology experiments we sent if we'd had an understanding of the surface chemistry of Mars that we *think* we have now [chuckles], although it continues to be the case that nobody's made the decisive chemistry experiments on the surface of Mars to test what is the common understanding now. The Beagle 2 lander should finally test that by trying to understand the oxidation chemistry on the martian surface.

MS: So are we ready for something like Titan in 2004?

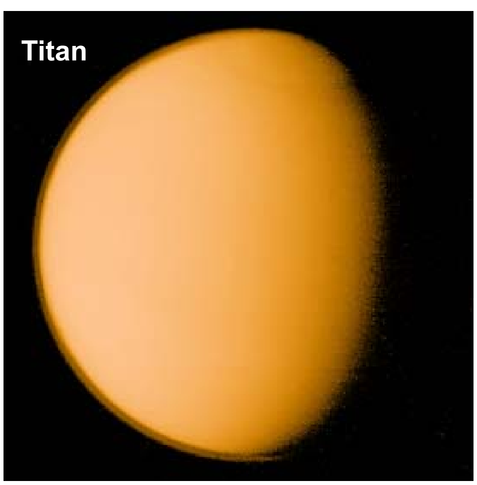
CC: We don't know very much and that's why it would have been silly to send a biology package. What we're doing instead is exploring it, right? It would have been silly also because it's enormously unlikely that there's life there based on what we know about life. But the way to deal with that level of ignorance is to explore, to go and see what's there. And, you know, if in the extremely unlikely event that there was some kind of biology present or protobiology even, we might get hints. If the GC-MS tells us there's chiralty among some of the organics, that would be intriguing. Now maybe that would be non-biological. That would be the conservative assumption. But maybe if life were based on organics, but with a non-polar solvent, then you might expect that the organics you sample would show some characteristics that would be more bizarre than you would expect from disequilibrium chemistry. Maybe chirality would be one of the best markers. So at this point, as far as those exotic circumstances are concerned, exploration's the way to go because we don't know enough to do any hypothesis testing, and because the speculations are too unlikely to justify spending a lot of resources on them. In the case of Viking we sent three experiments that would look for [carbon-based] metabolism. The assumption was still made that the life would be carbon based, but they were searches for metabolism. And we wouldn't send experiments like that today because we now think we understand that the oxidation chemistry in some respects mimics metabolic processes, those particular metabolic processes that were tested. I think the lesson is that knowing how to look for life in a particular environment depends a lot on knowing something about the context and it makes sense to explore and establish context first. Let me give a less exotic example, though. You've tried to prevent me from doing that.

MS: No, I'm not trying to prevent you from doing it! I just had that one question.

CC: I'm just giving you a hard time. The hypothesis of a deep origin... well, once again we actually have some real solar system examples that are germane to that question, although not decisive. We know we have carbonaceous meteorites that are from larger parent bodies. Theory suggests the larger parent bodies should have seen, if they were more than a few hundred kilometers across, liquid water for as much as 10^8 years early in the solar system. But we know from direct examination of meteorites, like the Murchison meteorite, that it did see liquid water. The time period is hard to constrain. So you had liquid water, you had organics present at the level of a few percent by mass, including amino acids, famously more than 75 amino acids in Murchison, including about 6 or 8 of the ones that are common in the biosphere, interestingly not most of the 20 [protein] amino acids but half a dozen or 8 of them. And you had certainly a variety of types of mineral surfaces present, and yet, to the extent this has been searched for, and I only know of one serious experiment, there's no hint [that] prebiotic chemistry progressed past the level of individual amino acids on Murchison or nucleotide bases. There's no hint of polymerization of amino acids, there's no hint of the synthesis of nucleotides.

MS: Although, to be fair, the method that they use to extract the amino acids from the meteorite may have some impact on what we end up seeing.

CC: And you've written a whole paper on the topic. I think there are maybe three things to say. One is that once again we have an example of a system that was at least part of a spatially much bigger system and temporally, the sort of estimates you see for Murchison are 10^4 years of liquid water, although those are very, I think,uncertain. But it was able to sample a temporal scale that's just inaccessible in the lab. So we need to pay attention to those results. Your work suggests that we need to give a lot more thought than we have given to whether we've really examined those environments as carefully as we need to. To my knowledge, John Cronin, in one paper published in Advances in Space Research, is the only person who's looked for polypeptides in Murchison. Maybe they're not there. That's what Cronin's work suggests.. What is it about that environment that's different from what we think the Earth's subsurface environment was like? What I don't see in the field is a whole lot of engagement with trying to use planetary environments to test ideas, and Mars and Europa are also germane here.



MS: Of course, this is where geochemistry [should] come in. We need to put these a chemical context for what the environment allows to happen. And maybe the differences or similarities between these bodies or could tell us something about how or why life may start in some environments and not in others.

CC: Yeah, I think that's potentially the case.

MS: It's also possible, for example, that in the carbonaceous chondrites, [that] it just froze too early or the system wasn't open enough or big enough to allow life actually to develop, but that it was on its way, in a sense. [It] froze in place, and we have this snapshot of what [also] happened on the early Earth... in terms of the chemical processes that may have been leading [toward] what eventually turned into life.

CC: That's possible, if the core of the Murchison parent body saw liquid water for 10^8 years, since that number gets disturbingly close to the time scale for the origin of life on Earth. It's not clear that Murchison saw liquid water for that long. In fact there are arguments that it didn't. But if it did, then you could make the temporal argument. Europa of course is intriguing in a similar way. It almost certainly has a liquid water ocean, whose volume is twice that of the Earth's ocean, and if that's the case, that ocean's been there for the history of the solar system, because the energy sources that we know of on Europa aren't sufficient to melt the ice if [they] have to overcome the latent heat. They're sufficient to maintain it as a liquid though.

MS: So the water's always been a liquid.

CC: Yeah, [there is] a 4 billion year old ocean on Europa. Maybe it's sterile... even that negative result would be awfully interesting. 4 billion years of a liquid water ocean, probably, but we don't know this yet, with hydrothermal circulation at the base and nothing happens?

MS: That would be odd, right?

CC: Oh, I don't know whether it's be odd or not, because I don't know... I don't know how common the origin of life is. Maybe it really is an incredibly unlikely event, and we just happen to have gotten very lucky. [Having] a few more worlds that saw liquid water early in their history or still have liquid water would help us.

MS: It would at least give us a reference point.

CC:Yup.

MS: Is the ocean on Europa likely to be sort of parallel to Earth's ocean?

CC: Well, we know a little bit there. We know from the magnetometer results from the Galileo spacecraft, which I think are the strongest indications of liquid water on Europa, that there's a near surface conductor that causes an induced magnetic field driven by the time varying Jupiter magnetic field that's incompatible with a permanent dipole. It's also not caused by a metal core, because quantitatively the core's too far away to account for what's measured.

MS: Does it matter if the core is liquid or solid?

CC: Well, what you need is a conductor. It could be either a liquid or solid; in principle it could be either a liquid or a solid conductor. But we know how strong the induced magnetic field is, because that's exactly what's measured, and quantitatively you can't get that from a deep core on Europa. It has to be a near surface conductor and that's consistent with a liquid water ocean under 10 or so kilometers of ice, provided that liquid water ocean is salty. And you can say what the salinity of it has to be to be consistent with the measurement. The salinity is about the same as the Earth's ocean, which is kind of an amazing result. The salts aren't likely to be the same; it's unlikely to be sodium chloride, at least if you use a carbonaceous chondrite model. Here's your geochemistry again; if you use a carbonaceous chondrite model the most likely salts are magnesium sulfate and then some sodium sulfate. It's dominated by magnesium sulfate. Magnesium sulfate is [also] a common interpretation of the near-infrared spectral features at the surface. So there's kind of a story here that seems to hold together. So it's probably a magnesium sulfate rich ocean.

MS: So the idea is that the crust of Europa interacts with the water, which accounts for the formation of the salts.

CC: Right. Europa started as some kind of big carbonaceous chondrite, and it differentiated. The water was removed from throughout the body and moved to the outer 100 km and either that way and/or through continual hydrothermal activity, you leach the salts from the matrix. But there are problems with that picture, no surprise. The problem is that the carbonaceous chondrite model for Europa is the kind of natural zeroth order model you choose for anything in the solar system, but some theoretical work of the formation of Europa in the jovian nebula when Jupiter formed suggests that it in fact should have been very depleted in volatiles, because the nebula was hot, and in fact, well, who knows? That's a kind of nebular chemistry result. If you look at the amount of water Europa has, it has about as much water... [hesitates]... it has about as much water as some estimates of the water in carbonaceous chondrites suggest. About 5 or 6 percent of Europa's mass is water. I wish I could tell you that that is the amount of water in carbonaceous chondrites, but in fact if you look at the literature, the figures are all over the map. But it's roughly in the range for carbonaceous chondrites. The other thing to worry about is that you may see magnesium sulfate at the surface, but the surface at Europa is an oxidizing surface so going from a sulfate that you see at the surface to inferring something about nature of the chemistry of the ocean is dicey.

MS: So where is the life on Europa if we're going to look for it?

CC: Well, if it's there's, it's in the ocean. That's probably not where we're going to look for it though. If it's there, it's in the ocean because you need liquid water.

MS: Because [the ocean is] too difficult to get to?

CC: Yeah, [below] 10 km of ice. That may be a mission that we do late this century. I would like to see us do it earlier than that, but right now we don't even know if we're going to get an orbiter to Europa in the next decade. But if there's life there, if it's anything like life as we know it, it's in the ocean. The challenge then is to come up with energy sources to drive that life. A few of us have been speculating about that. Photosynthesis is not impossible, in a model where the cracks viewed on the surface are communicating with the ocean.

MS: Is there enough sunlight to drive photosynthesis?

CC: You could imagine photosynthetic niches; [one] model of the cracks, due largely to Rick Greenberg and his collaborators, suggest[s] that the cracks open and close diurnally, and ocean water rises and falls in the cracks as they open and close to the tides. If this model were correct, you could imagine photosynthetic environments up toward the top of the crack, where you ride up with the water, photosynthesize like crazy for the half of the Europan day that you're up there, then you fall back down. And the energy advantage to that is so huge that if that model were right, I wouldn't rule photosynthesis out, just because there's so much energy per square centimeter available from the sunlight.

MS: Even at Europa?

CC: Even at Europa. You're down by a factor of twenty five [relative to] Earth. And we know terrestrial analogs can live under those conditions. Obviously not everything, but there are terrestrial microorganisms that can live under those conditions. That depends on the particular model. [What] we've been looking at has been ways to get biologically relevant electron donors and acceptors to the ocean. Clearly the ocean is in communication with the surface, because the surface is only about 50 million years old, based on crater counts, so somehow the surface is being resurfaced. There's a spectral feature that indicates carbon dioxide present in the ice. Radiation chemistry of that ice is going to produce both oxidants and simple organics like formaldehyde. And once again we have terrestrial analogs that can make their living off of that if it gets mixed into the ocean. And you can try to quantify just how much of that's available. Then there are other sources. So the answer to your question is, there's liquid water, there may be sources of biogenic elements; it may have formed with them, and even if it didn't, comets would have delivered biogenic elements in substantial quantities over the last 4 billion years. And then there are sources of free energy that you can put your fingers on. How do you actually sample it? Well, I think that you need an orbiter mission to tell. We could have gotten a lot of this from Galileo, but the antenna didn't unfurl. But I think it would be good to have on the order of a hundred meter resolution over the entire surface of Europa. And then we would choose a place to land that we thought was the place that was most likely to represent [a location] where water from the ocean has recently reached the surface. You can [sample] by melting, which is a real advantage... you can melt a lot of material, and concentrate the organics that may or may not be present in the material.

MS: So at this point, any missions to Europa would just be looking to see if life were there, [and] we can't actually answer the question of how it started there. It's a different perspective to take.

CC: It is a different question, because even if the Europan environment as it exists now is an environment which seems like it could sustain life as we know it, that's very different from saying if life could have originated there.

MS: 4 billion years ago.

CC: Yeah, or [even] now or whenever. There's a soil microbe called *Hyphomicrobium* that can live by combining formaldehyde and oxygen. I'm sure we'd have to talk about temperature ranges and so on. Can it really live in 273 degree (Kelvin) water? I don't know. But one can envision a contemporary Earth microbe that can make a living at Europa. That's not the same thing as saying that just because a competent, highly evolved organism can make a living there... that the origin of life could have happened there. We don't know whether there are hydrothermal vents there or not. And it's going to be long time [before we would know]. I mean, you're going to have to get through 10 kilometers of ice and then dive down to the bottom of a 100 km ocean, and then get extremely lucky. Right?

MS: Right, [and] we have a hard enough time finding them on this planet.

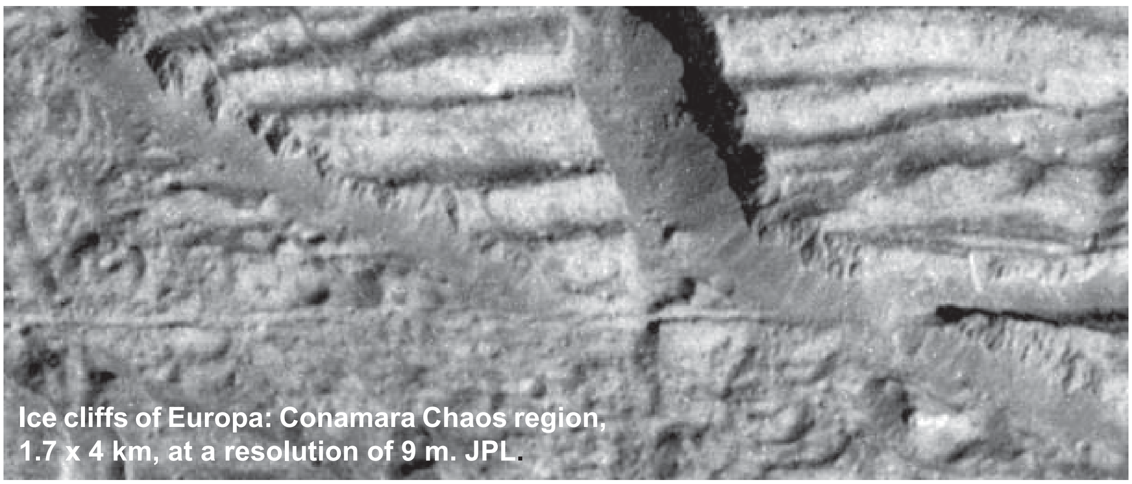
CC: Exactly. It's not like you're going to just drop one submarine into Europa's ocean and see tube worms. And for that matter, you wouldn't have the tube worms unless some nonphotosynthetic mechanism for building up oxygen was present.

MS: Well, this then sort of leads into another question that I've been thinking about lately, which we'll address in a future issue of the Geochemical News. [That] is this idea recently of Rare Earth. There was a book published...

CC: I know the book.

MS: And the main hypothesis of this book is that while microbial life might exist elsewhere, animal life or complex organisms is a very rare, if not exclusive-to-Earth phenomenon. So [if] we go to Europa and find a tube worm, that throws that right out the window. But what are really the chances for finding what's considered to be complex, or animal, life elsewhere?

CC: Well, we're as always in the position of trying to extrapolate from a single example. Metazoa didn't arise on Earth until there was a substantial concentration of oxygen in the atmosphere and therefore dissolved in the oceans. And that seems to be related to the fact that metazoa [have a] metabolism [based on] using molecular oxygen that produces 18 times as much energy as fermenting. And life had billions of years on Earth prior to the rise of oxygen to figure out a way to make metazoa without molecular oxygen being abundant and it didn't figure out how to do it. It's not quite true that there are no multicellular prokaryotes. I mean, there's some sense in which cyanobacteria are multicellular, and then there are these fruiting myxobacteria, that are separate organisms but can combine to form these macroscopic fruiting bodies that can be nearly a millimeter in size. And they take on different functions in the stalk, so there [are] some more or less multicellular examples from the prokaryotic world.



Ice cliffs of Europa: Conamara Chaos region, 1.7 x 4 km, at a resolution of 9 m. JPL.

MS: But [those are] more like communities.

CC: Yeah, I think that's fair. But metazoa seem to have required oxygen. If that's [the] requirement, then you need a world with photosynthesis to build up oxygen. [And] it's not enough to have photosynthesis, because on Earth, we had photosynthesis presumably from 3 and a half billion years ago. There had to be some other event that sequestered a substantial fraction of the produced organics so that you could build up the oxygen as a separate reservoir. There are speculations that that was ultimately associated with the plate tectonic history of the planet. Building up a thick oxygen atmosphere might involve a lot of contingencies. On the other hand, one can already envision ways, not ways I'd hang my hat on, but ways to build up oxygen in Europa's ocean. And this gets back to the heart of Rare Earth, and my concerns about the book. It's easy to look back along a particular history of evolution on this planet and point to all the specific things that had to be just right for things to have worked out. That's the contingent argument. There are so many contingencies. But then the question is, what about other ways of arriving at a functionally equivalent result? Of course if you look back along any particular thread you see all the things that were essential to that thread, but were there parallel threads? And in evolution, a classic example of that is flight. What an amazing thing flight is, and how many things have to be right for an organism to evolve flight! And yet, the birds did it, the mammals did it, the insects did it, the fish did it, the reptiles did it. There was a powerful evolutionary driver in that case, presumably. So there are different things going on with the Rare Earth hypothesis. One [is], do you ever get the planetary conditions that are going to be right? And there are so many ways for planetary conditions to go wrong. And the other is, even if you have the right conditions, is evolution going to result in metazoa, and then intelligence? But I have concerns with their planetary conclusions. You can't just sort of reach into an existing system with full knowledge, and say, oh, if I remove this element, the whole thing collapses. And boy, therefore, how fragile it is. You have to ask how the system would have been different from the start, if you had changed this or that element. So that's the planetary point and then there are other things too.

MS: We can get back to that on some other occasion, perhaps.

CC: Let's do that. Or not [laughs].

MS: Let's talk about something else.

CC: [Laughs] Ok, but one last comment. My last comment is that I think this is all very interesting but in the end the only way we're going really to find the answer to these questions is to go look. And that's what the SETI Institute's about; it's about searching.

MS: Well, this brings up another good thing to cover here, which is the function of SETI, and what it's evolved into. You're the Carl Sagan Chair for the Center for the Study of Life in the Universe. First of all, how did you come into that role, and where are you expecting to take this so that you can lead SETI in this respect?

CC: I guess the first thing I should say is that we're the SETI Institute. SETI I think of as a field of study like astrobiology is a field. There's an Astrobiology Institute and then there's Astrobiology. So there's SETI and then there's the SETI Institute. I think we're the leader of the field in the sense that we're doing the most sensitive search, where we're systematically walking through the thousand nearest, largely sunlike stars (at the ten percent level we look at other stuff) across about three gigahertz worth of frequency at the bottom of the microwave window. It's a numerically demanding problem because there are so many data. But that's the SETI science side of the Institute, and Jill Tarter holds the Oliver Chair and directs that group. And then this side, the Center for the Study of Life in the Universe, is directed by me, and I hold the Carl Sagan Chair. Towards the very end of his life, Carl was a board member of the SETI Institute. Another very prominent figure in SETI history is Barney Oliver, who more or less invented the pocket calculator for Hewlett Packard. Barney got interested in SETI as an intriguing scientific and technical problem from his engineering background. And when he passed away a few years ago, he left the Institute an endowment which, out of which the Oliver Chair and the Sagan Chair were created. So, it must be about 4 years ago now, those chairs were created and the Institute advertised for applicants for those positions. And I thought long and hard about it and ultimately applied to the Sagan Chair position. This was a wonderful opportunity. And also it meant I would get to rub elbows with people who were actually doing SETI proper, which is something I've always been intrigued by but hadn't been involved with in any research sense. We were able to couple this with a connection to Stanford, so I'm [also] an associate professor of research in Geological and Environmental Sciences at Stanford. More to my personal point, I co-direct the Center for International Security and Cooperation at Stanford, which is a major commitment. Not as major as this one, but...

MS: Did that grow out of your interest in international policy from long ago?

CC: Yeah, when it was clear that I would be coming here, I knew that I wanted to try to continue doing some policy relevant work. I tried to keep my hand in when I was a graduate student with Carl. I was involved with some very low level, what people in the field would call track 2, which means unofficial but still sort of plugged in, exchanges with Russian scientists. And then after my first postdoc I applied for the White House Fellowship. The interview process is out of this world, by the time you get through it you've had four days of interviews.

MS: That's worse than interviewing for a faculty position!

CC: They're serious. But since President Johnson created the program there's always been one position on the staff of the National Security Council and I was able to get that position my year. And then, after the fellowship year I was hired into the national security division of the White House science office. I was cold turkey on science during those years. I wrote one or two review articles but other than that I wasn't doing any science at all, any academic type science at all. Then I thought that probably two years of not doing any science at all was about as much as I could get away with and still go back to being a scientist. What's great about this position is that I get to pair both interests. I was affiliated with the Center for International Security and Cooperation my first year here and then, unexpectedly, after that first year they asked me if I would become a co-director. The Center's always had a political or social scientist and a natural scientist as co-directors since its founding. And that's because the Center tries to bring together people both from international relations and people from a technical background to address important world problems, whether it's nonproliferation of weapons of mass destruction, or arms control... we're now spending more time with other post cold war issues as well, such as peacekeeping and ethnic conflict. But we try to maintain this mix of people from scientific and engineering backgrounds and people from political science backgrounds. Ok, but you had asked me about what's going on here. Yeah, work across the Drake equation, work relevant to the origin of life, life elsewhere, has been part of what the SETI Institute has done from the very beginning. Our vision is that in the future we will have several research groups anchored by hard money positions doing cutting edge research related to understanding the origin and prevalence of life in the universe, and that those people would be in one SETI Institute facility together.

MS: What role in all of this future development for things like SETI do you see for the geochemical community in terms of participating in these kinds of interdisciplinary projects, for example?

CC: Well, let me give one example that we're looking at very carefully right now. We've had a set of meetings that has brought together academic scientists, scientists from research institutes, and scientists from the biotechnology industry. And it has to do with the idea of polymerization, one of the outstanding problems in origins of life. We all know how to make simple organic monomers, amino acids, say... how do you actually polymerize them, since the thermodynamics pushes you in the opposite direction? At least if you're doing it in liquid water. Well, one possible way of addressing that problem invokes catalytic mineral surfaces. But ok, the dilemna there is you pick one mineral, you make some decision about what that's going to be, you do an experiment, maybe that experiment takes weeks to months. If the mineral didn't work, didn't do anything interesting, ok, well, pick another of the several thousand minerals that are potentially relevant here. And if you do that two or three times and don't get an interesting result, you don't have your grad student continue to do that. You go do something else. And if you do get an interesting result, probably you bore in on that result and again don't examine this vast space of potential of prebiotically, early Earth plausible, potentially catalytic mineral surface that may have been important. It's kind of a throughput problem. Meanwhile the biotechnology industry is developing all this robotic technology to allow them to test ten thousand samples simultaneously for some sort of result, depending on the result they're looking for. And it's all done with robotics. Is there a way to make the high throughput robotic technology with these origins of life experiments, so that instead of examining one mineral surface at a time, we examine a thousand mineral surfaces at a time? And the answer is probably yes. So that's just one example. Let me reemphasize that one important lesson from Viking is that you need to understand the chemistry and the geology, [i.e.] the geochemistry [and] also the atmospheric chemistry if there's an atmosphere, in order to know how to go about searching for life. So in our search for life elsewhere, you've got to make contact with the geology and the chemistry. I chaired a meeting at Harvard to talk about how to look for life on Europa. One of the things that came through loud and clear in that meeting was there's a whole set of chemical characterizations we want to do first that are essential context.

MS: To make sure that we can distinguish between what is in a sense a geochemical signature from one that is a biological signature.

CC: Right. That, and also to give us context for biological speculations. You know, what anions and cations are present in solution, if any? What dissolved organics are present, if any? Just have that context to inform your interpretation and your speculation from the first. If there's a Europa lander that looks for life on Europa it may do a biology experiment, but that would be embedded in a whole suite of context setting experiments. So geochemistry really is relevant virtually across the entire suite. At the far end, we're dealing with the evolution of an entire planet to try to understand the potential setting for biology.

MS: If we can, let's talk for a minute about your role as a public figure. How does all of this publicity fit in with your research and your other duties? Is that too much of a question?

CC: No, it's a good question. Let me step back first to the sort of biggest picture. We are hurtling into a world this century where we're going to be faced rapidly with a whole set of important issues that have a strong scientific and technical component. That's going to be true from an international security point of view. If the anthrax attacks didn't make that clear last October, I don't know what will. But it's true across the whole suite of so-called weapons of mass destruction. It's true from a point of view of a broader definition, or broader understanding of security, in terms of global environmental issues. But it's also true in terms of profound ethical issues, especially I think, driven by biotechnology, as we begin to become more capable of reshaping human beings; it's nascent now, but it's completely clear where that trajectory is heading. So an understanding of science and technology is critical for our policy makers, and since this is a democracy (and we ought to be working towards a world where all the governments are democracies), it's important for the whole population of the world. Not that they all be scientists, but that they have some knowledge of science and technology that lets them make good political decisions. Yet, in the United States, the opposite's been happening. The Congress abolished the Office of Technology Assessment in 1995. Congress made a decision under budget pressure to eliminate its independent scientific research arm, that in principle would research whatever topic Congress asked it to research and give them good technical information about it. So at exactly the time when that kind of knowledge is more and more crucial to addressing issues that we face, we are doing a less and less good job of having that kind of advice [available]. There are a whole lot of things going wrong here. On the flip side, scientists need to do a better job of accepting other scientists who are involved either in policy or in educating the public. There's more lip service paid to that now than there used to be, but there's still, I think, skepticism, toward people, especially people who aren't yet tenured, spending a lot of time doing that kind of work.

MS: There are many examples of that.

CC: Yeah, it sends a kind of message. So the community just needs to get smarter. But beyond that, from a purely self-interested issue, if scientists don't understand that they're being funded by the federal government, which means it's taxpayers' money, and they have to justify their funding, as any other government program does, if they don't do that they cut their own throats. And you know, the country can't afford it. It's too important for the country.

MS: So you think it's important to be a public figure and do you welcome that role?

CC: Well, I think it's important that some scientists play a role there. I don't think every scientist needs to do that. But if you have the luxury to do it, then I think it's important in and of itself and the more scientists who spend time communicating with people on Capitol Hill, or with the Administration, or with the public, the better. So yes, I do think it's important.

MS: So then of course it becomes important, your role at Stanford, for example, where you're teaching these kinds of classes and trying to educate people into what the more important kinds of topics might be.

CC: Well, there are two different things I'm doing at Stanford, from that point of view, from the point of view of education. I have been teaching a graduate seminar called Origins of Life in the Solar System, but this year I'm teaching [an] undergraduate course. And we'll spend as much time in that course talking about history of science, and what science is, how we got to where we are, as we'll spend talking about astrobiology. Astrobiology is especially well-suited to that, because it, as you said earlier, covers the whole span of science, so it gives you a chance to give an integrated sense of the scientific view to students on topic that unquestionably people are interested in. The other thing though, is that I also do some lecturing on the security side at Stanford. I don't have my own course there, but I participate in the undergraduate political science course the Center co-teaches. And that takes students across the range of scientific and non-scientific departments at Stanford, but it has a technical content. So it's a way of getting people who are going to be political scientists to learn some technical content that is relevant. And then similarly the people who come in with a technical background get an overview of international relations. So it's a way for us to try to have an integrated curriculum. And we do that at graduate and postdoc levels at the Center as well. We have people both who are pursuing graduate degrees who spend time at the Center and people who've just come out of postdocs. We have a science fellows program, and if there's a way to mention this in your article, I'd appreciate it.
[Editor's Note: Information is available through Dr. Chyba via the associate editor, or at the Stanford CISAC website http://cisac.stanford.edu.] The whole point is to give them an opportunity to either make the transition or step in for a year, have a look, and then go back to what they were doing much better informed about the policy world than they had been.

MS: I think that's in fact where a lot of scientists, especially geologists have been slow [to act]. I think what you're doing is great because the policy side of things is going to have to hit us at some point and we'd better start now with trying to figure this out, [or] we're going to get left behind.

CC: It's already late in the day. There are so many issues that are scientific, so many security issues that have a strong scientific component and there's too little science input in those decisions. Of course the different fellowships that the different societies have, the AGU has such a fellowship to send people to Capitol Hill. Those are really important.

MS: This of course also brings up the somewhat controversial topic of the Alan Hills meteorite, because of the way that this announcement was made, and the general public's understanding of what's going on... do you have an opinion about the whole thing, from a person who's been in on the whole policy side of things?

CC: I would say that it's very much to NASA's credit that they had Bill Schopf at the original press conference. They had the voice of a skeptic at the press conference. I think they would have made a bad mistake if they had not had the skeptic right there. I think that the whole affair has been beneficial in that it may have made people who aren't scientists understand that a lot of science, most science at the forefront, doesn't give you certain answers. It gives you hypotheses or possibilities that have to be further examined. And so the public has gotten to watch this play out very publicly. I think many scientists' immediate reaction was, there's not enough here to make this claim. And I think that that's been borne out largely, with time. At the same time, we learned an awful lot; it's a damned interesting meteorite. So do I wish it had been publicized a little less initially? Yes, I probably do. But if you're going to have a long paper in Science magazine about evidence for life on Mars there's probably no way to avoid having it become extremely public. I think that the press conference with voices of skeptics as well as proponents at NASA, I think that was wise. And I think it's been a good thing for the public to watch how scientists have approached this critically.

MS: Do you think the public is still paying attention? You pointed out the national security issues... there was this anthrax scare, for example, and there don't seem to be any more anthrax letters coming out. Are people going to stop paying attention? Is that a problem?

CC: Well, it's understandable... an individual can only pay attention to some upper tier of issues at a time. People have to go to their jobs, they have to raise their family or care for their elderly parent. There's only so much news an individual can pay attention to or can stay on top of. The more worrying question would be whether in the absence of an immediate threat, the U.S. government stopped paying attention, and stopped explaining to people why it is that some of their tax dollars have to continue to be spent on these issues. One other thing to say is that the better scientists get at presenting their work in ways that are engaging and exciting, the more likely it is that that's what will rise above the threshold and that you'll get public attention. At the same time, you have to do that while absolutely maintaining your integrity. And the pressure from the press is to exaggerate, because the press always needs to be able to say that something is new. And if it's just a kind of incremental advance, it's hard for a reporter to justify writing the article. Sometimes that means that the reporter goes away unsatisfied, and doesn't write the story. And that's fine. You have to be willing to accept the outcome that the result of being honest is the reporter doesn't go anywhere with it.

Geochemistry at Royal Holloway, University of London

Academic staff: Dave Alderton, Geoff Batt, Robin Gill, Darren Gröcke, Sarah James, Dave Lowry, Dave Mattey, Martin Menzies, Euan Nisbet, Matthew Thirlwall, Derek Vance, Nick Walsh

Postdoctoral Researchers: Robert Anczkiewicz, Steve Grimes, Nathalie Grassineau

PhD Students: Corey Archer, Kai-Kim Chiang, Carol-Ann Craig, Dawn Munday, Adam Scrivner, Julia Shaw, Ingrid Ukstins, Ellen Wolfenden

Introduction

Royal Holloway is a College of the federal London University located in the Surrey green belt west of London. It is close to the M25 London orbital motorway, to Heathrow airport and Windsor. Geochemistry research is primarily housed within the Department of Geology, which shares with the Geography Department the Queen's Building, designed and constructed for these departments in 1986. The Geology Department was created by the merger of the Geology departments of Bedford, Chelsea and King's Colleges in 1986, each of which had thriving geochemical research groups focussed around the XRF in Bedford, microprobe at Chelsea and ICP-AES in King's College. This equipment was relocated to Royal Holloway and swiftly accompanied by radiogenic and stable isotope laboratories which form an indispensable basis for the majority of our current geochemical research. Several new staff members have recently been appointed in geochemical research areas resulting in intense research activity illustrated for example by 20 geochemical papers published in 2001. The Geology Department was rated as level 5 in the UK Government's 2001 Research Assessment Exercise ranking it amongst the top ten UK geology departments. The Department is also rated excellent in teaching quality and offers a diverse portfolio of courses leading to BSc and MSci degrees that may include use of the geochemical equipment for independent projects. An MSc course in Environmental Analysis and Assessment (contact D.Alderton) is also grounded in geochemistry, and we offer MSc in Geology by Research, which allows students to take a "taster" geochemistry (or other) research project without having to commit to PhD studies. EU and overseas students are especially welcome on our courses. Further details my be found on our departmental website http://www.gl.rhul.ac.uk or by email contact to staff listed in the text below (initial.surname@gl.rhul.ac.uk).

Since the days of Bedford, King's and Chelsea College we have operated our geochemical laboratories as large scale facilities in which we welcome visitors from other institutions and overseas. The XRF, radiogenic isotope and stable isotope laboratories have been members of ULIRS, the London University system for sharing research equipment, since their inception, whilst the ICP-AES has been a service facility of the UK Natural Environment Research Council (NERC) since 1978. In addition to visiting academics and postgraduates from the London area and the rest of the UK, we have hosted many international visitors, from the USA and Canada, Australia and New Zealand, China, India, Brazil, Russia as well as from many European countries.

Chemical analysis facilities include the NERC ICP-AES service and a Perkin-Elmer quadrupole ICP-MS (contact S.James) and a Philips PW1480 XRF (contact M.Thirlwall). The latter has specialised in attaining highest precision data for igneous rock analysis, with for example ±0.1ppm uncertainty in low-level Nb concentrations over a 12-year period. The Stable Isotope Laboratories (contact D.Mattey or D.Lowry) house VG (now Micromass) Prism, Optima and Isoprime mass spectrometers, with an automated laser fluorination system for O analysis in silicates, oxides and phosphates, automated acid bath for C and O analysis in carbonates, a stepped combustion/pyrolysis system for trace C analysis, Isochrome continuous He-flow system for C, N, S isotope analyses of a wide range of materials, and a Multiflow system for automated carbonate analysis. A new stable isotope mass spectrometer is to be installed in late 2002 and will be dedicated to atmospheric research. The Radiogenic Isotope laboratories (contact M.Thirlwall or D.Vance) house a VG (Micromass) 354 multicollector TIMS and Micromass IsoProbe multicollector ICP-MS with facilities for both solution nebulization and laser ablation. Recently refurbished clean room facilities include Sr-Nd and REE analysis (TIMS), and Hf, U-Th, REE, transition element and double-spike Pb analysis (IsoProbe), with isotope dilution available for Rb-Sr, REE, U-Th-Pb, Zr-Lu-Hf, Ba and K.

Ancient and Modern Atmospheres
(contact E.Nisbet, D.Lowry, N.Grassineau)

Royal Holloway has several groups studying the ancient and modern atmosphere. This work ranges from monitoring present-day greenhouse gases to the geological reconstruction of the inputs to Archaean air. The Methane group monitors CH_4, CO_2, CO and H_2 continuously in London air, and $\partial^{13}C$ in CH_4 in tanks of air from the Atlantic background from Svalbard (Spitsbergen), Mace Head (Ireland, in partnership with Galway University), and Ascension Island. The lab is equipped with cryogenic methane extraction lines, as well as GC and RGD, and is soon to take delivery of a new continuous flow instrument for small sample mass spectrometry work on methane.

The group participates in joint work with Cambridge modelling the global methane budget, and for several years has co-ordinated a major study of Russian methane emissions involving several Russian institutes and three EU nations. Previously, Royal Holloway had led the multi-nation west European methane budget experiment. Other methane work includes the study of landfill emissions and microbiology, and work on the role of methane in late glacial events.

Linked to the modern methane and microbiological work is the study of the early atmosphere. This focuses on very well preserved carbon-sulphide assemblages in drill cores and stromatolites from the Belingwe Greenstone belt, Zimbabwe and from Steep Rock, Canada, as well as other areas, including Isua, Greenland. The various microbial communities in each sedimentary facies are being studied by high resolution CF-IRMS isotopic work, to elucidate some of the major biochemical fractionations and reconstruct the microbiological facies. From this, constraints can be placed on emissions to the air. Very close to the sedimentary successions, superbly preserved komatiites occur, including rocks with olivines hosting large silicate liquid inclusions. These are being investigated for volatile content, and by inference to model the volatile contents of Archaean mantle.

Geochronology
(contact M. Menzies, G. Batt, R. Anczkiewicz, M. Thirlwall)

Sr isotope stratigraphy (M.Thirlwall) has been a major focus of research in our TIMS laboratory for the last decade, in close association with John McArthur of University College, London. Age resolution has been enhanced by improving the external precision of standard analyses to 0.710226±12 (2sd, N=207 from 8/2000-3/2002) and we have shown that with repeated sample analysis external precision can be improved to ±0.000006 2sd. We have also investigated the preservation of marine Sr isotope signals in a variety of fossil carbonates through laser ablation Sr isotope analysis on the IsoProbe MC-ICP-MS. We have obtained external precision on $^{87}Sr/^{86}Sr$ in a single belemnite of ±0.00003 2sd (500ppm Sr) and shown that diagenetically altered belemnite carbonate yields greatly elevated $^{87}Sr/^{86}Sr$ and $^{84}Sr/^{86}Sr$ compared with pristine carbonate, which reflects a combination of diagenetic modification to $^{87}Sr/^{86}Sr$ and a molecular isobar (Bailey, 2001).

Ar geochronology of minerals and whole rock rhyolites (Menzies, Ukstins, Wolfenden) allows conjugate rifted margins to be compared and contrasted in the southern Red Sea. Pre- and syn-rift chrono-stratigraphies in Yemen and Ethiopia reveal that mafic flood volcanism in Ethiopia predated mafic volcanism in Yemen by as much as 2 Ma. Felsic volcanism occurred at the same time on both margins. In Ethiopia volcanism youngs systematically from north to south parallel to the rifted margin. Pre-rift volcanics dominate in the northern sections and syn-rift in the southern sections. A hiatus in volcanism in Ethiopia matches an unconformity in the volcano-stratigraphy in Yemen. This may relate to the separation of Africa and Arabia (25Ma). An unconformity in the volcano-stratigraphy in Ethiopia may signal the opening of the Gulf of Aden/Red Sea (5-10Ma). The southern Red Sea acts as a template with which to compare Volcanic Rifted Margins (VRM) worldwide. Flood volcanism on VRMs may have reached a thickness of 4-7 km but syn-rift denudation has reduced several margins to thicknesses of 1-2km. While the eruption of pre- or syn-rift silicic volcanic rocks can last for up to 5Ma, magmatism and rifting are not necessarily synchronous. Magmatism can occur before, during or after rifting. In some VRMs a magmatic hiatus/ unconformity coincided with the peak of extension/exhumation. Rift mountains are uplifted and rapidly denuded by pre- and syn-rift processes. Seaward dipping reflectors and high velocity lower crust (ca 7.4 km/s) form in the continent-ocean transition by igneous processes and reach considerable thicknesses (10-15km).

Isotopic dating of rock-forming rather than accessory minerals in metamorphic rocks permits a more accurate interpretation of the measured age. Particular interest in garnet chronology is obvious due to its common occurrence and participation in most metamorphic reactions allowing PT estimates. Additionally, microstructural and microtextural studies of garnet bearing rocks often provide useful insight into tectonometamorphic evolution of orogens. This makes garnet one of the most important minerals used for quantifying geological processes. Currently we are applying Lu-Hf and Sm-Nd systems to garnet and apatite from high pressure and ultra-high pressure rocks from numerous collisional belts in Europe, North America and Asia (Anczkiewicz, Platt (UCL) and Thirlwall with NERC grant funding). Our interest focuses in particular on reliable garnet chronology. The presence of inclusions has long made garnet dating problematic, among which monazite, apatite, xenotime, epidote and zircon are particularly difficult to deal with. Our initial sulphuric acid leaching experiments prior to garnet dissolution allow us almost to eliminate the problem of phosphate inclusions. This technique enhanced the Sm-Nd ratios by more than 50% on unpicked garnet separates, relatively to "pure" carefully handpicked grains.

Palaeoclimatology, Palaeoceanography and Palaeoenvironmental Research
(contact D.Vance, D.Mattey, D.Grocke, S.Grimes)

Geochemical aspects of paleoceanography and palaeoclimatology are the focus of research by a number of groups in the department. The techniques applied range from stable isotope studies involving O, C, N, Zn, Fe and Cu through cosmogenic isotopes to radiogenic isotopes of Sr, Nd and Pb.

One aspect of the palaeoclimatology research conducted at RHUL focuses on the calculation of absolute palaeotemperatures across the Eocene – Oligocene boundary (Grimes, Mattey, Collinson, with NERC grant funding). This involves the measurement of the† $\partial^{18}O$ phosphate value of rodent tooth enamel, which due to the close association between the rodents and large water bodies allows the calculation of palaeo-local water $\partial^{18}O$ values using published metabolic fractionation equations. Combining the calculated local water value with the $\partial^{18}O$ value of a phosphate or carbonate organism that precipitated from the same water source then allows the calculation of palaeotemperatures using any number of phosphate or carbonate thermometers. However, due to the use of rodent tooth enamel and their small sample size (<1.5mg) a new laser fluorination technique for the determination of phosphate $\partial^{18}O$ values had to be developed. This new technique was reported in Lindars et al. (2001) and involves both a novel pre-treatment technique and a unique direct laser fluorination system (designed by David Mattey) attached to a duel inlet Optima Mass Spectrometer. This combination of systems allows us to target only the phosphate oxygen component of tooth enamel (biogenic apatite), which has been shown to be the most resistant to diagenetic alteration.

A key aspect of palaeoenvironmental research in the radiogenic isotope laboratories (D. Vance) is the use of isotopic systems to examine transfers between the continents and the oceans and the constraints that such data provide on mechanisms for palaeoenvironmental change. The research is supported by newly refurbished chemical preparation laboratories and uses the TIMS and IsoProbe multi-collector ICPMS (e.g. Vance & Thirlwall, 2002). Two current NERC-funded projects illustrate these applications. The origin of oceanic anoxia in the Mediterranean over the past few million years is a contentious issue, with proposed explanations ranging from increased productivity in surface waters to water column stagnation caused by a disturbance of the freshwater balance in the eastern Mediterranean. Freshwater excesses during the anoxic events have been proposed to derive both via an increase in the transport of moisture to the Mediterranean by temperate westerly winds and increased monsoonal activity in East Africa causing large Nile floods. The Nd isotope composition of the Nile is highly anomalous due to the fact that the river derives most of its dissolved load in the basalts of the Ethiopian Highlands. We are currently using foraminifera as records of Nd in the past

Mediterranean to examine variations in Nile outflow (Scrivner et al. 2001) and have identified distinct shifts towards the Nile value during periods of Mediterranean anoxia. A second project involves high-resolution studies of Heinrich events – periodic iceberg discharges from circum-Atlantic ice-caps at the height of the last glaciation. These events are clearly dominated throughout much of their history by material from the North American ice-sheet. However, the debate surrounding the ultimate mechanism for Heinrich events and the associated millennial climate change depends critically on their detailed provenance. Recent literature data for Heinrich layer 2 (H2) suggests that European ice-sheets kick the Heinrich events off. Sr-Nd-Pb data from this laboratory suggests that H4 is fundamentally different in that there is no evidence for such a European trigger (Vance and Archer 2001).

In the past 18 months we have been developing transition metal isotope tracers of surficial Earth processes. The ultimate aim of this development is to use the isotopes of Fe, Cu and Zn as nutrient tracers in the Quaternary oceans. However, initial research has centred around the investigation of microbiological fractionation of transition metal isotope systems in the Archean oceans. Fig. 2 shows new data for these systems in sulphides preserved in 2.7 Gyr old microbial mats from the Belingwe Belt in Zimbabwe (Archer and Vance 2001). These microbial sulphides exhibit the lightest Fe yet observed in a terrestrial sample and confirm the role of biological processes in the fractionation of these isotope systems.

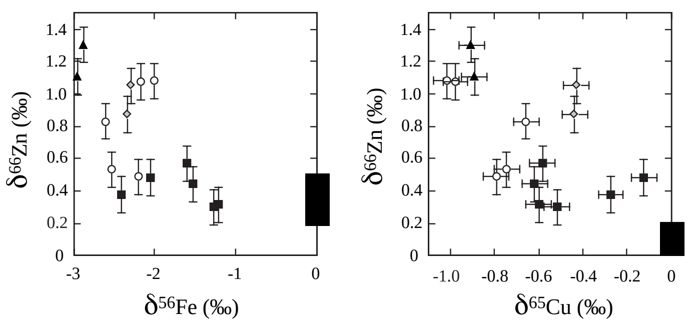


Figure 2: Fe-Cu-Zn isotopic data for individual sulphide grains (filled squares, open circles, stippled diamonds, representing different formations in Belingwe sediments) from 2.7Gyr microbial mats and associated black shales (solid triangles). Fe data expressed relative to IRMM-14 standard, Zn relative to the Lyons JMC 3-0749 L standard and Cu data relative to NIST SRM976. All errors are 2σs, those for Fe data are smaller than the symbols.

Recent collaboration between Darren Grocke and colleagues in Spain (Paul Palmqvist, Alfonso Arribas) has bridged the gap between biogeochemical and ecomorphological techniques in reconstructing and interpreting a Pleistocene faunal community. The debate regarding protein preservation is ongoing and it is best to consider that proteins are present unless proven otherwise. For example, the recovery of collagen from fossils with age > 1 Ma is not rare and high amino acid concentrations have been found in Pleistocene–Cretaceous fossils. We have analysed large mammal material from the Venta Micena locality (Guadix-Baza Basin, SE Spain). Protein preservation was not seen in many specimens and only 37 out of 57 showed collagen C:N ratios within the accepted range of 2.9–3.6. However, stable-isotope analysis of this collagen yielded data which was readily interpretable in terms of paleodiet and paleoenvironment (Palmqvist et al., 2002). Due to the age of these specimens and concerns regarding protein and isotopic preservation, ecomorphological tests were conducted on anatomical features not destroyed by the process of fossilization. The concordance between the ecomorphological and biogeochemical results was very good and led us to assert that collagen had survived longer than 1Ma in many specimens from Venta Micena (independent evidence also indicates exceptional preservation of immunoglobulin at Venta Micena). The results from this study have led to financial support from the Spanish Government in which Grocke is collaborating with colleagues in Spain (P. Palmqvist, A. Arribas) and Uruguay (R. Fariña, S. Vizcaìno) to investigate the ecomorphological and dietary evolution of large mammals over the past 1 Ma from the African–European and South–North American continents.

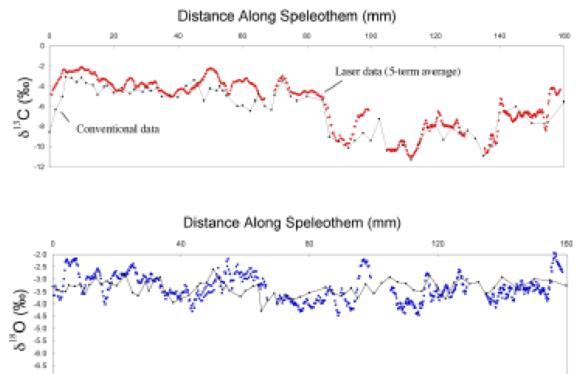


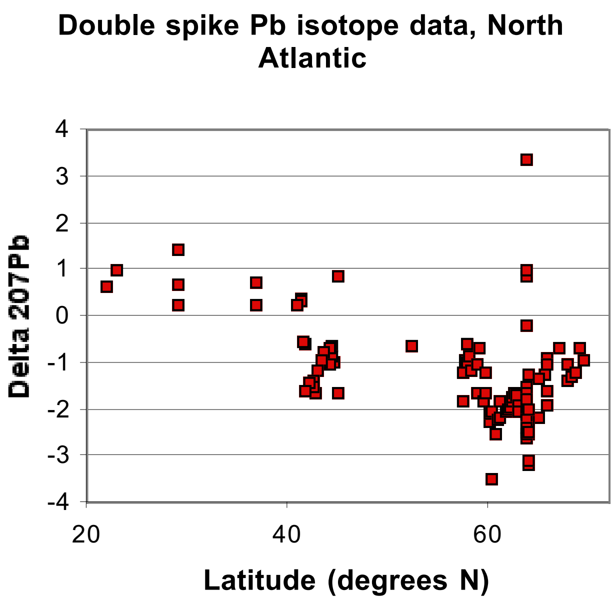
Fig. 3. Part of a high resolution oxygen isotope speleothem record obtained by laser ablation, comparing conventional analyses of drilled samples (tied symbols) with laser ablation data.

New high resolution oxygen isotope records from Holocene speleothem have been obtained by a novel laser ablation technique (D. Mattey). A laser ablation study of a 47cm stalagmite specimen from Crag Cave, SW Ireland provided 2,300 analyses representing a continuous climate record with a temporal resolution averaging 4 years (Fig. 3). These records clearly resolve numerous high amplitude short-lived events, including the 8.4 ka cooling event first identified in the GRIP ice core, and provide a basis for precise correlation of speleothem records over NW Europe.

Igneous Geochemistry
(contact M.Thirlwall, M.Menzies)

Oligocene volcanic rocks from the Red River Fault zone (China) have been used as lithoprobes to constrain the geodynamics of the Yangtze craton (Menzies, Xu). The chemistry of highly magnesian, potassic volcanic rocks indicates that the lower lithosphere beneath the Yangtze craton probably represents Tibetan lithosphere extruded to the east 40-50 Ma ago. The Indo-Asia collision provides a suitable mechanism and explains the link between the west Yangtze craton and northern Tibet in terms of provenance (Sr-Nd) and the seismic velocity structure.

Kimberlite-borne xenoliths (polymicts) have a complex history (Menzies, Zhang). They contain mixed lithologies that retain evidence of silica-melt movement, important for the formation of the peridotites that constitute much of Archaean keels. Elemental



and isotopic disequilibria are also found indicative of rapid entrainment and cooling. Overall these rocks are polybaric with llithologies/minerals of mixed provenance juxtaposed by fluid-assisted deformation.

Fig. 4. Δ^{207}Pb of mid-Atlantic ridge magmatism obtained using double spike techniques. Negative Δ^{207}Pb at 45˚ (collaborator L. Dosso, Brest) and 57-70˚ is associated with plume contamination of the ridge, in the latter case the Iceland plume. Analytical external precision is about ±0.2 Δ^{207}Pb units.

Much research in igneous geochemistry has been targeted around applications of the high-precision double spike Pb isotope analysis technique on both TIMS and IsoProbe (Thirlwall, 2000, 2002). Detailed study of Recent lavas from Iceland and adjacent midocean-ridges (Thirlwall, Gee and collaborators Taylor, Southampton and Mertz, Mainz) has shown that at least 6 mantle components can be identified in this region, with none identical to Atlantic MORB mantle further south.

Δ^{207}Pb shows strong provinciality along the mid-Atlantic Ridge, with negative values in the neighbourhood of Iceland reflecting the young recycling of the plume material (Fig. 4, Thirlwall et al., 1999). New double spike Pb analyses of Lesser Antilles magmas (Thirlwall, Munday) show that Δ^{208}Pb of the sedimentary component changes markedly from island to island, and that some islands display evidence of contamination by two different sedimentary components in the arc crust (Thirlwall et al., 2001).

The first unambiguous signs of asthenospheric decompression melting beneath the Alboran Sea in the western Mediterranean have been found, in the centre of the area affected by extensional collapse of the Betic-Alboran-Rif orogen (Gill, with collaborators Aparicio (CSIC Madrid), El Azzouzi (Rabat) and Hernandez (Lausanne)). Neogene volcanics from Alboran Island and dredge hauls from the Alboran Sea floor include samples that show the most MORB-like REE patterns yet discovered from this area, with only minor degrees of crustal contamination. REE and isotopic data support recent theories of delamination or convective removal of thickened lithosphere as the mechanism of orogenic collapse.

References

ARCHER, C. & VANCE, D. 2001. Large transition metal isotope fractionations associated with Archean microbial communities. *EOS* 82, F1324

BAILEY, T.R. 2001. Applications of strontium isotope stratigraphy: the potential of laser micro-sampling. PhD Thesis, Royal Holloway Univ. London.

BAKER, MACPHERSON, C., MENZIES, M.A., THIRLWALL, M.F., AL-KADASI, M., AND MATTEY D.P. 2000. Resolving crustal and mantle contributions to continental flood volcanism : constraints from mineral laser fluorination oxygen isotope data. Journal of Petrology 41, 1805-1820.

FAN, W., ZHANG, H.F., BAKER, J., JARVIS, K.E., MASON, P.R.D., AND MENZIES, M.A. (2000) On and off the North China craton : Where is the Archaean Keel? Journal of Petrology, 41, 7, 933-950.

LINDARS, E.S., GRIMES, S.T., MATTEY, D.P., COLLISON, M.E., HOOKER, J.J., & JONES T.P. 2001. Phosphate ∂^{18}O determination of modern rodent teeth by direct laser fluorination: an appraisal of methodology and potential application to palaeoclimate reconstruction. *Geochim. Cosmochim. Acta* 65, 2535-2548.

McDERMOTT, F., MATTEY, D.P. and HAWKESWORTH, C.J., 2001. Centennial-Scale Holocene Climate Variability Revealed by a High-Resolution Speleothem ^{18}O Record from SW Ireland. Science 294, 1328-1331.

MENZIES, M.A., BAKER, J., AND CHAZOT, G., 2001. Cenozoic plume evolution and flood basalts in Yemen: A key to understanding older examples. Geological Society of America Special Paper 352, “Mantle Plumes: Their Identification Through Time”, (Editors R. Ernst and K.L.Buchan) 23-36, 593pp.

PALMQVIST, P., GROCKE, D.R., ARRIBAS, A. & FARINA, R.A. 2002. Paleoecological reconstruction of an Early Pleistocene large mammals community: a comparative approach using biogeochemical (∂^{13}C, ∂^{15}N, Sr:Zn) and ecomorphological methods. *Paleobiology* (in review).

SCRIVNER, A., VANCE, D. and ROHLING, E. 2001. Neodymium isotope data for foraminifera indicates increased Nile outflow during Mediterranean anoxic events. *EOS* 82, F788.

THIRLWALL, M., TAYLOR, R., MATTEY, D., GEE, M. & MURTON, B. 1999. The Origin of Iceland Plume Mantle: Constraints from High-Precision Oxygen and Pb Isotope Analyses of Reykjanes Ridge Lavas. J. Conf. Abs. 4(1), 340.

THIRLWALL, M.F. 2000. Inter-laboratory and other errors in Pb isotope analyses investigated using a ^{207}Pb-^{204}Pb double spike. Chem. Geol. 163, 299-322.

THIRLWALL, M.F. 2001. Lead sources in the Lesser Antilles Arc: constraints from double-spike Pb isotope data. J. Conf. Abstracts 6(1), 386.

THIRLWALL, M.F., 2002. Multicollector ICP-MS analysis of Pb isotopes using a ^{207}Pb-^{204}Pb double spike demonstrates up to 400ppm/amu systematic errors in Tl normalization. Chem. Geol. 184, 255-279.

UKSTINS, I.A., RENNE, P., WOLFENDEN, E., BAKER, J., AND MENZIES, M., 2002 Matching conjugate volcanic margins: ^{40}Ar/^{39}Ar chronostratigraphy of pre- and syn-rift basalt-rhyolite, Ethiopia. *Earth and Planetary Science Letters (in press)*

VANCE, D. & ARCHER, C. 2001. Sr-Nd-Pb Isotope Study of IRD in Heinrich Layer 4 at DSDP site 609 Suggests no Europe-derived Precursor. *EOS* 82, F765.

VANCE, D. & THIRLWALL, M.F., 2002. An assessment of mass discrimination in MC-ICPMS using Nd isotopes. Chem. Geol., in press.

XU, Y.G., MENZIES, M.A., THIRLWALL, M.F., AND XIE, G.H., 2001. Exotic lithosphere beneath the Western Yangtze Craton: Petrogenetic links to Tibet using highly magnesian ultrapotassic rocks. Geology 29, 863-866.

ZHANG, H.F., MATTEY, D.P., GRASSINEAU, N., LOWRY, D., BROWNLESS, M., GURNEY, J., AND MENZIES, M.A. 2000. Recent fluid processes in the Kaapvaal Craton, South Africa: coupled oxygen isotope and trace element disequilibrium in polymict peridotites. Earth and Planetary Science Letters, 176, 57-72

ZHANG H.-F., MENZIES M. A., MATTEY, D.P., HINTON, R.W., AND GURNEY, J.J., 2001. Petrology, mineralogy and geochemistry of oxide minerals in polymict xenoliths from the Bultfontein kimberlites, South Africa: implication for low bulk-rock oxygen isotopic ratios. Contributions Mineralogy and Petrology 141, 367-379.

ZHANG, H., MENZIES, M.A., GURNEY, J.,& ZHOU, X. 2001. Cratonic peridotites and silica-rich melts: diopside-enstatite relationships in polymict xenoliths, Kaapvaal, South Africa. Geochimica Cosmochimica Acta. 65, 3365-3377.

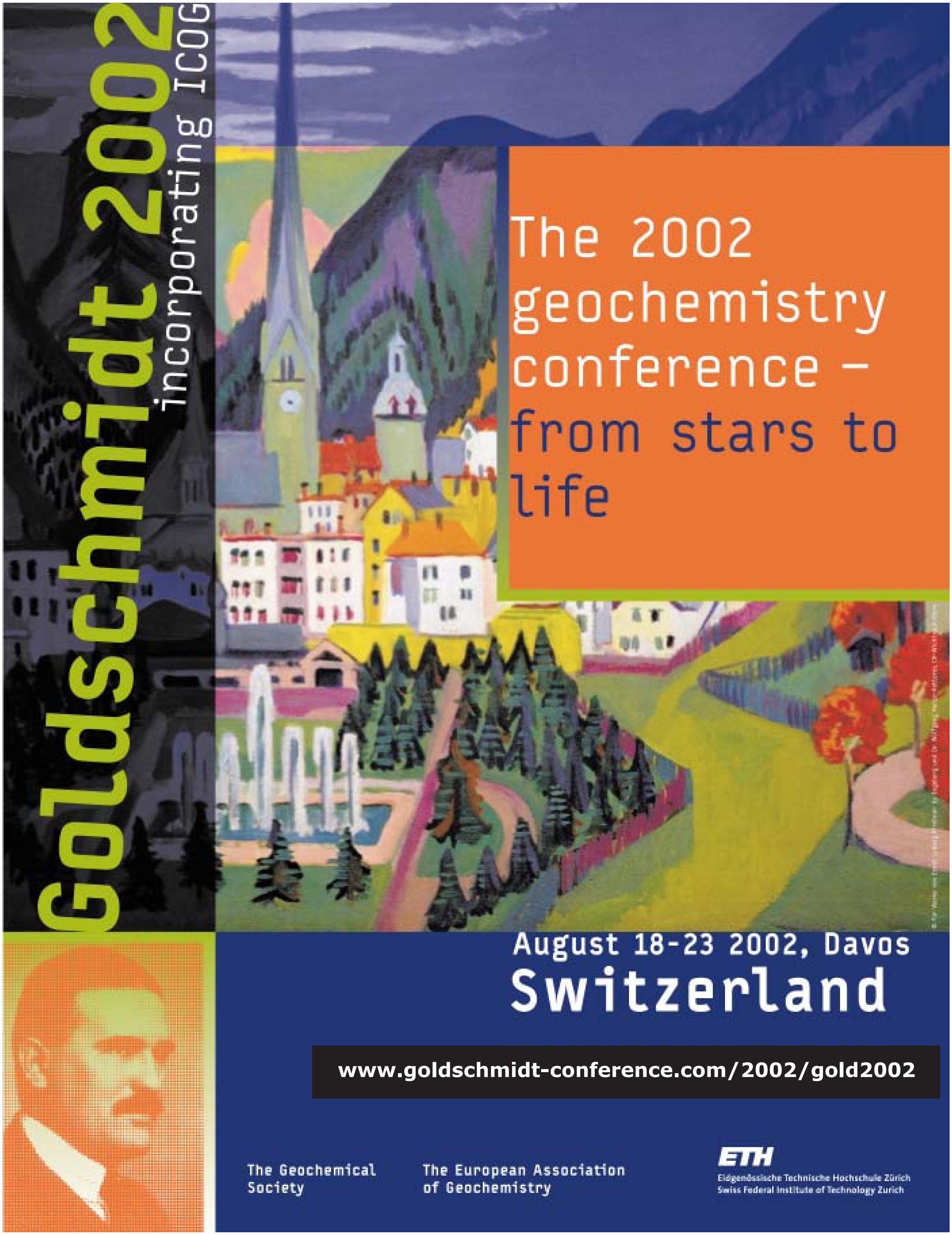
ZHANG, H.F., MATTEY, D.P., GRASSINEAU, N., LOWRY, D., BROWNLESS, M., GURNEY, J., AND MENZIES, M.A. 2000. Recent fluid processes in the Kaapvaal Craton, South Africa : coupled oxygen isotope and trace element disequilibrium in polymict peridotites. Earth and Planetary Science Letters, 176, 57-72

Meetings Announcements

FIFTH INTERNATIONAL CONFERENCE ON SOLVO-THERMAL REACTIONS (ICSTR)

Abstracts are being solicited for an international conference on solvo-thermal reactions (ICSTR). The meeting will be held on July 22-26, 2002 at the Hilton East Brunswick, in East Brunswick, New Jersey, which is conveniently located near all major forms of transportation. Solvothermal reactions are chemical reactions performed in aqueous and nonaqueous solvents at elevated temperature and pressure. They are a novel low temperature means (soft chemistry approach) for synthesis and processing of materials, nanotechnology, pharmaceuticals, environmental remediation, energy applications, catalysis and many other applications.

The abstract submission deadline is March 15, 2002. Reduced rate early-bird registration must occur prior to May 15, 2002. Reduced registration rates are available for graduate students. More information on this meeting can be found at www.ICSTR.rutgers.edu or by contacting Professor Richard E. Riman at Rutgers University via riman@email.rci.rutgers.edu/732-445-4946(v)/732-445-6262.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Meetings Announcements

14TH MEETING OF THE BRITISH ORGANIC GEOCHEMICAL SOCIETY 2-3 JULY 2002

This year's meeting of the British Organic Geochemical Society (BOGS) will be hosted by NRG at the University of Newcastle on Tuesday 2 to Wednesday 3 July.

Topics covered will include: Organic Geochemistry, Petroleum Geochemistry, Environmental Geochemistry, Biogeochemistry, Marine Biogeochemistry, Palaeoceanography, Archaeological Chemistry, Microbial Geochemistry, Geomicrobiology

As in previous years, this will be an informal event, with most of the presentations being given by research students. Talks will be approximately 20 minutes long (15 minutes, plus 5 minutes discussion), and posters will be on continuous display throughout the meeting - with time set aside to allow viewing of posters. Depending on the number of oral presentations we may also include poster talks (approximately 5 min each, 1 overhead). This decision will be made nearer the time and all presenters of posters will be notified accordingly.

Abstracts must be submitted by 1 May to allow the programme to be finalised, and a book of abstracts produced. There will also be a full social program including the follow up to the highly successful BOGS BBQ of 1997. Registration fees will be at the bargain rate of £10 for students and £20 for others. Please make cheques payable to the British Organic Geochemical Society. We will send you a receipt.

All information relating to the BOGS 2002 meeting can be found at: **http://nrg.ncl.ac.uk/bogs/bogs.html**. The site will be updated regularly as more details are formalised. Registration forms and abstract submission forms are available to download and/or email from this site. Details of accommodation and travel directions are also available. Please make your own arrangements with hotels, B&Bs or the Halls of Residence directly. Most of these are within easy walking distance of the Department and the city centre. Book early to avoid any problems!

In order to have an indication of likely numbers for BOGS 2002, it would be VERY helpful if you could send me an email (h.m.talbot@ncl.ac.uk) or some other initial response in the next week or so. Please outline whether you are likely to attend, and if so whether you intend to submit an abstract (as a talk or poster).

For more background information contact **h.m.talbot@ncl.ac.uk** or see:

British Organic Geochemical Society website:
www.science.plym.ac.uk/bogs/

GEOCHEMICAL AND GEOPHYSICAL MONITORING OF VOLCANIC SYSTEMS MELT INCLUSION TECHNIQUES AND APPLICATIONS

September 26-30, 2002

Organizers: B. De Vivo and R. J. Bodnar

Where:GRAND HOTEL MOON VALLEY in Seiano di Vico Equense (Sorrento Peninsula, near Napoli, Italy) with a field trip to Vesuvius

Presenters: A. Anderson, H. Belkin, J. Blundy, R. Bodnar, M. Carroll, G.Chiodini, B. Chiarabba, B. Chouet, F. Cornet, L. Danyushevsky, G. De Natale, B. De Vivo, D. Dingwell, L. Fedele, M. Frezzotti, A. Godon, A. Gudmundsson, C. Hawkesworth, R. Hervig, J. Lowenstern, C. Mandeville, C. Oppenheimer, A. Sobolev, H. Shinohara, S. Sparks, R. Thomas, R. Tracy, P. Wallace, J. Webster, S. Williams.

Registration fees (estimated): $350 ($200 for students) plus food and lodging at Grand Hotel Moon Valley at discounted prices.

THE 39TH ANNUAL MEETING OF THE CLAY MINERALS SOCIETY

Will be held at the University of Colorado in Boulder, Colorado June 8-13, 2002. For more information, please see:

http://www.colorado.edu/geolsci/cms/

The workshop "Teaching Clay Science" will be held on June 8. A field trip: "Clays and the Front Range", will take place June 13. Symposia include the following:

- Clay Membrane Processes
- Computational and Experimental Chemistry of Nanomaterials in Aqueous Systems
- Interactions of Microbes with Clay Minerals
- Isotopic Tracing and Dating of Clay Mineral Processes in Diverse Crustal Environments
- Mineralogy and Petrology of Mudrocks: Geological and Industrial Applications
- Structure, Crystal Chemistry, and Surface Reactivity of Environmental Minerals

Also, consider participating in "The Reynolds Cup" quantitative mineral analysis contest (see the Mudrocks symposium for more details). We hope to see you there!

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FOURTH INTERNATIONAL WORKSHOP ON OROGENIC LHERZOLITES AND MANTLE PROCESSES

August 26 to September 3, 2002
Samani, Hokkaido, Japan

Second circular now available at the official web site: http://earth.s.kanazawa-u.ac.jp/LherzoliteWorkshop2002/. Deadline for registration and abstract submission is on 30 April, 2002.

The Workshop is aimed at discussion and exchange of ideas on a wide range of topics related to the origin, evolution and emplacement history of continental and oceanic mantle rocks, and physical and chemical processes in the mantle. It will consist of a three-day indoor meeting (August 29-31) to be held in the Town Hall of Samani, and a two-day field excursion in the Horoman peridotite (August 27-28 and September 1-2). The Organizing Committee strongly hopes to bring together geologists, petrologists, geochemists and geophysicists with diverse approaches and methodologies.

Main scientific themes and key topics of the workshop are summarized as follows, but the list is in no way exclusive. (1) Origin of heterogeneity on various scales as documented in mantle derived ultramafic rocks, with particular emphasis on mechanisms for forming layered structures; (2) Mechanisms of melt production and modification of partial melts during melt segregation, melt transport, and mantle-melt reactions; (3) Rheology of solid and partially molten mantle and flow dynamics in the mantle; (4) Recycling and processing of lithosphere into the mantle on local and lobal scales and the geochemical evolution of the Earth's mantle.

Meetings Announcements

Conference Announcement: Geology Without Frontiers: Magmatic and Metamorphic Evolution of Central European Variscides

Czech and Slovak Geological Societies organize an international conference Geology Without Frontiers: Magmatic and Metamorphic Evolution of Central European Variscides that will take place in Blansko–Ceskovice (Czech Republic) on May 29–June 1, 2003. The conference is aimed to continue in the tradition of successful meetings (1st Conference on the Bohemian massif, Prague 1988, and Joint Meeting of the Deutsche Geologische Vereinigung and the Czech Geological Society, Prague 1994) providing a platform for exchange of the latest scientific ideas regarding the origin, nature and evolution of magmatic and metamorphic rocks forming the Variscan orogen in Europe. The following symposia are being prepared:

1. **Igneous rocks – an important key to understanding the Variscan orogen**
   Fritz Finger, Universität Salzburg
   Igor Petrík, Slovak Academy of Sciences

2. **Accessory minerals – small but important**
   Hans-Jürgen Förster, Universität Potsdam
   Igor Broska, Slovak Academy of Sciences

3. **Radiogenic isotopes – rates and duration of processes**
   Urs Schaltegger, University of Geneva
   Vojt_ch Janou_ek, Czech Geological Survey

4. **Rocks with memory – deciphering metamorphism and P–T–t–d paths**
   Paddy O'Brien, Universität Potsdam
   Jana Kotková, Masaryk University
   Marián Janák, Slovak Academy of Sciences

5. **Tectonic framework of the pre-Mesozoic Europe – refining the picture**
   Gernold Zulauf, Universität Erlangen–Nürnberg
   Stanislaw Mazur, University of Wroclaw

Post-conference excursion 1 (31 May)
The conference field trip will follow a cross-section (W–E) through the Variscan nappe pile on the eastern margin of the Bohemian Massif, proceeding from the tectonically uppermost and at the same time highest-grade Variscan Moldanubian Zone through Moravian Zone to the Cadomian Brunovistulian basement. It will focus on petrologic and structural phenomena like HT/HP metamorphism and crustal-mantle interactions, UHT metamorphism and partial melting, high-K magmatism, and inverted Barrovian metamorphism.

Post-conference excursion 2 (1 June)
In the case of sufficient demand, it will be organized another, half-a-day excursion, which will further exemplify the phenomena seen during the first excursion. We shall visit Visean conglomerates containing pebbles/boulders of various Moldanubian rocks including those not present at the current erosional surface.

Abstracts will be published in the Journal of Czech Geological Society, and selected contributions will appear in peer reviewed international journal Geologica Carpathica. The pre-registration deadline is July 15, 2002. For further information and on-line pre-registration form see our WWW page:

http://www.natur.cuni.cz/~cgs/nofrontiers

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e-mail: cgs@mail.natur.cuni.cz

Meetings Calender

March 3-6, 2002: The Society for Organic Petrology (TSOP) 18th Annual Meeting, Westchase Hilton and Towers Meeting and Convention Center, Houston, TX, USA Contact: Coleman Robison, ChevronTexaco, Energy Research Tech. Co., 4800 Fournace Place, Bellaire, TX 77401-2324; Phone: +1 713 432 6828; Fax: +1 713 838 4628; E-mail: ColeRobison@chevrontexaco.com Web: http://www.tsop.org). NEW DATE! (Postponed from September 2001)

March 4-7, 2002: GeoProc2002, Bremen, Germany. Topic: Geochemical processes with long-term effects in anthropogenically affected seepage and groundwater. Contact: Fachbereich 5 - Geowissenschaften, Universität Bremen, Postfach 330 440, D-28 334 Bremen, Germany; Prof. Dr. Horst D. Schulz; Phone / Fax: +49 421 218 3393 / 432; E-mail: hdschulz@uni-bremen.de; Dr. Astrid Hadeler; Phone / Fax: +49 421 218 3950 / 4321; E-mail: ahadeler@uni-bremen.de; Web site: http://www.geochemie.uni-bremen.de/index.html?/projects/spp/geoproc/geoproc.html

March 6-9, 2002: Karst Frontiers: Florida and Related Environments, Gainesville, Florida, USA. Contact: J. Mylroie, Department of Geosciences, P.O. Box 5448, Mississippi State University, Mississippi State, MS 39762, USA; Phone: +1 662 325 8774; Fax: +1 662 325 9423; E-mail: mylroie@msstate.edu; Web site: http://www.karstwaters.org/.

March 10-13, 2002: 2002 AAPG National meeting, Houston, Texas, with poster session on Geochemical Indicators of Depositional Environments. Web site: http://www.aapg.org/indexaapg.html

March 11-13, 2002: Geo 2002: The 5th Middle East Geosciences Exhibition and Conference, Bahrain. Contact: Overseas Exhibition Services Ltd., 11 Manchester Square, London W1M 5AB, UK; Phone: +44 207 8622000; Fax: +44 202 862 2078; E-mail: pmckean@montnet.com.

March 18-19, 2002: TSG meeting: transport and flow processes within shear zones, Burlington House, Piccadilly, London, UK. Convenors: Ian Alsop, Crustal Geodynamics Group, School of Geography & Geosciences, University of St. Andrews, Fife, Scotland, KY16 9AL UK, gia@st-andrews.ac.uk; Ken McCaffrey & Bob Holdsworth, Reactivation Research Group, Dept of Geological Sciences, University of Durham, Durham DH1 3LE, UK; E-mail: k.j.w.mccaffrey@durham.ac.uk, R.E.Holdsworth@durham.ac.uk; Martin Hand, Geology & Geophysics, University of Adelaide, Adelaide SA 5005, Australia; E-mail: martin.hand@adelaide.edu.au; Web site: http://www.st-and.ac.uk/~www_sgg/tsg2001.html

March 19-22, 2002: 19th Colloquium of African Geology, El Jadida, Morocco. Organized by Chouaïb Doukkali University, Faculty of Sciences, El Jadida, Morocco and the Geological Society of Africa. Field trips start on March 23. Contact: Secretariat du 19éme CIGA, Université Chouaïb Doukkali, Faculté des Sciences, Département de Géologie, B.P.20, 24000, El Jadida, Morocco; Phone: + 212 23 34 23 25 / 23 34 30 03; Fax: +212 23 34 21 87; E-mail: cag19@ucd.ac.ma. Web site: http://www.ucd.ac.ma/geologie/cag19.html.

March 20-27, 2002: Annual Meeting National Earth Science Teachers Association, San Diego, CA, USA. Contact: NESTA Meetings, 2000 Florida Avenue, N.W., Washington, D.C. 20009, USA; Phone: +1 202 462 6910: Fax: +1 202 328 0566; E -mail: fireton@kosmos.agu.org.

March 24-27, 2002: EMPG IX - Ninth International Symposium on Experimental Mineralogy, Petrology and Geochemistry, Zurich, Switzerland. Contact: EMPG IX Organizing Committee, Institute for Mineralogy and Petrography, Department of Earth Sciences, ETH Zentrum, Sonneggstrasse 5, CH-8092 Zurich, Switzerland; Phone: +41 1 632 3779 (or 3955); Fax: +41 1 632 1294; E-mail: empg@erdw.ethz.ch; Web site: http://eurasia.ethz.ch/empg/

March 25-27, 2002: 17th Himalaya-Karakoram-Tibet Workshop, Gantok, Sikkim, India. Contact: Chandra Shekhar Dubey; E-mail: csdubey@vsnl.com, chandrasdubey@vsnl.net, csdubey@yahoo.com. Web site: http://csdubey.topcities.com/fpexp/index.htm

April 7-11, 2002: Geochemistry Division, American Chemical Society 223rd National Meeting, Orlando, Florida, USA. Includes for instance symposium on Stable Isotope Signatures for Establishing Palaeoenvironmental Change and on Complexity at the Water-Solid Interface: Mineral Surfaces and Nanoparticles.

May 31-June 3, 2002: 8th ESF-IMPACT workshop on 'Impact Tectonism', Tre Hotell i Mora, Mora, Sweden, ESF-IMPACT. Contact: Ilka von Dalwigk, Dept. of Geology and Geochemistry, Stockholm University, SE-10691 Stockholm, Sweden; Phone: +46-(0)8-164757; E-mail: ilka@geo.su.se. Web site: http://www.geo.su.se/geologi/impact/index.htm

June 3-7, 2002: Zeolite 2002, Aristotle University, Thessaloniki, Greece. Under the auspices of the International Committee on Natural Zeolites (ICNZ), by the Aristotle University of Thessaloniki and the Institute of Geology and Mineral Exploration (IGME). Contact: Prof. Panagiotis Misaelidis, Aristotle University, Department of Chemistry, P.O. Box 1547, GR-540 06 Thessaloniki, Greece; Phone: +30 31 997789; Fax: +30 31 997753; E-mail: misailid@chem.auth.gr. Web site: http://www.chem.auth.gr/activities/zeo2002/.

June 4–7, 2002: Fission-Track Analysis: Theory and Applications, Cadiz, Spain. Contact: Luis Barbero; E-mail: ftcadiz2002@uca.es

June 7-9, 2002: The Third Informal Conference on Reaction Kinetics and Atmospheric Chemistry, Helsingør, Denmark. Theoretical and Experimental Reaction Kinetics; Atmospheric Chemistry and Particulates; Isotope Effects; Gas-phase, Heterogeneous and Aqueous Reactions; Mercury Spectroscopy Combustion. Web site: http://kl5alfa.ki.ku.dk/noneck

June 8-13, 2002: The Clay Minerals Society 39th Annual Meeting: Bolder Clays, Boulder, Colorado, USA. Contact: Kathryn Nagy, Department of Geological Sciences, University of Colorado, Boulder, CO 80309; Phone: 303/492-6187; Fax: 303/492-2602; E-Mail: kathryn.nagy@colorado.edu. Web site: http://cms.lanl.gov/ or http://www.colorado.edu/geo/sci/cms/

June 9-15, 2002: 3rd Biennial Workshop on Subduction Processes in the Kurile-Kamchatka-Aleutian Arcs, Fairbanks, Alaska. Contact: John Eichelberger: E-mail: e-mail: eich@gi.alaska.ed

June 10-14, 2002: ASLO 2002 Summer Meeting: Inter-disciplinary Linkages in Aquatic Sciences and Beyond, Victoria, British Columbia, Canada. Web site: www.aslo.org /victoria2002

June 12-15, 2002: GEORAMAN 2002 - 5th International Conference on Raman Spectroscopy Applied to the Earth Sciences, Prague, Czech Republic. Contact: E-mail: georaman@natur.cuni.cz; Web site: www.natur.cuni.cz/~georaman

June 16-22, 2002: 16th Caribbean Geological Conference, Bridgetown, Barbados. Contact: 16th Caribbean Geological Conference, Energy and Natural Resources Division, c/o National Petroleum Corporation Building, Wildey, St. Michael Barbados; E-mail: cgc16th@hotmail.com; Web site: www.fiu.edu/orgs/caribgeol/.

June 17-21, 2002: Volcanism and the Earth's Atmosphere, 10th Anniversary Chapman Conference, Thera, Greece. Convener: Alan Robock, Rutgers University, New Brunswick, New Jersey, USA; E-mail: robock@envsci.rutgers.edu. Web site: http://www.agu.org/meetings/cc02bcall.html.

June 17-21, 2002: 6th International Symposium on Cultural Heritage in Geoscience, Mining and Metallurgy, Idrija, Slovenia. Contact: Tatjana Dizdarevic, Idrija Mercury Mine. Idrija Mercury Mine, Arkova 43, SI-5280 Idrija, Slovenia; Phone: +386 05 3773 007; Fax: +386 05 3771 082; E-mail: tatjana.rzs.idrija@s5.net. Web site: http://www.rzs-idrija.si

June 24-25, 2002: 6th European Workshop on Laser Ablation ICP-MS, Utrecht, The Netherlands. Web site: http://laicpms.geo.uu.nl/

July 2-3, 2002: 14th meeting of The British Organic Geochemical Society, NRG, University of Newcastle, UK. Contact: Dr Helen M. Talbot, Fossil Fuels and Environmental Geochemistry Newcastle Research Group (NRG), Drummond Building, University of Newcastle, Newcastle Upon Tyne, NE1 7RU, UK; Phone: +44 (0)191 222 6605; Fax: +44 (0)191 222 5431; E-mail: h.m.talbot@ncl.ac.uk . Web site: http://nrg.ncl.ac.uk/bogs/bogs.html

July 9 - 11, 2002: Microscience 2002, ExCel Conference and Exhibition Centre, London, UK. Contact: Carole Staniford, Catalyst Communications; Phone: +44 (0) 207 932 2500 or +44 (0) 1767 600716; Fax: F: +44 (0) 207 932 2519; E-mail: carole@staniford.fsworld.co.uk or

Meetings Calender

Rebecca Morden, MicroScience 2002 Conference Enquiries, Royal Microscopical Society; Phone: +44 (0) 1865 248768; Fax: +44 (0) 1865 791237; E-mail: E: rebecca@rms.org.uk

July 14-17, 2002: Fifth International Conference on arsenic exposure and health effects, San Diego, California, USA. Society for Environmental Geochemistry and Health. Web site: http://www.cudenver.edu/as2000/

July 21-25, 2002: 9th International Platinum Symposium, Holiday Inn - Grand Montana, Billings, MT, USA. By the IGCP 427/SEG/SGA. Contact: Roger Cooper, Dept. of Geology, Lamar University, P.O. Box 10031, Beaumont, TX 77710, USA; Phone: +1 409 880 8239; E-mail: cooperrw@hal.lamar.edu. Web site: http://www.platinumsymposium.org

July 21-26, 2002: 20th Anniversary Conference of the International Humic Substances Society, Northeastern University, Boston, USA. Contact: Elham A Ghabbour, The Barnett Institute of Chemical and Biological Analysis, Mugar Hall, Northeastern University, Boston, MA 02115-5000, USA; Phone: +1 617 373 7988; Fax: +1 617 373 2855; E-mail: e.ghabbour@neu.edu; Web site: http://www.hagroup.neu.edu/IHSS11.htm

July 22-26, 2002: The Earth System and Metallogenesis - 11th Quadrennial IAGOD Symposium and GEOCONGRESS 2002, Windhoek, Namibia. Main theme: Sedimentary and magmatic responses to compressional and extensional tectonics and the associated ore-forming processes. Hosted by: The Geological Society of Namibia, the Geological Society of South Africa, The Geological Society. Contact: IAGOD / Geocongress 2002 Conference Secretariat, P.O. Box 9870, Windhoek, Namibia; Phone: + 264 61 251014; Fax: + 264 61 272032; E-mail (Alice Kaukuetu-Hue): geoconference2002@conferencelink.com.na. Web site: www.geoconference2002.com.

July 22-26, 2002: 65th Annual Meeting of the Meteoritical Society, UCLA DeNeve Plaza Conference Center, Los Angeles, CA, USA, the Meteoritical Society, Lunar and Planetary Institute. Contact: Paul H. Warren, Institute of Geophysics, UCLA, Los Angeles, CA 90095-1567, USA; Phone: +1 3108253202; E-mail: pwarren@ucla.edu; Web site: http://www.lpi.usra.edu/meetings/upcomingmeetings.html/

Aug. 12-15, 2002: 12th Stockholm Water Symposium - Balancing Competing Water Uses - Present Status and New Prospects, Stockholm City Conference Centre, Stockholm, Sweden. Contact: David Trouba, SIWI, Sveav-gen 59, 113 59 Stockholm, Sweden; Phone: +46 8 522 139 89; Fax: +46 8 522 139 61; E-mail: sympos@siwi.org. Web site: http://www.siwi.org

Aug. 14–21, 2002: World Congress of Soil Science, Bangkok, Thailand. For info: Contact o.sfst@nontri.ku.ac.th Web site: http://www.17wcss.ku.ac.th

Aug. 17-21, 2002: Biogeomon 2002, University of Reading, Reading, UK. Main Themes: Catchment monitoring /manipulations /models - Stable and radiogenic isotopes in the environment - Nutrient and metal cycling in natural and restored ecosystems - Archives of global change on the continents - Scaling of biogeochemical processes Web site: http://www.rdg.ac.uk/biogeomon/

Aug. 18-23, 2002: Twelfth Annual V.M. Goldschmidt Conference, incorporating ICOG X, Davos, Switzerland. Contact: Cambridge Publications, P.O. Box 27, Cambridge CB1 8TR, U.K; E-mail: Gold2002@campublic.co.uk. Web site: http://www.goldschmidt-conference.com/2002/gold2002/.

Aug. 26-31, 2002: MPMPS-6 High Pressure Mineral Physics Seminar, Verbania, Italy. Web site: http://www.hpmps.bgi.uni-bayreuth.de/

Aug. 26-Sept. 3, 2002: 4th International Workshop on Orogenic Lherzolites and Mantle Processes, Samani, Hokkaido, Japan. Web site: http://earth.s.kanazawa-u.ac.jp/LherzoliteWorkshop2002/

Aug. 29–31, 2002: Natural glasses 4, Lyon, France. For info: Contact Prof. Bernard Champagnon E-mail: natglasses@univ-lyon1.fr; Web site: http://natglasses.univ-lyon1.fr/

Aug. 31-Sept. 4, 2002: 8th FECS Conference on Chemistry and the Environment, Athens, Greece. Contact: Cambridge Publications, P.O. Box 27, Cambridge CB1 8TR, U.K; E-mail: Gold2002@campublic.co.uk. Web site: http://www.scientificjournals.com/espr/fecs/8thConf.2002

Aug. 31-Sep 4, 2002: CSCOP-TSOP meeting - "Emerging Concepts in Organic Petrology and Geochemistry", Banff, Alberta, Canada. Abstract deadline: January 31, 2002. Web site: www.cscop-tsop2002.com

Sept. 1-6, 2002: Mineralogy for the new millenium (IMA 2002), 18th General Meeting of the International Mineralogical Association, Edinburgh, United Kingdom. Contact: Mr K. Murphy, Executive Secretary, Mineralogical Society of Great Britain and Ireland, 41 Queen's Gate, London SW7 5HR, United Kingdom: Phone: +44 171 584 7516; E-mail: IMA@minersoc.demon.co.uk; Web site: http://www.minersoc.org/IMA2002

Sept. 2-7, 2002: Holocene environmental catastrophes and recovery, Brunel University, West London, UK. Co-sponsored by Brunel University, INQUA and PAGES. Contact: Contact: Prof. Suzanne A. G. Leroy, Department of Geography and Earth Sciences, Brunel University, Uxbridge, Middlesex UB8 3PH, (West London), UK; Phone: +44 1895 20 31 78; Fax: +44 1895 20 32 17; Phone secr: +44-1895-20 3215; E-mail: suzanne.leroy@brunel.ac.uk. Web site: http://www.brunel.ac.uk/depts/geo/Catastrophes/.

Sept. 4-6, 2002: 20th European Conference - SEGH 2002 - Heavy Metal Contamination and the Quality of Life. Debrecen, Hungary. The Society for Environmental Geochemistry and Health. Web site: www.date.hu/rendez/segh2002

Sept. 8-11, 2002: Hedberg Research Conference - The Hydrocarbon Habitat of Volcanic Rifted Passive Margins, Stavanger, Norway. Contact: Debbi Boonstra, AAPG Education Department, Post Office Box 979, Tulsa, OK 74101-0979, USA; Phone: +1 918 560 2630; Fax: +1 918 560 2678; E-mail: debbi@aapg.org; Web site: http://www.aapg.org/education/hedberg/index.shtml

Sep. 8-12, 2002: 21st IMOG Meeting (EAOG), Krakow, Poland. Web site: http://www.eaog.org/meetings/imog2003.html

Sept. 8-13, 2002: Fifth International Conference on Subsurface Microbiology (ISSM02), Copenhagen, Denmark. Deadline abstracts: 15 March 2002. Contact: ISSM02, Helsingevej 23, DK-2830 Virum, Denmark; Fax: +45 4583 9727; E-mail: issm02@er.dtu.dk, Web site: http://www.er.dtu.dk/.

Sept. 9–10, 2002: Geochemical speciation: determination, controls, significance - Mineralogical Society - Geochemistry Group Meeting, Salford University, UK. Mineralogical Society - Geochemistry Group Meeting. Contact: Dr Linda S. Campbell (Salford) and Dr Steven A. Banwart (Sheffield); E-mail: L.S.Campbell@salford.ac.uk or S.A.Banwart@sheffield.ac.uk. Web site: http://www.geolsoc.org.uk/template.cfm?name=Meeting_1

Sept. 9–11, 2002: Iron Ore 2002, Perth Australia. Web site: http://www.ausimm.com. See also GN 110 (January 2002, page19).

Sept. 11-14, 2002: Geologica Belgica International Meeting "On the crossroads...", Leuven/Louvain, Belgium. Web site: http://www.kuleuven.ac.be/geology/leuven2002/

Sept. 16-20, 2002: Uranium Mining and Hydrogeology III - International Mine Water Association. Symposium - Mine Water and The Environment, Freiberg, Germany. Contact: Prof. Dr. B. Merkel, Dr. Christian Wolkersdorfer, Lehrstuhl für Hydrogeologie; Gustav-Zeuner-Str. 12; D-09596 Freiberg/Sachsen, Germany; Phone: +49 3731 39 3309; Fax: +49 3731 39 2720; E-mail: UMH@IMWA.de. Web site: http://www.IMWA.de.

Meetings Calender

Sept. 18-20, 2002: Environmental Radiochemical Analysis (ERA), Kent, UK. Web site: http://www.rsc.org/lap/confs/radiochem2002.htm

Sept. 18-25, 2002: Atmospheric Chemistry in the Earth System, Crete, Greece. Contact: IGAC, E-mail: igac2002@chemistry.uoc.gr. Web site: http://atlas.chemistry.uoc.gr/IGAC2002

Sept. 26 - 30, 2002: Workshop/Short course Geochemical And Geophysical Monitoring Of Volcanic Systems: Melt Inclusion Techniques And Applications, Seiano di Vico Equense (Sorrento Peninsula, near Napoli) Italy. With a field trip to Vesuvius. Contact: Dr A. Sava, info@ersambiente.com.

Sept. 30-Oct. 3, 2002: Third Mediterranean Clay Meeting, Jerusalem, Israel. Web site: www.agri.huji.ac.il/clay_meeting/

Oct 21-25, 2002: IAG International Symposium on Recent Crustal Deformations in South America and Surrounding Areas**,** Santiago de Chile, Chili. Web site: http://www.igm.cl/Espanol/Informacion%20congreso/ProgramaIgles.htm

Oct. 22-23: The 2002 William Smith Meeting - Life in earth: Energy, minerals, Mars and the deep biosphere, Geological Society, Burlington House, Piccadilly, London, UK. Convened by Steve Larter, Ian Head (University of Newcastle U Tyne, UK) and Heinz Wilkes (GeoForschungsZentrum Potsdam, Germany). Abstract deadline: May 1, 2002. Contact: steve.larter@ncl.ac.uk. Web site: http://nrg.ncl.ac.uk/news/news44.html

Oct. 26-27, 2002: Phosphates: Geochemical, Geobiological and Materials Importance, Golden, CO, USA. Short Course organizers: John Rakovan, Matthew Kohn, and John M. Hughes. At the Geological Society of America Meeting, sponsored by Mineralogical Society of America.

Oct. 27-30, 2002: Geological Society of America Annual Meeting, Denver, Colorado, USA. Contact: GSA Meetings, Box 9140, Boulder, CO 80301-9140, USA. Phone: +1 303 447 2020, ext. 164; Fax: +1 303 447 1133. Web site: http://www.geosociety.org/meetings/2002/

Dec. 2002: Plastic Deformation and Deformation Structures of Minerals, short course. Organizers: Shun-ichiro Karato and H.-R. Wenk. At the AGU Fall meeting. Sponsored by Mineralogical Society of America.

Dec. 6-10, 2002: AGU Fall Meeting, San Francisco, California, USA. Web site: www.agu.org.

Dec. 14-19, 2002: Geochemistry of Crustal Fluids: The Role and Fate of Trace Elements in Crustal Fluids, Seefeld in Tirol, Austria , by the European Science Foundation. Contact: Dr. J. Hendekovic, European Science Foundation, EURESCO Unit, 1 quai Lezay-Marnesia, 678080 Strasbourg Cedex, France; Phone: +33 388 76 71 35: Fax: +33 388 36 69 87; E-mail: euresco@esf.org. Web site: http://www.esf.org/euresco/02/lc02106

Jan. 6-10, 2003: 10th International Symposium on deep seismic profiling of continents and their margins, Huka Village Conference Centre, Taupo, New Zealand. By the IASPEI; Royal Society of New Zealand, IGNS, Geoscience Australia. Contact: Dr Fred Davey, Institute of Geological & Nuclear Sciences; Phone: +64-4-570-1444; Fax: +64-4-570-4600; E-mail: seismix2003@gns.cri.nz. Web site: http://www.gns.cri.nz/news/conferences/seismix2003

Mar 29-Apr 2, 2003: 3rd International Limnogeology Congress, Presidio Plaza Hotel, Tucson, AZ, USA. Contact: Andrew Cohen, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721, USA; Phone: +1 520 621 4691; E-mail: acohen@geo.arizona.edu.

April 24-26, 2003: 15th Argentine Geological Congress, El Calafate, Santa Cruz Province, Southern Patagonia, Argentina. Contact: President Dr. Miguel Haller or Secretary Dr. Roberto Page, Asociacion Geologica Argentina, Maipu 645, 1 er Piso, Buenos Aires, Argentina; Phone: +54 11 4325 3104; Fax: +54 11 4325 3104; E-mail: haller@cenpat.edu.ar or fomicruz@internet.siscotel.com.

May 5-8, 2003: 3rd JGOFS Open Science Conference, Washington DC, USA. Contacts: Roger Hanson, JGOFS International Project Office, SMR, University of Bergen, PO Box 7800, 5020 Bergen, Norway; Phone: +47 555 84244; Fax: +47 555 89687 or Ken Buesseler, Department of Marine Chemistry and Geochemistry, WHOI, MS 25 Woods Hole, MA 02543, USA; Phone: +1 508 289 2309; Fax: +1 508 457 2193.

May 12-17, 2003: GEOFLUIDS IV - on fluid evolution, migration and interaction in sedimentary basins and orogenic belts, University of Utrecht, Utrecht, The Netherlands. (Special Issue of Netherlands Journal of Geosciences: 'Geofluids in the Netherlands', early 2003. Deadline for manuscripts: January 15, 2002.) Contact: Mrs. Drs. J.M. Verweij, Scientific Organizing Committee (chair), Netherlands Institute of Applied Geoscience TNO -National Geological Survey, Department of Geo-Energy, PO Box 80015, 3508 TA Utrecht, The Netherlands; Phone: +31 30 256 46 00; Fax: +31 30 256 46 05; E-mail: j.verweij@nitg.tno.nl; Web site: http://www.nitg.tno.nl/eng/geofluid2.pdf

May 18-24, 2003: 39th Forum on the Geology of Industrial Minerals, John Ascuaga's Nugget Hotel & Casino, Sparks, Nevada, USA , by the Nevada Bureau of Mines and Geology, Nevada Division of Minerals, and Nevada Mining Association. Contact: Terri Garside, NBMG/MS 178, University of Nevada, Reno, NV 89557-0088; Phone: +1 775-784-6691 ext 126; Fax: +1 775-784-1709; E-mail: tgarside@unr.edu. Web site: http://www.nbmg.unr.edu/imf2003.htm

May 20-23, 2003: GERM 4, Lyon, France. Contact: Janne Blichert-Toft, Laboratoire de Sciences de la Terre (CNRS UMR 5570), École Normale Supérieure de Lyon, 46, Allée d'Italie, 69364 Lyon Cedex 7, France; Phone: +33 (0)472 72 84 88; Fax: +33 (0)472 72 86 77; E-mail: jblicher@ens-lyon.fr.

June 7–1, 2003: The Clay Minerals Society 40th Annual Meeting, Athens, Georgia, USA. Jointly held with the Mineralogical Society of America. Web site: http://cms.lanl.gov

June 16-18, 2003: 5th International Conference on the Analysis of Geological and Environmental Materials, Rovaniemi, Finland. Web site: http://www.gsf.fi/geoanalysis2003

June 22–26, 2003: Euroclay 2003, Modena, Italy. Web site: www.unimo.it/euroclay2003/

June 22–27, 2003: 8th International Kimberlite Conference, Victoria, British Columbia, Canada. Contact: Dr. Roger H. Mitchell, Geology Department, Lakehead University, Thunder Bay, Ontario, Canada P7B 5E1; Phone: +1 807343 8287; Fax: +1 807-623-7526; E-mail: Roger.Mitchell@lakeheadu.ca. Web site: www.venuewest.com/8IKC.

Augustus 2003: XVth International Congress on the Carboniferous and Permian (XV ICC-P) and 55th Meeting of the International Committee for Coal and Organic Petrology (55 ICCP). Web site: http://www.nitg.tno.nl

Aug. 10-15, 2003: Chemistry at the interfaces, 39th IUPAC Congress and 86th Conference of The Canadian Society for Chemistry, Ottawa, Canada. Web site: www.nrc.ca/confserv/iupac2003

Aug. 16 - 22, 2003: SCANDIUM 2003. An International Symposium on the Mineralogy and Geochemistry of Scandium. Geological Museum at the Natural History Museums and Botanical Garden, University of Oslo, Norway. Web site: http://www.nhm.uio.no/geomus/scsymp/

Sept. 7-11, 2003: 6th International Symposium on Environmental Geochemistry (ISEG), Edinburgh, UK. Contact: Dr. John G. Farmer, Department of Chemistry, University of Edinburgh, West Mains Road, Edinburgh EH9 3JJ, UK; E-mail: J.G.Farmer@ed.ac.uk.

Sept. 7-12, 2003: 13th V.M. Goldschmidt Conference, Kurashiki, Japan. Web site: http://www.ics-inc.co.jp/gold2003/

Fall, 2003: Biomineralization Short Course. Organizers: Patricia Dove , James J. DeYoreo and Steve Weiner. At the AGU fall meeting or MRS Fall Meeting. Sponsored by Mineralogical Society of America.

Oct. 6-9, 2003: North Africa & Mediterranean Geoscience Conference, Tunis. Web site: http://www.eage.nl/conferences/index2.phtml?confid=15

Nov. 2–5, 2003: Annual meeting GSA, Seattle, Washington. Web site: http://www.geosociety.org/meetings/index.htm.

Dec. 8-12, 2003: AGU Fall Meeting, San Francisco, California, USA. Web site: www.agu.org.

Aug. 20-28, 2004: 32nd International Geological Congress (IGC), Florence, Italy. Geochemical Society/IUGS. Web site: http://www.32igc.org/

2005: IAVCEI, Continental Basalt Volcanism, China.

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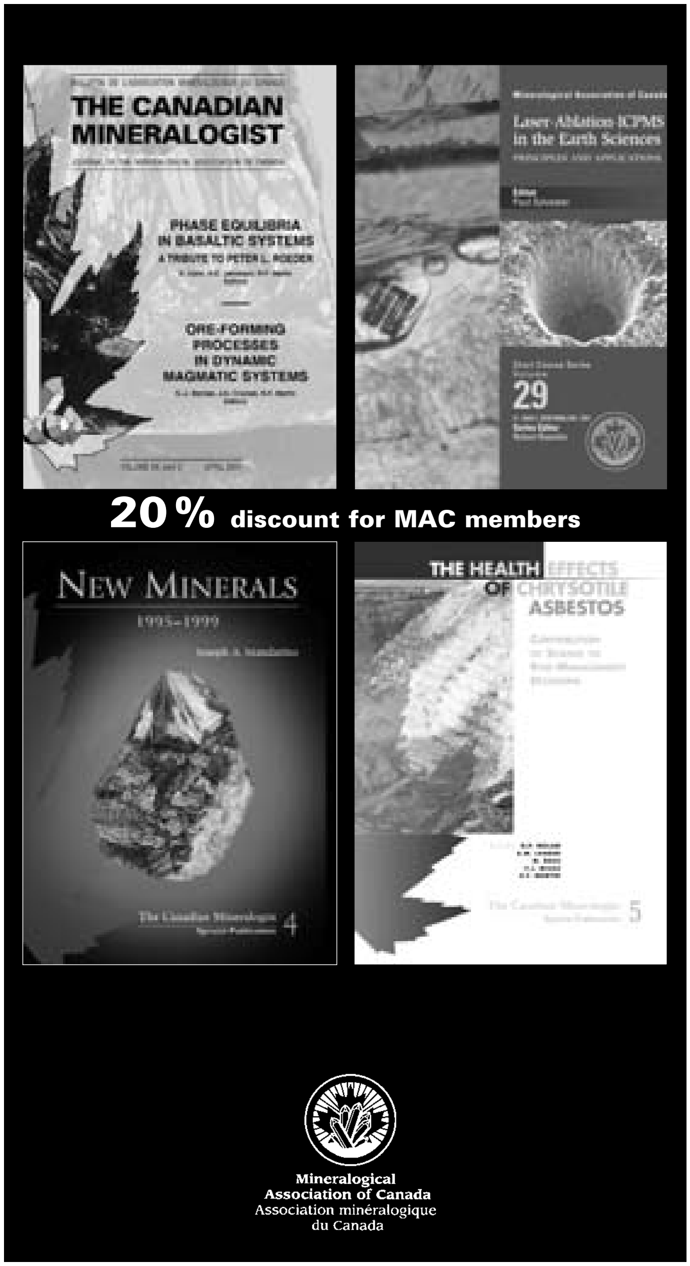

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Editors: R.P. Nolan, A.M. Langer, M. Ross, F.J. Wicks, R.F. Martin

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