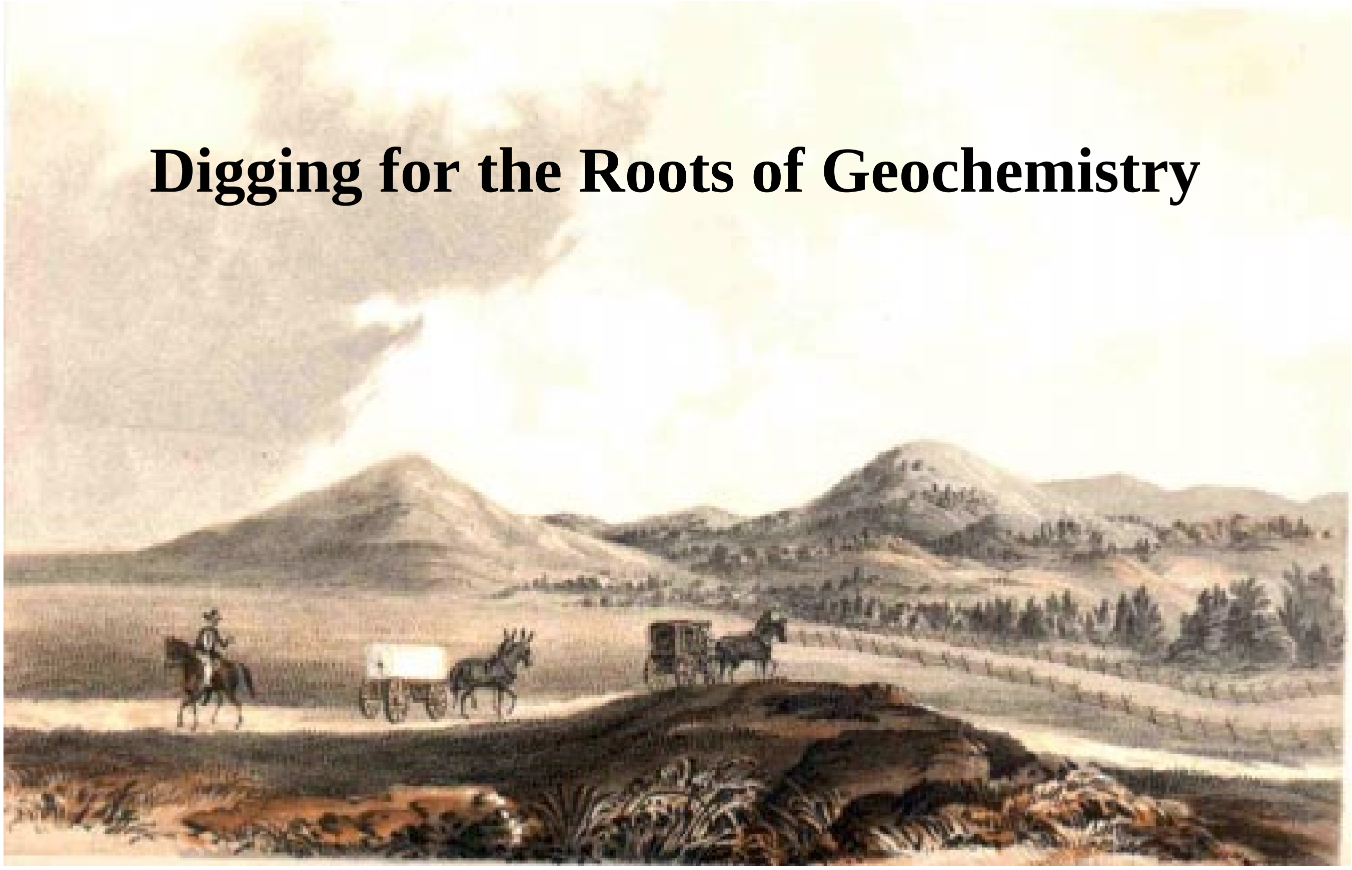
THE GEOCHEMICAL NEWS

Quarterly Newsletter of The Geochemical Society

NUMBER 100 *ISSN 0016-7010* **JULY 1999**

Digging for the Roots of Geochemistry



In this issue:

9th V.M. Goldschmidt Conference
Harvard University
Cambridge, MA, U. S. A.
August 22-27, 1999

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(see page 5 for more information)

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REVIEWS IN MINERALOGY AND GEOCHEMISTRY (CO-EDITOR)
Scott Wood, University of Idaho

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 Association of America), and the journal ***Geochimica et Cosmochimica Acta*** (jointly with the Meteoritical Society); grants the **V.M. Goldschmidt, F.W. Clarke** and **Clair C. Patterson Awards**, and, jointly with the European Association of Geochemistry, the **Geochemistry Fellows** title; sponsors the **V.M. Goldschmidt Conference**, held in North American in odd years and elsewhere in even years, jointly with the European Association of Geochemistry; and co-sponsors the Geological Society of America annual meeting and the American Geophysical Union spring meeting. The Society honors the memory of our first President, F. Earl Ingerson, and our first Goldschmidt Medalist, Paul W. Gast, with the **Ingerson** and **Gast Lectures,** held annually at the Geological Society of America 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.

Editor's Corner

See you at the Goldschmidt Conference.

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ASSISTANT EDITOR

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Geochemical Transactions

The ACS Division of Geochemistry, in conjunction with the Royal Society of Chemistry, is proud to announce the publication of *Geochemical Transactions*, a fully electronic journal devoted to all areas of geochemical research.

Mission Statement

Geochemical Transactions is intended to provide a medium for the rapid publication of high quality research in all areas of chemistry as it relates to materials and processes occurring in the Earth's aquasphere and geosphere. Reports describing the results of novel investigations of geochemical and/or biogeochemical processes, molecular and isotopic analyses of geologic and hydrologic products, molecular and elemental cycles and instrumental or analytical techniques applying to the foregoing will be published. Numeric or computational models of these processes will also be considered. Both fundamental and applied research reports will be welcome. Articles, communications and technical comments on published research are welcome. Invited topical reviews may also be published from time to time.

Editorial Board

Dr. Ken B. Anderson, Argonne National Laboratory
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Initial Call for Papers:	~September 1999
First Papers Published:	~January 2000

CALL FOR NOMINATIONS

The National Academy of Sciences is accepting nominations for the **NAS Award for Initiatives in Research**, sponsored by Lucent Technologies, to recognize innovative work by a young scientist in geochemistry/geophysics. The prize will be given to a young investigator (preferably no older than age 35) who is a citizen of the United States. Nominations accepted through September 1, 1999.

The National Academy of Sciences is accepting nominations for the **J. Lawrence Smith Medal**, awarded for an original and meritorious investigation of meteoric bodies. Nominations accepted through September 1, 1999.

National Academy of Sciences
Awards Program, Room 185
2101 Constitution Avenue, NW
Washington, DC 20418
Phone: (202) 334-1602/Fax: (202) 334-2153
E-mail: sgrodin@nas.edu
Web: national-academies.org/nas/

Geological Society Of America Selects Sara Foland As New ExecutiveDirector/CEO

Sara S. Foland, CEO and president of Farallon Energy Group Ltd., Denver, has been named executive director/chief executive officer of the Geological Society of America. Her appointment is effective June 30, 1999. She succeeds Donald M. Davidson, Jr., executive director of GSA since 1994, who will retire at the end of June.

Gail Ashley, president of GSA and professor of geology at Rutgers University, is enthusiastic about Foland's role and contribution to GSA's future. "Sara is joining us at a time of growth and development in new directions," said Ashley. "Her leadership experience in business and on boards of not-for-profit organizations will serve GSA well."

When asked about her goals for the organization, Foland said, "GSA is all about science, stewardship and service. We have a long-standing tradition of academic excellence that will continue. At the same time, we're expanding our commitment to geoscience in service of society. We see ourselves as stewards of earth-science knowledge and of Earth itself."

At Farallon Energy Group, Foland built an organization and investment portfolio for acquiring gas-producing properties throughout the United States. Prior to joining Farallon, she held leadership and geotechnical positions at Amoco Production Company in Denver.

Foland earned Bachelor of Science degrees in geology and chemistry and an Executive MBA from Indiana University. She holds an M.S. in geology from the University of Montana, and will complete a Ph.D. in tectonics at the University of California-Santa Cruz in the next year.

Foland has been a member of GSA since 1983. She is also a member of the American Association of Petroleum Geologists, the American Geophysical Union, the Society of Exploration Geophysicists, the Rocky Mountain Association of Geologists, Sigma Xi, and the American Association of University Women.

The Geological Society of America, founded in 1888, is a 16,000-member scientific society headquartered in Boulder, Colorado. Through its meetings, publications, and programs, GSA supports integrated science, encouraging cooperative research among earth, life, planetary, and social scientists. The Society also fosters public dialogue on geoscience issues, and supports all levels of earth-science education.

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THE GEOCHEMICAL SOCIETY

2000 Officer Candidates

The Geochemical Society has a 16-member Board of Directors composed of 9 Officer-Directors and 7 Non-officer Directors. The terms of Directors are either two years (President, Vice-President, Past-President, Organic Geochemistry Division Chair) or three years (all other Directors) and are staggered. Officer-Directors whose terms continue through at least 2000 are Michael F. Hochella, Jr. (President-elect), David J. Wesolowski (Secretary), S. Ross Taylor (International Secretary), Michael J. Drake (Current President), Scott A. Wood (Special Publications Editor), Michael D. Lewan (OGD Chair), and Steven A. Macko (OGD Secretary). Non-officer Directors through at least 2000 are R. Keith O'Nions, Alexandra Navrotsky, Everett L. Shock and K. Vala Ragnarsdottir. Directors whose terms expire at the end of 1999 include Alex N. Halliday (Past-President), Donald Elthon (Treasurer), Lynn M. Walter (Director), Jochen Hoefs (Director) and Albrecht W. Hofmann (Director). By a majority vote of the Board, the Executive Editor of *Geochimica et Cosmochimica Acta* will become an officer-director of the Society beginning January 1, 2000. Listed below are the candidates for Vice President and Treasurer. A separate notice will appear in a later issue of *The Geochemical News* with the remaining Director candidates for 2000.

The By-Laws of the Geochemical Society require that its members be notified of the candidates for new Officers and Directors, who are proposed by the Nominations Committee and approved by the Board of Directors of the Society, well before the end of the calendar year in which the current Directors' terms expire. The purpose is to allow the general membership to nominate additional candidates for those positions that are up for election. Please consider the candidates listed below carefully and propose others only if you feel this is in the best interest of the Society.

Additional nominations may be made by at least ten (10) members of the Society and the nominees must agree to serve if nominated. If you are satisfied with the proposed slate of officers for 2000, do nothing. Additional nominations must be submitted by October 1, 1999, to the Secretary of the Geochemical Society (Dr. David J. Wesolowski, Chemical and Analytical Sciences Division, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee, 37831-6110, USA (Tel: 1-423-574-6903; Fax: 1-423-574-4961; Email: dqw@ornl.gov).

Proposed Slate of New Officers of the Geochemical Society

OFFICERS:	*For Vice President (2000-2001)*	*For Treasurer (2000-2002)*
	Judith McKenzie ETH-Zentrum. Geological Institute Zürich, Switzerland	Rebecca Ann Lange Geological Sciences University of Michigan Ann Arbor, MI, USA

Ninth Annual V. M. Goldschmidt Conference

August 22–27, 1999 Cambridge, Massachusetts

http://cass.jsc.nasa.gov/meetings/gold99/

Sponsors

Geochemical Society
European Association of Geochemistry
Lunar and Planetary Institute
Harvard University
National Aeronautics and Space Administration

The Ninth Annual Goldschmidt Conference will be held at Harvard University, Cambridge, Massachusetts, August 22–27, 1999. The conference will be hosted by the Department of Earth and Planetary Sciences. Professor Stein B. Jacobsen is the Conference Chair.

The Goldschmidt Conference is an annual international conference of geochemists, and is held alternately in Europe and North America. The meeting is a forum for presenting and discussing new chemical and isotopic measurements, experimental and theoretical results, and discoveries in geochemistry and cosmochemistry.

The program committee welcomes your suggestions for potential symposia topics, and solicits volunteers to act as symposia organizers. Please send your suggestions for topics and offers to organize to goldschmidt@eps.harvard.edu.

Schedule

March 5, 1999	Second announcement mailing, including logistical and registration information and call for abstracts
May 21, 1999	**Abstract deadline**
June 28, 1999	Final announcement mailing
August 22–27, 1999	Ninth Annual Goldschmidt Conference
August 28–29, 1999	Field trips

Contact

Stein B. Jacobsen, Department of Earth and Planetary Sciences, Harvard University, Cambridge MA 02138 (phone: 617-495-5233; fax: 617-496-4387; e-mail: goldschmidt@eps.harvard.edu).

The Geochemical Society 2000 Awards Nominations

V.M. Goldschmidt Award

The V.M. Goldschmidt Award shall be made for major achievements in geochemistry or cosmochemistry, consisting of either a single outstanding contribution, or a series of publications that have had great influence on the field. The award will normally be given annually at the V.M. Goldschmidt Conference. Current members of the Geochemical Society Board of Directors and past recipients of the award are ineligible for nomination. Nominations should specify the name, address, and chief fields of specialization of the nominee, and be accompanied by a curriculum vitae and bibliography of the nominee, limited to two pages each, and up to three supporting letters. Nominations should also be accompanied by a letter from the nominator giving name, address, phone number, signature, and a brief summary of why the candidate is suitable for the award. Awards are based solely on scientific merit, without regard to citizenship or membership in the Society.

Past Recipients: P.W. Gast (1972), R.M. Garrels (1973), H.E. Suess (1974), H.C. Urey (1975), H.P. Eugster (1976), S. Epstein (1977), G.J. Wasserburg (1978), H. Craig (1979), C.C. Patterson (1980), R.N. Clayton (1981), K.B. Krauskopf (1982), S.S. Goldich (1983), A.O. Nier (1984), J.B. Thompson (1985), C.J. Allégre (1986), W.S. Broecker (1987), H.C. Helgeson (1988), K.K. Turekian (1989), E. Anders (1990), A.E. Ringwood (1991), S.R. Hart (1992), S.R. Taylor (1993), H.D. Holland (1994), R. Berner (1995), A.W. Hofmann (1996), D. Lal (1997), W. Stumm (1998), J.L. Bischoff (1999)

Nominations for the 2000 V.M. Goldschmidt Award should be submitted before December 31, 1999, to:

Dr. Heinrich D. Holland
Dept. Earth Planet. Sci.
Harvard University, 20 Oxford Street
Cambridge, Mass. 02138
USA

Tel: 1-617-495-5892
Fax: 1-617-495-8839
Email: holland
@eps.harvard.edu

F. W. Clarke Award

The F.W. Clarke Award shall normally be made annually at the V.M. Goldschmidt Conference to an early-career scientist for a single outstanding contribution to geochemistry or cosmo-chemistry, published either as a single paper or a series of papers on a single topic. Candidates must have held a recognized doctorate or its equivalent for no more than six (6) years, or be not more than thirty-five (35) years of age, whichever anniversary date is later in the year of the nomination deadline. Current members of the Board of Directors and past recipients of the award are ineligible for nomination. The Clarke and Patterson medals cannot be awarded for the same accomplishment. Nominations should specify the name, address, and chief fields of specialization of the nominee, and be accompanied by a copy of the paper(s) for which the nominee is being considered for the award, and up to three supporting letters. Nominations should also be accompanied by a letter from the nominator giving name, address, phone number, and signature, together with a brief statement explaining the significance of the nominee's work. This letter should also specify the nominee's date of birth and final degree received, the degree advisor's name, the year granted, and the name of the granting institution. Awards are based solely on scientific merit, without regard to citizenship or membership in the Society.

Past Recipients: D.A. Papanastassiou (1972), H. Ohmoto (1973), L. Grossman (1974), D. Walker (1975), J.R. Wood (1976), B. Mysen (1977), D.J. DePaolo (1978), A.C. Lasaga (1979), R.W. Potter (1980), J.F. Minster (1981), P.J. Patchett (1982), E.B. Watson (1983), A. Mackenzie (1984), E.M. Stolper (1985), M.D. Kurz (1986), E. Takahashi (1987), F.M. Phillips (1988), R.J. Walker (1990), D. Sherman (1991), E. Klein (1992), Y Zhang (1993), C. Agee (1994), R. Lange (1995), P.M. Dove (1996), J. Blundy (1997), M. Humayun (1998), A.M. Scheidegger (1999)

Nominations for the 2000 F.W. Clarke Award should be submitted before December 31, 1999, to:

Dr. Donald B. Dingwell
Bayerisches Geoinstitut
Universität Bayreuth
Bayreuth, D-95440
Germany

Tel: 49-921-55-3708
Fax: 49-921-55-3769
Email: Don.Dingwell
@uni-bayreuth.de

Clair C. Patterson Award

The Clair C. Patterson Award, for a recent innovative breakthrough in environmental geochemistry of fundamental significance, published in a peer-reviewed journal, will normally be made annually at the V.M. Goldschmidt Conference. The award has no age or career stage restrictions, but the Clarke and Patterson medals cannot be awarded for the same accomplishment. Members of the Geochemical Society Board of Directors and past recipients of the award are ineligible for nomination. Nominations should include the name, address, and chief fields of specialization of the nominee, and be accompanied by a curriculum vita of not more than two pages, a list of no more than 10 peer-reviewed publications relevant to the accomplish-ment being recognized, and up to three support letters. Nominators should include a letter of not more than two pages, giving name, address, phone number, signature, and a brief description of the nominee's contribution to environmental geochemistry. Awards are based solely on scientific merit, without regard to citizenship or membership in the Society.

Past Recipients: M.L. Bender (1998), R.L. Edwards (1999)

Nominations for the 2000 Clair C. Patterson Award should be submitted before December 31, 1999, to:

Dr. Malcolm T. McCulloch
Australian National University
GPO Box 4
Canberra, ACT 020
Australia
Email: malcolm.mcculloch@ucd.ie

Tel: 61-6-249-4227
Fax: 61-6-249-5443

Alfred E. Treibs Award

The Organic Geochemistry Division (OGD) of the Society bestows this award, for major achievements in organic geochemistry. A separate nominations call will be announced, and inquiries may be made to OGD Secretary Steven A. Macko, Dept. Environmental Science, University of Virginia, Charlottesville, Virginia 22903, USA (Phone: 1-804-924-6849; Fax: 1-804-982-2137; Email: sam8f@virginia.edu).

Cees Van der Weijden Retires

"I am going to make a highly provocative statement now: You can consider the entire globe as one big chemical system."

With these words, Professor Dr Cees Van der Weijden challenged the audience, which was gathered at Utrecht University in The Netherlands on April 9, 1999. He added that there is, however, an increasing awareness of biological influences on this system and proceeded with an overview of geochemical developments during the past decades. Cees retired from his position as Chair Marine Geochemistry and Hydrogeochemistry at Utrecht a few days earlier. In his honor, the Dutch 'Geochemische Kring' organized a day of presentations covering topics as diverse as fungi in plant-soil interactions, gas hydrates and climate change, lake sediments and sorption reactions at birnessite. Cees's research interests also span a wide range of geochemical issues, somewhat skewed toward the aquatic environment. His current work focuses on rock-water interactions in Portugal, on porewaters and early diagenetic processes in the Arabian Sea area as well as on sedimentary records as paleoceanographic proxies in that area.

Cees was born in Amsterdam and did not take the well-trodden straightforward pathway to academia. He initially worked as a bank employee and later turned himself into a chemical analyst. He enrolled as a part-time Master's student in his late twenties and obtained his PhD at age 41. This is particularly unusual in The Netherlands, where students are supposed to start their PhD work between the ages of 25 and 30 - which is slowly changing now. Cees then went on to Penn State and the University of Rhode Island for about a year, after which he returned to the University of Utrecht. He became a full professor in 1980 and dean of the Earth Sciences Department in 1982. He took another sabbatical in 1986, which he spent at Scripps Institution of Oceanography.

Those who have worked with him in one way or another describe him as a very pleasant person, with 'his heart in the right spot'. He supervised 17 PhD students in the past and still has 9 'under his wing'. Cees is known to have a genuine and altruistic interest in students and their work, which - let's face it - is less common than it ought to be.

Fortunately, Dr Philippe Van Cappellen will soon be leaving the Sapelo Island salt marshes and its mosquitoes and travel to the lowlands of Utrecht, where he is due to start in September. Philippe received his Bachelor's and Master's degrees in geology and mineralogy from the Free University of Brussels, Belgium. He spent two years in Morocco as a teacher of natural sciences in a public high school, after which he returned to Belgium and joined the Marine Pollution Control Unit at the Ministry of Public Health. He was awarded the Herbert Hoover Fellowship of the Belgian American Educational Foundation in 1985 and started graduate school at Yale University. At Yale, he conducted research in low-temperature geochemistry under the guidance of Robert A. Berner. He was a Postdoctoral Fellow in the research group of Werner Stumm at the Swiss Federal Institute of Aquatic Sciences (EAWAG-ETH) and joined the Georgia Institute of Technology as an Assistant Professor in 1991. He is currently an Associate Professor of Geochemistry at Georgia Tech.

Philippe Van Cappellen will assume the post vacated by Cees Van der Weijden

Recent recognition for his work includes the 1996 Sigma Xi Young Faculty Award and a keynote address at the 4th International Symposium on the Geochemistry of the Earth's Surface (1996, Ilkley, England). Philippe is co-Editor-in-Chief of the *Journal of Hydrology*, member of the Editorial Board of the journal *Geology*, and serves as an Associate Editor of the *American Journal of Science*. He has also been described as a 'user-friendly' speaker. Philippe's research interests are in biogeochemistry, mineral-water interface geochemistry such as marine authigenesis , transport-reaction modeling and in the links between geochemical cycles and global change.

In the meantime, Dr Gert de Lange is holding the fort at Utrecht.

Angelina W. M. G. Souren
Vrije Universiteit, Amsterdam

7th LATIN-AMERICAN CONGRESS
ON ORGANIC GEOCHEMISTRY

Foz do Iguaçu, Brazil
October 22 - 26, 2000

NEW PERSPECTIVES ON ORGANIC GEOCHEMISTRY FOR THE THIRD MILLENNIUM

For further information, contact:

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Cidade Universitária, Avenida 1, Quad. 7, Ilha do Fundão
21949-900 - Rio de Janeiro - RJ - Brazil
Phones: 55-21-5986459 or 55-21-5986420
Fax:55-21-5986799
http://www.lamce.ufrj.br/alago
e-mail: alago@cenpes.petrobras.com.br

Mineralogical Society of America Short Course Announcement

Uranium: Minerals, Chemistry and the Environment

The low crustal abundance of uranium belies its mineralogical and geochemical significance; over five percent of minerals known today contain uranium as an essential constituent. Once thought to be rare, uranium is more abundant than mercury, antimony, silver, or cadmium. Uranium is a geochemical and geochronological indicator, and the U-Pb decay series has long been one of the most important systems for dating rocks and minerals. Uranium is also an energy source, and the uranium fuel cycle has generated a great deal of interest in uranium mineralogy and geochemistry since the first controlled nuclear fission reaction nearly sixty years ago. Current interest in uranium geochemistry stems in a large part from the energy cycle, especially with regard to environmental issues such as coping with uranium mine and mill tailings and other uranium-contaminated sites, as well as permanent disposal of highly radioactive uranium-based fuels in deep geologic repositories.

More than twenty years have passed since the 1978 MAC Short Course in Uranium Deposits. Since then much research related to uranium geochemistry has shifted focus, from exploration and exploitation to environmental remediation and geological "forecasting" of potential future impacts of decisions made today. In addition, the last twenty years have produced remarkable advances in our understanding of uranium mineralogy and geochemistry, as well as technological and theoretical advances in analytical techniques, revolutionizing research of trace-elements, including uranium. Continued interest in uranium mineralogy and geochemistry makes this an auspicious time for a short course about a truly fascinating element.

The MSA Short Course, *Uranium: Mineralogy, Geochemistry and the Environment*, will address fundamental issues such as uranium crystal chemistry, systematic uranium mineralogy, aqueous chemistry of uranium, uranium-ore genesis, and isotopic systems. More specialized subjects will also be addressed, including microbial influences on uranium geochemistry, remediation of uranium-contaminated sites, applications to radioactive waste disposal, and the natural fission reactors in Gabon, Africa. The accompanying *Reviews in Mineralogy* volume also addresses analytical methods useful for mineralogical and geochemical research on uranium.

Topics and Speakers/Authors

Overview [*no lectures*]
- Introduction, Robert Finch & Peter C. Burns
- Radioactivity and the 21st Century, Rodney C. Ewing

Crystal Chemistry and Mineralogy
- Crystal Chemistry of Uranium, Peter C. Burns
- Systematics and Paragenesis of Uranium Minerals, Robert Finch & Takashi Murakami

Isotope Systematics and Age Determination
- Uranium-Lead Systematics and Age Determination, T. Kurtis Kyser & Mostafa Fayek
- Stable Isotope Systematics of Uranium Deposits, Mostafa Fayek & T. Kurtis Kyser

Actinide Geochemistry & the Formation of Ore Deposits
- Aqueous (Geo)Chemistry of Actinides, William M. Murphy & Everett L. Shock
- Geology and Genesis of Uranium Deposits, Jane A Plant, Peter R Simpson, B. Smith & BF Windley
- The Oklo Natural Reactor, Janusz Janeczek

Environmental Aspects
- The Impact of Microorganisms on the Form and Distribution of Uranium and Other Actinides, Jillian Banfield & Yohey Suzuki
- Environmental Remediation, Abdessalam Abdelouas, Werner Lutze & Eric Nuttall
- Uranium Mineralogy and the Geologic Disposal of Spent Fuel, David Wronkiewicz & Edgar Buck

Instrumental Techniques [no lectures]
- Spectroscopic Techniques Applied to Uranium, John Hanchar
- Infrared Spectroscopy and Thermal Analysis of Uranium Minerals, Jirí Cejka
- Analytical Techniques for Measuring Uranium in Minerals and Groundwaters, Stephen F. Wolf
- X-ray Diffraction Identification of Uranium Minerals, Francis Hill

Dates: Friday and Saturday, October 22-23, 1999 (preceding the Mineralogical Society of America-Geological Society of America Annual meeting in Denver, Colorado)

Location: Short Course sessions are between 8:00 am - 5:00 pm at the Holiday Inn Denver West Village, 14707 West Colfax Ave, Golden, Colorado 80401, U.S.A. voice: (303) 279-7611, (800) 729-2830, fax: (303) 278-1651.

Conveners: *Peter C. Burns*, Department of Civil Engineering & Geological Sciences, University of Notre Dame, Notre Dame, IN 46556-0767, TEL: (219) 631-7380, FAX: (219) 631-9236, E-mail: Peter.Burns.50@nd.edu.

Robert Finch, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439-4837, USA, TEL: (630) 252-9829, FAX: (630) 972-4457, E-mail: finch@cmt.anl.gov.

Fees: *on or before 8/31/99 (after 8/31/99)*
Professional Registration: Member $265 ($315)
Non-member* $355 ($405)
Student Registration: Member $165 ($215)
Non-member* $195 ($245)
* Fees include MSA membership dues for 2000.

Registration: Registration forms are available from the MSA Business Office, 1015 Eighteenth St NW Ste 601, Washington, D.C. 20036-5274, USA. Tel: 202-775-4344 Fax: 202-775-0018 E-mail: business@minsocam.org; or the MSA Home Page (http://www.minsocam.org). Registration form with payment must be returned to the MSA Business Office.

Practical: The registration fee includes MSA short-course sessions, refreshments at breaks, a Saturday evening banquet, and the *Reviews in Mineralogy* volume. There is an informal welcoming reception beginning at 5:30 PM Thursday evening, October 21, on a self-pay basis at the Holiday Inn. The registration fee does not include room, other meals, or transportation costs to or from Golden. Participants must contact the Holiday Inn Denver West Village, 14707 West Colfax Ave, Golden, Colorado 80401, USA voice: (303) 279-7611, (800) 729-2830, fax: (303) 278-1651 to make reservations and pay for rooms. A block of rooms is reserved for short course participants at the Holiday Inn until September 30, 1999.

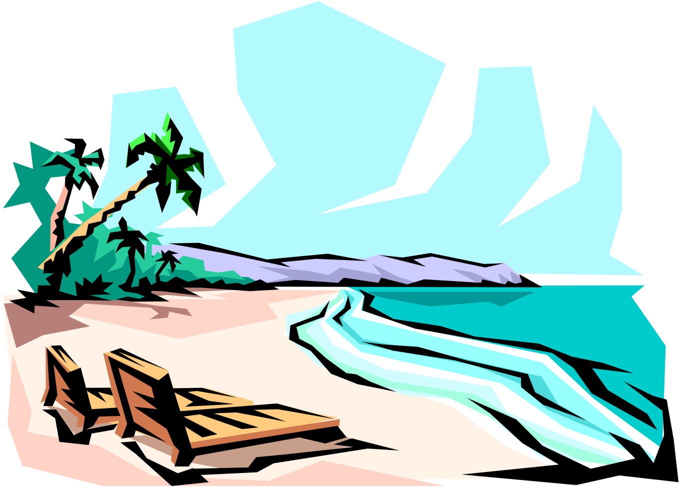
Local Transportation: Ground transportation to and from the Denver International Airport (DIA) is available. Among the services available to Golden is *Golden West Commuter* (303) 342-9300, regularly scheduled to leave DIA approximately every hour. Reservations must be made to return from Golden to Denver or DIA. Cost is $18 each way.

Student Scholarships: There is support from the University of Notre Dame to provide short-course registration-fee waivers for students. Each student must provide a one-page summary with the registration form explaining why attending the short course will be beneficial to the student's professional development. The deadline for receiving requests for fee waivers is July 31, 1999. Successful applicants will be selected by the organizers.

Topical Session: The *Uranium* short course will be held in conjunction with an MSA topical session at the Mineralogical Society of America - Geological Society of American Annual Meeting in Denver, Colorado. If you submit an abstract for this special session, please let the short course conveners know.

9th V. M. Goldschmidt Conference
Harvard University
Cambridge, MA, U. S. A.
August 22-27, 1999

(see page 5 for more information)



31st International Geological Congress
Rio de Janeiro, Brazil, August 6-17, 2000

Symposium Coordinators Needed! Don't Hesitate!

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Digging for the roots of geochemistry

One could say that the history of geochemistry goes back to the times of Thales, Aristotle and Empedocles. One could even go further and point to our ancestors, who knew how to make iron and bronze tools. Geochemistry as we know it is however a fairly recent development. Geology didn't become a science of its own until the 19th century and the inclusion of chemistry in geology seems to have sprung from agricultural and economic concerns. Aqueous geochemistry of freshwater appears to have been spawned mainly by environmental and health concerns. Both were boosted to a much higher level by the input from physical chemistry, the discipline exploring the borderland between physics and chemistry, created about a century ago. Physical chemistry also influenced chemical oceanography, the foundations of which were laid by Gay-Lussac, Boyle and Lavoisier, but chemical oceanography has always been fairly close to physical chemistry.

Aqueous and environmental geochemistry

Environmental concerns may appear typical of our era, but a look at the history of the city of Amsterdam reveals that they already cropped up in the 15th century. In 1394, the water from the Amstel river and the canals of Amsterdam was still clean enough to be used in beer brewing.

The quality of freshwater is essential for the quality of beer.

Eighty years later, pollution had forced the breweries to obtain their water from elsewhere. The city council now also routinely tested the environmental quality of the ice that was used in a form of winter entertainment called 'ice biting'. In 1530, professions that were known to pollute heavily, such as the tanning of leather and dyeing of cloth, became subject to regulations. More regulations, prohibitions, as well as a system of fines attempted to get a grip on pollution during the following centuries, without a great deal of success. In 1794, the citizens of Amsterdam suffered a bout of lead poisoning. This was caused by the use of peat as fuel, in turn leading to a form of acid rain which dissolved the lead from paints and gutters. The lead subsequently got into the basins near the churches from where drinking water was distributed to the population. The Clean Freshwater Society had been founded in 1786, but didn't start publishing chemical analyses of drinking water until 1825. One can assume that they also checked the levels of lead. Of course, oxygen still had a molecular weight of 8 in those days.

Geology and geochemistry

By this time, the science of geology was well on its way, as a result of the work of James Hutton (1726-1797), the so-called 'father of geology'. Until the times of Hutton, the earth sciences did not have a domain of their own, but were part of other studies. In countries with a history of mining, such as Germany and France, geochemistry had stronger roots than in countries without ore mines. The French École des Mines already built an analytical chemistry laboratory in as early as 1838.

North America had only just started to develop, so Europe was still ahead in most aspects. The first American professor in science was Benjamin Silliman. Silliman, a 22-year old law student became professor of chemistry at Yale in 1802. Although American geology picked up surprisingly rapidly during first half of the 19th century, early American geology was dedicated to stratigraphy and paleontology. Thomas Jefferson's strong interest in vertebrate paleontology played a role in both the rapid development of geology as in its bias toward the non-chemical aspects.

Nevertheless, some remarkable geochemical feats were accomplished as well. In 1827, Lardner Vanuxem drew attention to the chemical interaction between the atmosphere and the earth's crust and in 1844, Henry D. Rogers estimated how much carbon was taken from the air and stored in rocks. If only they knew how important these topics are today! James Dana introduced the concept of metamorphism in 1843. Although the discussion of these ideas may have been limited to academic circles, chemistry certainly was a normal part of 'ordinary' geological studies. This becomes evident upon browsing through some of the geological reports of that period.

'As a measure of economy, as far as this state is concerned, I was pleased to learn that the chemical work could all be done in your laboratory at New Harmony, and would be pleased to learn what annual expense this state will incur under such an arrangement, and for all instruments which I presume you have and can use in the prosecution of the work, including office-rent and fuel, whilst doing the office-work at New Harmony.

As you know best the kind of wagons and camp equipage you will require to suit you, I presume it would be better for you to procure and ship them to Jacksonport, Arkansas, than to obtain them in this state. The horses and mules which you would require, could, perhaps be obtained in Arkansas, as well as common laborers.

We shall have to be confined to the amount of appropriation by the law, and that is so small for such an important work, we will have to use economy to accomplish much good, and I shall depend greatly on your experience and good management in the whole matter.'

Ignore the part about the horses and the mules and these words sound almost awkwardly familiar. They are part of a letter that appoints David Dale Owen, M.D. as State Geologist for Arkansas. The letter was published in Little Rock in 1858, as part of the *"First report of a geological reconnaissance of the northern counties of Arkansas, made during the years 1857 and 1858..."*

William Elderhorst, M.D. was the State Geologist's Chemical Assistant. He wrote the chapter titled 'Chemical Report of the Ores, Rocks, and Mineral Waters of Arkansas'. The samples of well and river waters were analyzed in the field 'with comparatively limited means', but all other analyses were performed at the laboratory. Elderhorst describes the ores, gives the analyses and includes a methods section for each type of analysis. The State Geologist also had a Geological Assistant. This was a certain Edward T. Cox, whose part of the report also includes chemical compositions, albeit mainly of waters. Cox often added remarks such as '*It is, therefore, a weak saline sulphuretted water, and its medicinal properties will be that of a mild laxative, it will also be found beneficial in all cutaneous diseases.*'

Apart from the fact that chemistry was clearly a well-established aspect of field geology, two other issues jump out: the State Geologist and his Chemical Assistant were both medical doctors and the water analyses are seen in terms of health implications.

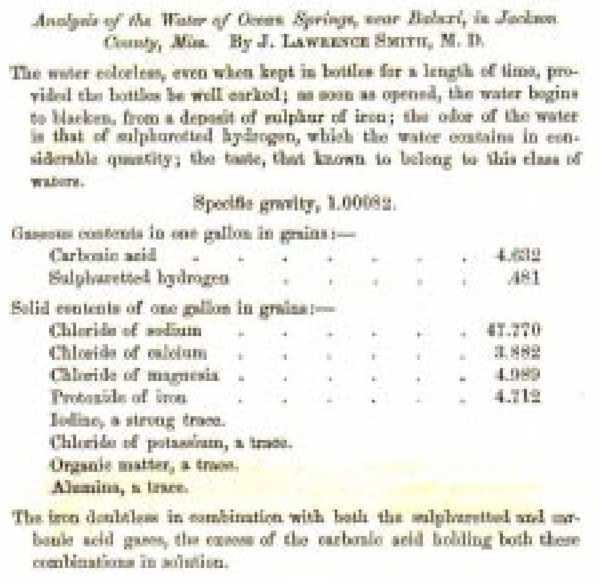
Sugar Loaf Mountain, Marion County, Arkansas, in the middle of the 19th century. This is how the State Geologist traveled in those days, if he got lucky. He describes some of the roads in Marion County as 'very rough and disagreeable to travel over'. The prevailing rocks of this county are 'varieties of magnesian limestone, with some intercalated sandstones'.

Another excerpt, from the *"Report on the agriculture and geology of Mississippi embracing a sketch of the social and natural history of the State"* further illustrates the practical use of chemistry in geology and shows aspects of the ongoing discussions at that time. The report was written by B.L.C. Wailes, 'geologist of Mississippi; member of the American Association for the Promotion of Science; corresponding member of the National Institute, and of the Boston Society of Natural History, etc. etc.' and published in 1854 by Lippincott, Grambo and Co. for E. Barksdale, State Printer.

'It is well known that some soils are, by nature, unsuited to the production of particular plants, even where climate and other conditions would favor their cultivation, and that from other soils, originally prolific, the productive elements are continually abstracted in the course of tillage until, in the end, they become exhausted and sterile. It is the province of Agricultural Chemistry, therefore, to determine the elements of plants derived from the earth in which they grow, and the presence or deficiency of those elements in the soils in which they are cultivated, in such manner as to make this knowledge available to the husbandman, and to instruct him also in the chemical composition of the manures, animal or mineral, proper to be applied to supply the exhaustion, or to fit the otherwise unfruitful soil for his purpose. As to the practical value of analysis of soils as usually conducted, or the ability, in the present state of chemical knowledge, of determining those minute constituents in a soil - such as alkali or potash and phosphoric acid - generally regarded as the greatest cause of fertility, eminent chemists are at issue, and, in our own country, many distinguished for high scientific attainments are found to agree with Boussingault, that we are much less interested in the chemical composition of the soil than in its mechanical mixture.

But, whatever may be the differences of opinion as to the value of analysis of soils, and whether the benefits would justify the expense attending the minute and multiplied chemical examinations required to impart a useful knowledge of their properties, there can be none as to those of the marls or mineral fertilizers employed, as no one would be willing to apply an ingredient to his land, which a simple test might prove to be not only unsuitable, but absolutely pernicious. In view of the general use into which they must come eventually, when their existence and value shall be better known, adequate analyses of all the varieties of marls which abound in the State are highly desirable.'

These words are the beginning of the chapter 'Analysis' and are followed by analyses of marls, mineral waters, cotton, cottonseed and other materials.



Analysis of the Water of Ocean Springs, near Baluxi, in Jackson County, Miss. By J. LAWRENCE SMITH, M. D.

The water colorless, even when kept in bottles for a length of time, provided the bottles be well corked; as soon as opened, the water begins to blacken, from a deposit of sulphur of iron; the odor of the water is that of sulphuretted hydrogen, which the water contains in considerable quantity; the taste, that known to belong to this class of waters.

Specific gravity, 1.00082.

Gaseous contents in one gallon in grains:—	
Carbonic acid	4.632
Sulphuretted hydrogen	.481
Solid contents of one gallon in grains:—	
Chloride of sodium	47.770
Chloride of calcium	3.882
Chloride of magnesia	4.989
Protoxide of iron	4.712
Iodine, a strong trace.	
Chloride of potassium, a trace.	
Organic matter, a trace.	
Alumina, a trace.	

The iron doubtless in combination with both the sulphuretted and carbonic acid gases, the excess of the carbonic acid holding both these combinations in solution.

'Analysis of the Water of Ocean Springs, near Baluxi, in Jackson County, Miss. .'

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Impact of physical chemistry

Chemistry had gathered momentum in the 18th century and developed more or less independently of physics during the 19th century. Although the physical aspects of chemistry had already drawn attention, it was the ‘ionists’, Svante Arrhenius, Jacobus Henricus van ‘t Hoff and particularly Wilhelm Ostwald, who really catapulted physical chemistry into orbit at the end of the 19th century (http://www.nidlink.com/~jfromm/history/physical.htm). They wanted chemistry to study the conditions under which compounds formed. They wanted to look at reactions, kinetics, equilibrium and chemical affinities and not focus only on the compounds themselves. In the United States, physical chemistry became quite ‘hot’ in the beginning of the 20th century, where it strongly impacted many disciplines, notably igneous and metamorphic petrology and geochemistry.

It seems only natural that physical chemistry should become so crucial to petrology. In 1851, Robert Bunsen had already noted that magmas were in fact solutions and that they were probably ruled by the same principles that applied to solutions. In 1857, the French petrographer J. Durocher realized that magmas and alloys also shared similarities. These ideas remained undeveloped until the 1890s, when Arrhenius (http://nobel.sdsc.edu/laureates/chemistry--1903-1-bio.html) and Van ‘t Hoff (http://nobel.sdsc.edu/laureates/chemistry-1901-1-bio.html) started applying their ionist ideas to rocks. Arrhenius also designed a theory of the importance of the CO2-content of the atmosphere for the climate and Van’t Hoff tackled marine chemistry issues.

However, physical chemistry wasn’t exactly received with open arms in Europe and European geologists were also reluctant to embrace the new ideas. Although the competition from organic chemistry in Germany was fierce, physical chemistry managed to flourish at Germany’s fast-growing Technische Hochschulen. For instance at Leipzig, where Ostwald (http://nobel.sdsc.edu/laureates/chemistry-1909-1-bio.html) continued to promote physical chemistry as a science of processes as opposed to structures. In Britain, inorganic chemists strongly opposed the ionists’ views and physical chemistry didn’t even get a foothold in Britain until after World War I. This was largely owing to William Ramsay, a chemist at University College London, and to the University of Liverpool, not to Oxford and Cambridge. Ramsay opened his lab to many of the ionists’ followers, such as Alexander Findlay, whose name would later become strongly associated with the application of the phase rule in Europe. In France, physical chemistry found homes at Nancy, Toulouse and Bordeaux but neither at the Sorbonne nor at any of the other Paris institutions. Arrhenius, Van ‘t Hoff and their students worked at the new Nobel Institute and at the relatively young University of Amsterdam. Americans did not have to fight their way into existing labs; they were still building them. It is easy to see the advantages and disadvantages of that situation. The advantages won. The American situation proved highly beneficial to both the progress of physical chemistry and its incorporation into petrology and geochemistry.

The first Stanford Geological Survey, Summer, 1893, worked along rivers near the present location of Shasta Lake in northern California. Pictured are (left to right) Henry Cory, E.B. Kimball, Frank L. Cole, Jack Sheehan, Professor James Perrin Smith and William Stuart.

Physical chemistry wasn’t the only science to expand rapidly at the turn of the century. So did geology. Many American chemists, who went to Germany to study chemistry, acquired a working knowledge of rocks. American geology students on the other hand could hardly avoid picking up some of the new chemical know-how in Germany. Back in America, these chemists and geologists discovered that they had more in common besides having been trained at the same German institutions. They compared notes and were struck by the similarities between geology and physical chemistry. Important geological questions were postulated in the 1880s and 1890s. How could a single body of magma lead to various rock types? Did it have to do with assimilation of country rock, was it mainly a result of fractional crystallization or should the origin be sought in the liquid itself? Could the order in which minerals crystallized in magmas be influenced by pressure, magma composition and the rate of cooling, as was the case for aqueous solutions? Did pressure have a similar effect on the fusibility of minerals as it had on the solubility of salts in water? And what about supersaturation and the effect of the presence of other minerals?

The phase rule and the Phase Ruler

The phase rule, that familiar petrologists’ tool, was formulated in 1876 by Josiah Willard Gibbs (http://www-groups.dcs.st-and.ac.uk/history/Mathematicians/Gibbs.html) and then forgotten. Gibbs was a solution chemist and physicist at Yale, where he laid the foundations of chemical thermodynamics. Later, Hendrik W. Bakhuis Roozeboom and Van der Waals, a chemist and a physicist respectively at the University of Leiden in The Netherlands (http://ci.mond.org/9707/970715.html), rediscovered Gibbs's work on the phase rule. They induced a lively interest for it, particularly among scientists in the Low Countries but also elsewhere. Wilder Dwight Bancroft reintroduced the phase rule in America. Bancroft went to Leipzig to study with Ostwald, who happened to be preparing a translation of Gibbs's papers. After Bancroft received his Ph.D. in 1892, he first went to Berlin to work with Helmholtz. Then he traveled to Amsterdam where he continued his potentiometric studies in Van 't Hoff's lab and where he became further acquainted with the phase rule. Bancroft initially wasn't impressed. He thought that "*people made a good deal of unnecessary fuss over the phase rule*", which seemed to him "*an interesting mathematical relation but nothing more*". Back at Harvard, Bancroft studied solubility relations in ternary systems and had his work severely criticized several times. It was then that he started looking at these systems with the phase rule in mind. He later joined the chemistry department at Cornell and went on to become such an advocate and authority on the phase rule that he was nicknamed the 'Phase Ruler'.

Incidentally, Bancroft may have been quite a character. It is said that he ingested 1,000 mg of thiocyanate a day for a period of 23 years in the process of studying the cumulative properties of this chemical. He reported only positive effects from the experiment.

The phase rule was so attractive, because it finally enabled physical chemists to deal with problems in geology, medicine and industry, that usually could not be handled by conventional mathematics. In fact, Bancroft saw little promise and practical use in mathematical chemistry and he overestimated the realm within which the phase rule could be applied.

Bancroft's work however was considered too 'practical' for academia and too abstract for industry. Most physical chemists were not concerned with the phase rule and Bancroft moved on to other topics, although he never lost interest in the phase rule. Wilder Bancroft is also known as a pioneer in the field of colloid chemistry which he summed up as follows: "*essential to anyone who really wishes to understand oils, greases, soaps, glue, starch, adhesives, paints, varnishes, lacquers, cream, butter, cheese, cooking, washing, dyeing, colloid chemistry is the chemistry of life.*"

Tying the knot between the two disciplines

Joseph Paxson Iddings and Charles R. Van Hise, two petrographers, were instrumental in securing the link between physical chemistry and geology in America. Iddings was actually the first American geologist who drew attention to the implications of the ionists' work for geology. He incorporated the works of Arrhenius and Van 't Hoff into his own papers. He also conducted experiments on the electrical resistance of molten rocks, in an attempt to substantiate the analogy with aquous salt solutions. A magma turned out to be composed not of minerals but of ions, a long-awaited follow-up of the early observation of Bunsen.

Iddings tried to explain magmatic differentiation with a combination of Van 't Hoff's theory of osmotic pressure and C. Soret's empirical findings that, given a temperature gradient, solute molecules tend to concentrate in the cooler portion of a solution. Although this wasn't correct, Iddings's approach nudged more geologists toward physical chemistry.

Mr and Mrs Charles Van Hise. Original owned by the University of Wisconsin Archives.

Charles Van Hise was driven beyond his duties as a geologist within the USGS, to theories about ore deposition and metamorphism. Blessed with an unusual discipline and tenacity, he pushed himself forward to make up for the gaps in his education and also arrived at the conclusion that physical chemistry was vital to petrology. Van Hise focused on the study of metamorphic rocks, but geology wasn't the only topic that caught his attention. Charles Van Hise's speech on "*The regulation of competition versus the regulation of monopoly*", which he gave at the Economic Club of New York in 1912, can be perused at http://library.wisc.edu/etext/WIReader/WER0134.html.

Both Iddings and Van Hise were very eager to start laboratory work in which physical chemistry could join forces with geology. Such a project, where high-temperature and high-pressure work could be done and for which also a fair amount of platinum would be needed, for its crucibles, was going to be expensive and also somewhat esoteric. It was not easy to get such a lab off the ground. Van Hise kept pushing the idea within the USGS and at the turn of the century, the USGS launched a laboratory in which geology finally would team up with chemistry and physics. This was the big turning point. The lights went on green for the study of the physicochemical aspects of geology.

Two other important names in the history of geochemistry are those of Arthur L. Day and E.T. Allen, a physicist and a chemist. Day, Allen and Iddings did a lot of work on the thermal properties of the albite-anorthite solid solution series. They tried, in vain, to explain their experimental results in terms of Van 't Hoff's theories. They then turned to Bakhuis Roozeboom's work and discovered that the plagioclases already fit into one of the

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Dutchman’s system categories.

In 1905, Day and Allen published the fish-shaped equilibrium diagram, which has become such a fixture on the menu of today’s petrology courses. This concept, with compositions shifting along the solidus and liquidus through the (P)T domain, helped explain many phenomena, such as the hitherto puzzling compositional zoning of feldspar crystals.

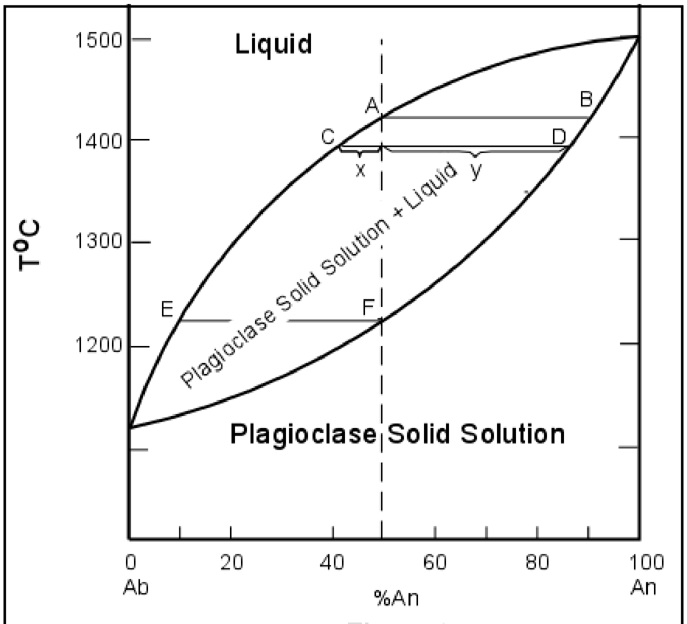

Figure 3

The plagioclase diagram.

For an extensive explanation of the plagioclase diagram, other binary phase diagrams and the phase rule, see http://www.tulane.edu/~sanelson/geol212/2compphasdiag.html. For definitions and interpretations of the phase rule, see http://jwgibbs.cchem.berkeley.edu/phase_rule.html, http://chemengineer.miningco.com/library/weekly/aa022398.htm and http://clayir.gly.uga.edu/schroeder/geol3010/phaserule.html.

The Geophysical Laboratory

The research started by Allen and Day at the USGS blossomed. In 1907, the Carnegie Institution in Washington opened its Geophysical Laboratory, which rapidly became a leader in petrological and mineralogical research. Van Hise and Iddings also played a crucial role in the conception of the Geophysical Laboratory and more particularly, in pushing the physical chemistry of petrogenesis as its main research topic.

Day and Allen became its first director and chief chemist. The Geophysical Laboratory employed many chemists who had studied with Gilbert Newton Lewis and Arthur Amos Noyes at MIT, renowned physical chemists who both had trained with Ostwald. Lewis did a lot of frontier work on chemical bonds but also on chemical thermodynamics, so essential to for instance geothermobarometry. Noyes undertook some of the earliest work in X-ray crystallography. Norman Levi Bowen was of those MIT-trained scientists. The Day and Allen group carried on with the hunt for the data, necessary to construct the phase diagrams for a host of binary and ternary mineral systems. These diagrams fit in very well with Bowen’s theory of the evolution of igneous rocks. Put forward in 1922, it became another of those obligatory petrology course ingredients. In the meantime, Wilder Bancroft was very pleased with these developments, of course, and he dubbed the Geophysical Laboratory the “Phase Rule Laboratory” but it was much more than just that. It was truly a lab of applied physical chemistry, in the broadest sense.

Geochemistry on its way to the 21st century

Both geologists and physical chemists benefited enormously from the co-operation. There were several industrial spin-offs, for instance for the production of quartz glass and ceramics. During World War I, companies like Bausch and Lomb opened the doors for scientists from the Geophysical Laboratory. This trend continued after the war, when the industry had realized what physical chemistry had to offer. A phase diagram can also describe Portland cement, for instance, and phase diagrams became widely applied in many areas. In the early 1920s, physical chemists were ‘hot’ and enjoyed a multitude of widely varying opportunities, such as in metallurgy and pharmacology.

Hard-rock petrology and geochemistry had received an enormous boost and would never be the same. Nuclear chemistry and analytical developments further advanced the field. Tools such as EPMA and XRF were introduced and a progression of mass spectrometers and computers continues to march into the labs. More hyphenated techniques, the cluster concept and computational chemistry will be new fuels to keep the ovens of geochemical research going.

Stanford enters field of isotope geology. Stanford Geology Department’s mass spectrometry lab circa 1961. Graduate student William Taft (seated) operates the Consolidated 21-401 Mass Spectrometer under supervision of Professor John W. Harbaugh. Vacuum system for preparation of gas samples for mass spectrometric analysis is in the background.

Coincidentally, as we move into another century, yet another discipline is being added to petrology and geochemistry: biology. Ten, twenty years ago, the role of microorganisms in ore formation wasn’t even mentioned in ore geology courses. Today, most geologists are well aware of the role of bacteria in the redox reactions that can lead to the precipitation of ore minerals. Chemical oceanographers are talking with marine biologists and actually enjoying it. What is chemically unlikely, such as trivalent manganese remaining in solution or celestite not dissolving instantaneously in seawater, can be mediated by biology. Fungi have been observed to head straight for apatite inclusions in feldspars in order to procure their phosphate. They secrete organic acids and dissolve the apatite and who knows which implications this has had for some whole-rock analyses in the past. Bacteria are found in hard-rock cores obtained from great depths. Geochemists now also find themselves studying apatite aggregates that enclose the fossilized remnants of early life forms and ponder Archean nitrogen geochemistry. As geochemistry moves into the next millennium, it also moves toward more and more multidisciplinarity. Biophysicogeochemistry?

Note: This article does not pretend to be an extensive and complete overview of the history of geochemistry. For a timetable of petrology for the years 1800-1899, see http://www.gl.ciw.edu/TofP-1899.html. Except the geological reports quoted in the article, several other publications were used for its preparation, notably:

Bensaude-Vincent B. and Stengers I. (1996) *A history of chemistry.* Translated by Deborah van Dam. Harvard University Press, Cambridge, Massachusetts. 305 pp.

Hogener, K. (1997) *Costelijck Stadswater. Geschiedenis van de Amsterdamse waterhuishouding in vogelvlucht.* Stadsuitgeverij/Dienst Riolering en Waterhuishouding Amsterdam. Amsterdam, The Netherlands. 112 pp.

Nye, M.J. (1996) *Before big science. The pursuit of modern chemistry and physics 1800-1940.* Twayne Publishers/New York and Prentice Hall International, London, England. 282 pp.

Servos, J.W. (1990) *Physical chemistry from Ostwald to Pauling. The making of a science in America.* Princeton University Press, Princeton, New Jersey. 402 pp.

Angelina W. M. G. Souren
Vrije Universiteit, Amsterdam

The disagreements between theoretical and experimental results can generally be resolved if one multiplies the experimental findings by a factor equal to the ratio of the theoretical expectation to the experimental measurement.

Wilder Bancroft

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Characterization of High Maturity Fluids. J. M. Moldowan, Dept of Geological and Environmental Sciences, Stanford University, Stanford, CA 94305-2115, email: moldowan@pangea.stanford.edu; J. Dahl, Dept of Geological and Environmental Sciences, Stanford University, Stanford, CA 94305-2115dahl@pangea.stanford.edu.

Geochemistry and Deepwater Petroleum Exploration. A. N. Bishop, Texaco UTD, 3901 Briarpark, Houston, TX 77042, email: bishoan@texaco.com; Paul Taylor, Unocal, 14141 Southwest Freeway, SugarLand, TX 77478, email: paul.taylor@unocal.com.

The Integration of Organic Geochemistry and PVT Studies in Petroleum Exploration and Production. G. Macleod, Shell E&P tech Co., 3737 Bellaire Blvd., Houston, TX, 77025, email: gmac@shellus.com; P. Meulbroek, Woods Hole Oceanographic Institute, 360 Woods Hole Rd. MS#4, Woods Hole, MA 02543, email: pmeulbroek@whoi.edu.

New Insights into the Petroleum Geochemistry of NSO Compounds. H. Wilkes, Institute for Petroleum and Organic Geochemistry (ICG-4), Research Center Jülich, D52425 Jülich, Germany, email: h.wilkes@fz-juelich.de; P. Taylor, Unocal, 14141 Southwest Freeway, SugarLand, TX 77478, email: paul.taylor@unocal.com.

Organic Solids in Petroleum Production. B. A. Stankiewicz, Shell E&P TechCo., 3737 Bellaire Blvd., Houston, TX 77025, email: artur@shellus.com; E.Tegelaar, Baseline Resolution, Inc., Suite 810, 2000 Avenue G, Plano, TX 75074, email: ETegelaar@brilabs.com.

Geochemical Analysis in the New Millennium. L. W. Elrod, Geotechnology Research Inst., Houston Advanced Research Ctr., 4800 Research Forest Dr., The Woodlands, TX 77381, email: lwe@gtri.harc.edu; M. A. Engel, University of Oklahoma, School of Geology & Geophysics, 100 East Boyd St., Norman, OK 73019, email: ab1635@ou.edu.

Werner Stumm, 1924-1999

Werner Stumm, the founding father of Aquatic Chemistry, died on April 14 1999 at the age of 74. Fighting a severe illness he devoted his last years to writing the third edition of his classic textbook *"Aquatic Chemistry"*. Here is a personal look to some aspects of his life – from the perspective of two of his Ph.D students:

The poor man's lab

Werner Stumm's research in the seventies and eighties happened mainly within his group of 5-8 Ph.D. students (Table 1). His main job was that of a director of the Swiss Federal Institute for Environmental Science and Technology (EAWAG) - one of four federal labs in Switzerland. Besides his many duties his favorite activity was to shepherd his gang of Ph.D. students. Although he was always running on a tight schedule he was very generous with his time and support for us. Our lab had quite simple equipment like automatic titrators and pH meters. For more sophisticated measurements we collaborated with the senior scientists at EAWAG or at other institutions. During summer Werner often had visitors from the US. Then he proudly showed his friends around and stopped by in the student's lab. There he had his standard joke: "You see this is a poor man's lab. No big machines, only bright young people". Werner gave us the feeling that it is people that make the difference, not machines. He encouraged us to think about new experiments, to take risks by following crazy new ideas. The hardest part of a Ph.D. with Werner was to invent THE crucial experiment. With this attitude he encouraged cooperation and creativity within his Ph.D. group. We had a kind of personal guarantee that risky Ph.D. projects could fail without a loss of support from his side.

From Zürich to Harvard

Werner studied inorganic chemistry at the Swiss Federal Institute of Technology (ETH). There he did a Ph.D with Gerold Schwarzenbach – who shaped the field of complex chemistry by carefully applying titration techniques to determine stability constants of inorganic complexes. In his thesis Werner studied chemical equilibria on ion exchange resins (1). One of his colleagues during that time was Walter Schneider who later became a professor of inorganic chemistry at ETH. He recalls how Werner was quite furious after a discussion with his advisor. Werner could not understand why he should extract his ions into organic solvents and analyze them by conventional methods, while the very elegant radiochemical methods were just established in the United States as a new the state of the art. Anyway, equilibria at the solid-liquid interface remained one of the central research interests of Werner throughout his professional career.

After completing his Ph.D., Werner joined the staff of the Institute for Water Resources and Water Pollution Control (EAWAG). At that time it was a small unit set up to assist the sanitary engineers in a large scale effort to connect the majority of the Swiss population to sewage treatment plants. Werner started his job by reading all of the few dozen books he could find in the library of the small institute. He liked to emphasize that it was this small investment in time, which gave him an edge in competence in the field of water protection and sanitary engineering. Werner realized how much had to be done to generate a sound scientific basis for the operation of drinking water supplies, sewage treatment systems and set up regulations for water protection. With his wife, Elisabeth Stumm-Zolliger he moved to Harvard. There he started a visionary scientific program to understand natural and technical water systems using basic chemical principles. As a postdoc he funded his own research in the Division of Engineering and Applied Physics. In 1956 he became an assistant professor and later he was promoted to Gordon McKay Professor of Applied Chemistry. He initiated research on corrosion, kinetics of redox reactions of iron and manganese and coagulation and filtration of particles. Stumm and his group were strong advocates to use chemical knowledge on speciation and complex formation in solution and at the solid-water interface to understand such processes quantitatively. The field of coagulation and the electrochemistry of interfaces had at that time been an almost exclusive domain of physics – charge distribution, the DLVO-theory of the electric double layer, etc. Werner added the specific chemical perspective that the ions of sodium, calcium and aluminum behave completely differently and that this behavior cannot be modeled by their charge difference alone. By introducing chemical variables into the field of filtration, Stumm and his postdoc Charles O'Melia were able to improve the efficiency of particle collisions in water and the efficiency of filtration processes. The success of these approaches opened the new field of aquatic surface chemistry, which remains very lively and active today.

The roots of Aquatic Chemistry

In his acceptance note for the 1998 Goldschmidt Medal, Stumm remarked that the papers by Lars Gunnar Sillén (2) were very influential for his scientific development. Sillén was one of the few chemists at that time who addressed global questions (" what determines the chemical composition of the atmosphere and oceans?") with simple concepts of chemical equilibria. Throughout his life Werner remained in Sillén's tradition of a laboratory chemist asking grand questions. He favored an experimental approach and was skeptical about large scale monitoring campaigns. "One bottle – one experiment – one Ph.D. thesis!"

On the other hand, the geochemistry groups of Bob Garrels and Ray Siever at Harvard began to look at water chemistry from the perspective of water-rock equilibria. Joint seminars between Stumm's group - "the sanitary engineers" - and the geochemists were instrumental to further develop equilibrium concepts for natural water systems. In collaboration with Jim Morgan (Werner's first Ph.D. student) the idea of a textbook on "*Aquatic Chemistry*" evolved. Stumm was an intense person and writing was an intense process for him. He used to say, "every sentence in '*Aquatic Chemistry*' equals one cup of coffee." The first edition appeared in 1970 (3). It defined a new field of science.

Fight for your ideas

Werner liked scientific debates and was very serious about convincing others. Stumm's world was governed by chemical phenomena like complex formation, catalysis and redox reactions. Electric double layer theories were just taking care of correction factors in surface chemistry. Microorganisms were just good enough as environmental catalysts. In a discussion with Jim Morgan at a recent conference we wondered why a scientist with this drive for the simple could be so successful. "Well", said Jim "publishing alone does not do the job, you have to fight for your ideas". Although Werner published about 300 papers and many books he did not wait until everybody had read them. He was an "evangelist" of his research. The series of conferences on the Chemistry of Solid/Liquid Interfaces organized by the Rudger Boscovic Institute was one of the several arenas where Stumm was engaged in a continuous debate. At the interface between "East" and "West" this conference brought together surface scientists with both physical and chemical backgrounds. It was a forum, where DLVO theory clashed with Stumm's surface complexation approach to explain ion adsorption at the solid-water interface. The papers published in *Croatica Chemica Acta* over a period of twenty years (4,5) document the development of "his" research field in aquatic surface chemistry.

Werner initiated his research on the geochemistry of the solid-water interface together with his students C.P. Huang and R. Jenkins. They quantified equilibria between aqueous oxide surfaces and protons and cations. Electrostatic corrections were first calculated with the Gouy-Chapman diffuse layer models. However, a much simpler approach developed in the lab of Paul Schindler in Bern (6,7) convinced Werner to forget about complicated correction factors. He became a strong advocate of this “constant capacitance model”. During late hours at some meetings the model was renamed “the Swiss Cheese Model” - because of the theoretical holes in it… In the seventies and eighties several surface complexation models were competing on the scientific market. The different models could fit titration data equally well. Therefore Werner vigorously defended the simplest approach.

However, he was far more fascinated about the perspectives of surface complexation than about computer models. If surface complexation could explain cation adsorption it should also work for ligands. Laura Sigg provided experimental evidence that metal centers at solid surfaces exchange their ligands in strict analogy to dissolved cations (8). If surface complexation can explain equilibria it should also work as a kinetic framework. During the eighties Stumm’s gang of Ph.D. students was busy dissolving oxides, precipitating carbonates and analyzing redox reactions catalyzed by oxide surfaces. In order to “spread the gospel” Werner invited his many friends and scientific relatives to intense workshops and then edited books on the results (9, 10). Later he published a teaching book (11) to promote the surface complex as the center of a chemical universe where iron corrodes, mountains dissolve and sedimentary particles precipitate.

Director Stumm

In 1970 Werner moved back to Switzerland to become a director of EAWAG and a Professor of ETH Zürich. The former director of EAWAG, Otto Jaag, had been quite successful as an advocate of better water pollution control. New regulations to subsidize sewage treatment plants had initiated a substantial effort to reduced wastewater discharge to rivers and lakes. The oil crisis during the mid seventies changed the political priorities quite dramatically. Now the environment became a high priority on the political agenda. It was a wise move of the new director not to jump blindly on a bandwagon, but to use the public support to build a world class scientific institution. Within a few years Werner hired an interdisciplinary group of scientists: René Schwarzenbach and Walter Giger (organic chemistry), Dieter Imboden (physics), Peter Baccini (resource management), Willi Gujer and Markus Boller (sanitary engineering), Joseph Zeyer (microbiology). This team of (at that time…) young scientists collaborated in developing the interdisciplinary field of aquatic sciences. After about a decade they all were professors at ETH and the independent federal lab of EAWAG was firmly established as one of the leading environmental institutes in Europe.

However, as a director of EAWAG, Stumm had again enough opportunities to fight for his ideas. Eutrophication of lakes was a major political concern in central Europe. Werner and his group of scientists at EAWAG were successful in promoting a ban of phosphorus in detergents in addition to the end-of-pipe technologies in sewage treatment. As a result of this policy most Swiss lakes have now again similar phosphorus concentrations as in the early fifties.

Although he was heading a rapidly growing institution Werner never gave up science and teaching. Most of his experimental science was done in his group of “self organizing” Ph.D. students. In the eighties, acid rain became a hot topic and Werner himself did a comeback to field work. He went on field trips to analyze acidic mountain lakes in Southern Switzerland (Figure 1). He spent many nights titrating acidic fog samples. He had fun constructing log c – pH diagrams for atmospheric water. Of course, the third edition of “Stumm & Morgan” now sports a chapter on atmosphere-water interactions…

Fig. 1. Sampling acidic lakes in the southern Alps. Left to right: Laura Sigg, Werner Stumm, David Kistler, Jerry Schnoor.

The teacher

Werner’s teaching style was slightly chaotic, but never boring. He was always fixing a point slightly above and far beyond his audience. He explained that he feared to lose his thread by looking into the many faces of his students. He could give capturing lectures using his favored graphical methods such as pe-pH diagrams to SHOW how natural waters behave.

When he went on field excursions with his students he was always dressed as “Herr Professor” –white shirt and a tie but with gumboots (Figure 2). The phenomenon of fashion was an irritation to him – he used to buy his clothes always in the same store just indicating the catalogue number of his shirts and suits.

Grand old man

After his retirement as a director of EAWAG in 1992 he managed to completely detach himself from the politics of the institution. He concentrated on writing and walked around as a friendly and supportive living encyclopedia of environmental science. Together with his co-author Jim Morgan he patiently wrote the third edition of “Stumm and Morgan” – a thick, up-do-date overview of his growing field of research (12).

During his career Werner Stumm received many honors for his professional achievements such as the “Albert Einstein World Award of Science” (1985), the “Tylor Prize for Environmental Achievment” (1986), the Swiss “Marcel –Benoist Prize” (1991), the “European Science Prize” (1992), the “V.M. Goldschmidt Medal” (1998) and the “Stockholm Water Prize” (1999).

In his last years he had a hard fight with his illness and he died shortly after he was aware that he had to give up working completely.

Bernhard Wehrli and Gerhard Furrer
EAWAG/ETH

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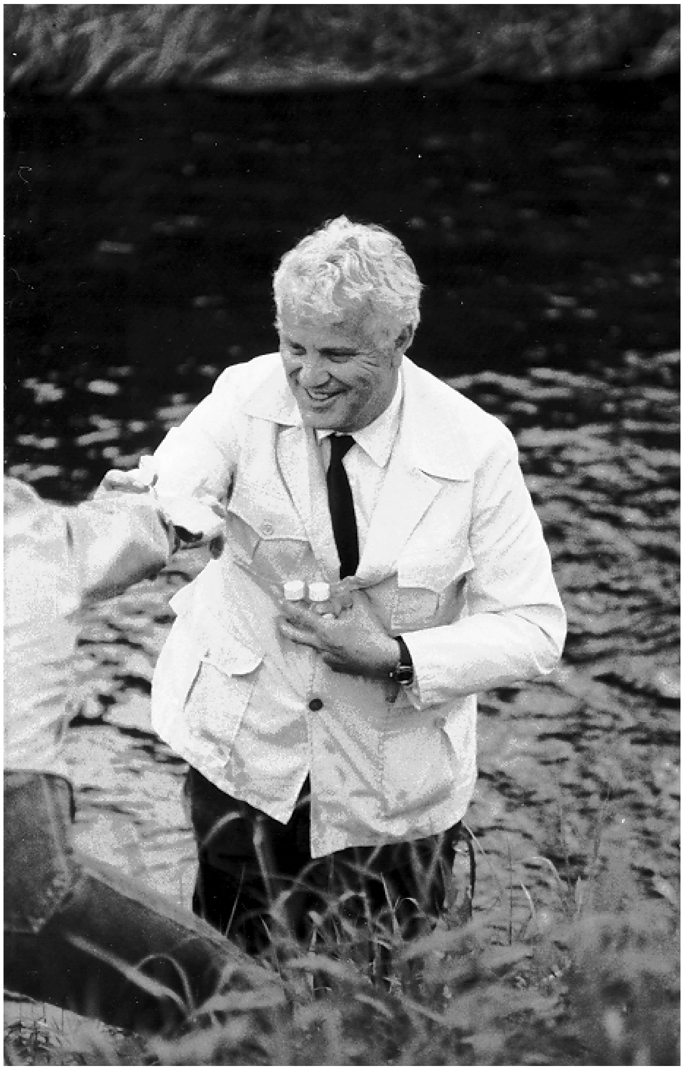

Fig. 2. Werner Stumm sampling river water for a lab course with students in 1984.

Table 1 The PhD family of Werner Stumm

Harvard:
Paul Busch, Robert L. Champlin, Yi-Shon Chen, Hermann Hahn, Chin Pao Huang, Steven R. Jenkins, James O. Leckie, James J. Morgan, Philipp C. Singer, Mark W. Tenney
Zürich:
Steven Bandwart, Madeleine V. Biber, Markus A. Boller, Gianluca C. Bondietti, Felix Dalang, Yivei Deng, Dieter Diem, Georg Furger, Gerhard Furrer, Slavica Ibric, Robert Kummert, Bruno Kunz, Albert Losher, Christina A. Matter-Müller, Michael Ochs, Gertrud K. Osman-Sigg, Dieter Raab, Martin Reinhard, Adrian Ruf, Hansruedi Siegrist, Christophe Siffert, Laura Sigg, Jürg Sinniger, Daniel Suter, Norbert Svoboda-Colberg, Markus Thüer, Jürg Tschopp, Hans-Jakob Ulrich, Bernhard Wehrli, Ulrich Weilenmann, Paul Wersin, Erich Wieland, Bettina Zinder

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When did the Earth's atmosphere become oxic? A Reply

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In the fall 1997 issue of *The Geochemical News,* H. Ohmoto (1) outlined two very different views regarding the evolution of atmospheric oxygen: the Cloud-Walker-Kasting-Holland (C –W-K-H) model and the Dimroth-Kimberley-Ohmoto (D-K-O) model. The first maintains that oxygen was absent or very low in the atmosphere prior to ca. 2.3 Ga, and that pO_2 rose rapidly to values = 0.03 atm during the Great Oxidation Event (G.O.E.) between ca. 2.25 and ca. 2.05 Ga. The second model postulates an essentially constant atmospheric pO_2 level (probably within ± 50% of the present atmospheric level [PAL]) since ca. 4 Ga. Ohmoto (1) concluded that "lines of evidence in favor of the D – K – O model appear to be accumulating". This reply attempts to point out that these appearances may be misleading, and that the bulk of the available evidence, especially the newer evidence, bearing on the history of atmospheric oxygen strongly favors the C-W-K-H model. I will follow the same sequence of topics addressed by Ohmoto (1).

The evolution of continental crust and atmospheric O_2: are they linked?

The simple answer is: probably not. Neither of the models for the history of atmospheric oxygen depends critically on the continent evolution curve. Both models are compatible with most of the curves of crustal evolution which are currently being debated. It is critical, however, to know when oxygenic photosynthesis began. Beaumont and Robert (2) suggest on the basis of the δ^{15}N value of organic matter in Precambrian cherts that organisms with photosystem 2 began to be important between 2.7 and 3.4 Ga. Their data do not settle the matter conclusively, since other interpretations are equally reasonable; if they are right, the atmosphere was essentially oxygen– free at least until 3.4 Ga and possibly until 2.8 Ga.

Banded iron formations (B.I.F.s): products of a globally anoxic ocean or regionally anoxic basins?

The notion that the iron in B.I.F.s was introduced hydrothermally into anoxic, deeper parts of the oceans is now generally accepted (3). The shallower parts of the oceans need not have been anoxic. In fact, the current C-W-K-H model includes a rather high atmospheric oxygen content (> 15% PAL) during the deposition of the B.I.F.'s that are younger than ca. 2.05 Ga. These include the 1.88 Ga Sokoman iron formation and all of the late Proterozoic I.F.s. The formation of B.I.F.s tells us more about the oxidation of the deeper parts of the oceans than about the atmosphere. The cessation of B.I.F. deposition ca.1.8 Ga may be a signal that the deep ocean basins became oxygenated, (i.e. $mO_2 > 0$ mol/kg) at that time, and that during the following 1 Ga. the hydrothermal flux of iron was oxidized and precipitated close to the vents, as they are today.

Both geological and geochemical lines of evidence speak against the proposition that the environment and processes of mineralization for Superior-type B.I.F.s were similar to those in the modern Red Sea. The extensive and well studied B.I.F.s of the Campbellrand Platform in South Africa can be traced unequivocally from deep water to an extensive, shallow water carbonate platform (4). There is no evidence for rifting or submarine volcanism as in the Red Sea. In addition, these B.I.F.s, like all others, are essentially free of the base metals which always accompany black smoker emissions, and that are present in the Red Sea brines in quantities high enough to encourage mining ventures. In the most common C-W-K-H model the absence of base metals in B.I.F.s is explained by precipitation during their long passage from source vents to B.I.F. depository.

Pyrite in Shales: Evidence for an Anoxic Atmosphere?

The great antiquity of sulfate reducing bacteria is now generally accepted, and, as Ohmoto points out, microscale variations of δ^{34}S in pyrite grains in 3.4 – 3.2 Ga sediments were probably formed by bacterial sulfate reduction. There is considerable disagreement, however, about the concentration of sulfate in seawater that is required to account for the magnitude of the observed sulfur fractionation (5). There is also considerable uncertainty about the concentration of sulfate in seawater that can be sustained by the disproportionation of volcanic SO_2 into H_2S and H_2SO_4. It is therefore premature to claim that the present isotopic data for sulfur in Archean sedimentary pyrite is an argument for a high value of pO_2 in the Archean atmosphere.

Uraninite and pyrite in pre –2.2 Ga alluvial sediments: detrital or hydrothermal?

The origin of the gold-uranium ores of the Witwatersrand continues to be hotly debated, but the early petrographic work of Ramdohr (6), Liebenberg (7) and Schidlowski (8), which demonstrated that some of the uraninite and pyrite in these sediments are detrital has not been refuted, and the relatively high Th and REE content of the detrital uraninites sets them apart from hydrothermal pitchblendes. However, later hydrothermal events have surely altered these ores considerably, and arguments regarding the oxygen content of the atmosphere based on their mineralogy, petrography, and chemistry have been received with some skepticism. Fortunately, Rasmussen and Buick's (9) recent report of abundant detrital pyrite and siderite in Archean conglomerate – sandstone successions in Australia has done much to confirm earlier inferences based on the Witwatersrand ores. Contrary to Ohmoto (1), sulfides do not appear to be "extremely rare detrital minerals in normal alluvial sediments of all geologic age, including those of Archean age".

It is difficult to use the presence of detrital uraninite, siderite, and sulfide minerals in sedimentary rocks to set firm upper limits on atmospheric pO2 (10, pp.329-332), but it is clear that their presence in pre – 2.3 Ga sediments is much more consistent with a low (< 10^{-2} PAL) - than with a high – oxygen atmosphere during the deposition of these sediments.

Paleosols: evidence for or against a pre – 2.2 Ga anoxic atmosphere?

As Ohmoto (1) indicated, the chemistry of paleosols is the single most important reason for suggesting a dramatic rise in pO2 between ca. 2.3 and ca. 2.05 Ga. Since Ohmoto's (1) article appeared, Rob Rye and I have published a long, exhaustive review of the paleosol literature (11). Rock units had to satisfy a number of demanding criteria before they were accepted into the canon of paleosols, and great care was exercised in choosing from among those accepted the paleosols which can tell us something about the chemistry of the atmosphere at the time of their formation. Figure 1 summarizes our findings. All of the well studied paleosols younger than 2.0 Ga are highly oxidized. All those of age 2.4 Ga and older are reduced. The data for paleosols between 2.2 and 2.4 Ga are somewhat equivocal, largely because of uncertainties in their age. The published age of the Hekpoort paleosol, for instance, is 2.22 Ga (12); but unpublished data suggest an age of ca. 2.4 Ga. These uncertainties will probably be resolved during the next few years.

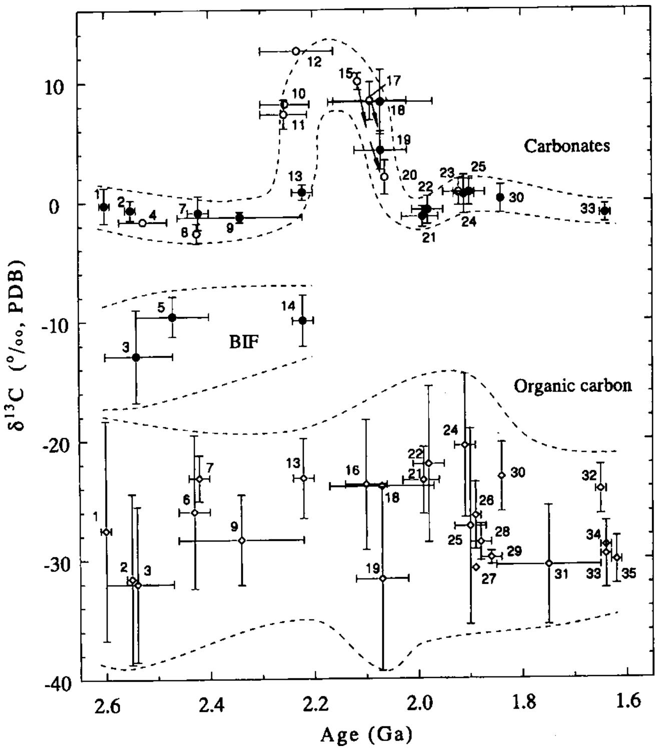

Figure 1. Carbon isotopic composition vs. age in sedimentary carbonates and organic matter during Paleoproterozoic time.

Ohmoto's (1) suggestion that the observed losses of Fe^{+3} and Fe^{2+} from pre -2.3 Ga paleosols were caused by organic acids is most unlikely, since it is hard to see why this effect should be so pronounced in the older, pre -2.3 Ga paleosols and absent in the younger, post -2.0 Ga paleosols. His suggestion that iron was lost during the passage of hydrothermal fluids is also unlikely, since ripup clasts of iron-depleted paleosols in the overlying units indicate that iron loss ocurred during, not after weathering.

We have shown recently that vanadium acted as an immobile element during the formation of the Paleoproterozoic Hekpoort and the late Archean Mt. Roe paleosols. The V/Al, V/Ti, and V/Zr ratios in these paleosols, are constant from top to bottom. This observation supports the notion that weathering occurred in a low–O2 or no–O2 environment, since V is mobile in oxygenic soil environments.

Variations in $\delta^{13}C$ of organic C: evidence for the diversity in organisms and redox environments?

As Ohmoto (1) points out, the large range in the value of $\delta^{13}C$ in Precambrian organic matter is generally consistent with the C-W-K-H model, but he claims that large fluctuations in the $\delta^{13}C$ value of organic matter in sedimentary basins during 100 Ma. periods "would only have been possible when the ocean was basically oxic". I believe that we need to know a good deal more about the causes of variations in and the variability of the $\delta^{13}C$ value of Precambrian organic matter before we can decide whether this proposition is correct.

Positive $\delta^{13}C$ shifts in carbonates: evidence for dramatic rises in pO2?

The existence of a dramatic positive excursion of $\delta^{13}C$ in marine carbonates deposited between 2.25 and 2.05 Ga is now generally accepted. The representation of the excursion in Figure 2 is taken from the paper by Karhu and Holland (13). During this excursion values of $\delta^{13}C$ well in excess of $+10\ ^{0}/oo$ are common.

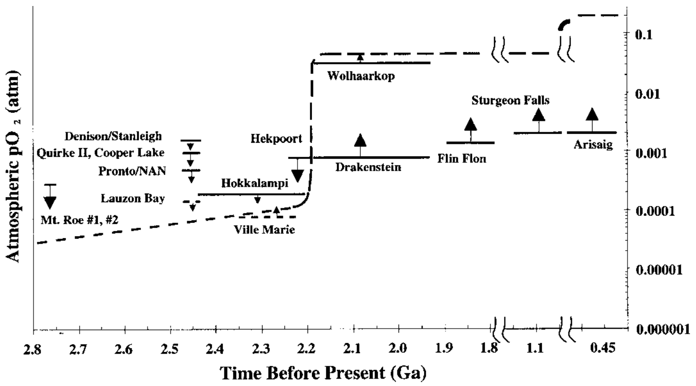

Figure 2. Atmospheric pO2 during the last 2.8 Ga.

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The excursion is the largest known in Earth history, and coincides precisely with the rise in pO2 that is indicated by the chemistry of paleosols and by several other indicators of atmospheric oxygen. If the carbon cycle was operating at its present rate, the amount of excess oxygen inferred from the magnitude and duration of the $\delta^{13}C$ excursion is much larger than the oxygen content of the atmosphere today. The excess may well have been consumed in the oxidation of material in reduced "niches". Ohmoto's (1) suggestion that the excursion is related to the glaciation that occurred shortly before 2.22 Ga is unconvincing, since it is hard to see how the effect of the glaciation on the carbon flux from the continents to the ocean and on the carbonate precipitation rate could have persisted for 150 ± 75 Ma, the length of the $\delta^{13}C$ excursion.

Organic carbon contents of Archean shales: evidence for the constancy in production and consumption rates of atmospheric oxygen?

The organic carbon content of sedimentary rocks and the ratio of organic carbon burial to carbonate carbon burial is almost certainly determined by the oxidation state of volcanic gases (14, pp. 284-296). At steady state the ratio of reduced to oxidized carbon is determined largely by the requirement that the redox state of the output of sedimentary processes is the same as the redox state of the inputs. It can be shown that this is true regardless of the oxidation state of the atmosphere (14). Ohmoto's argument is therefore not useful as a means of defining the evolution of the oxidation state of the atmosphere.

Conclusions

As Ohmoto (1) pointed out, it is definitely too early to declare that the D-K-O model is correct. At this time it is much more likely that the model is incorrect. The presence of easily oxidized detrital minerals in pre – 2.3 Ga conglomerate-sandstone successions, and the reduced nature of pre –2.3 Ga paleosols both point to a low–O2 ($<10^{-2}$ PAL) atmosphere prior to 2.3 Ga. The complete (or nearly complete) absence of redbeds older than 2.3 Ga is highly suggestive, as is the absence of excess uranium and vanadium in highly carbonaceous marine shales. The available evidence strongly supports the C-W-K-H model for the evolution of atmospheric oxygen.

Acknowledgments

The author wishes to thank Roger Buick, James Kasting, Lee Kump, Fred Mackenzie, Michael Mottl, and Kenneth Towe for their helpful reviews. Imperial College in London and the University of Hawaii at Manoa were generous hosts during the writing of this paper. Financial support was made available through NASA grants NAGW – 599 and NAGS – 4174 to Harvard University.

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Aug. 22-27, 1999: 9th V. M. Goldschmidt Conference, Cambridge, Massachusetts, USA. Contact: Stein Jacobsen, Dept. Earth & Planetary Sci., Harvard University, Cambridge, MA, 02138, USA; tel. 617-495-5233; fax 617-496-4387; e-mail: goldschmidt@eps.harvard.edu; website: http://cass.jsc.nasa.gov/meetings/gold99/

Aug. 22-27, 1999: 4th International Symposium on Subsurface Microbiology,Vail, Colorado. Abstract deadline and discounted registration deadline: March 1, 1999. Contact: American Society for Microbiology. Tel: + 1 202 -942-9248; E-mail: meetinginfo@asmusa.org; Web Site: http://www.asmusa.org/mtgsrc/issm'99.htm

Aug. 28-Sept. 1, 1999: Annual Meeting of the Austrian Mineralogical Society, together with the German Mineralogical Society and the Hungarian Geological Society, Geo-Zentrum of the University of Vienna, Althanstrasse 14, Vienna, Austria. Web site: http://www.univie.ac.at/Mineralogie/minwien.htm

Sept. 1-15, 1999: 5th National Romanian Symposium on Mineralogy, Geological Museum, Bucharest (Romania). Contact: Magda Ciulavu, Geological Institute of Romania, 78344 Str. Caransebes 1, Bucharest 32, Romania; Phone: +40 1 224 1530 or +40 1 224 1593; Fax: +40 1 224 0404; E-mail ciulavu@ns.igr.ro.

Sept. 4-10, 1999: EUROCLAY 1999 Conference of the European Clay Groups Association (EGCA), Institute of Geological Sciences, Polish Academy of Sciences, Kraków (Poland), 4-10 September 1999. Contact: Mrs. Aka Srodon, Euroclay 1999, Institute of Geological Sciences (PAN), Senecka 1, PL-31 002 Kraków, Poland, Fax +48 12 422 1609; E-mail: ndsrodon@cyf-kr.edu.pl. Web Site: http://www.ing-pan.krakow.pl/

Sept. 5-11, 1999: Processes and Consequences of Deep Subduction, Verbania, Lago Maggiore, Italy. Organised by Bayerisches Geoinstitut of Bayreuth University, Geophysical Laboratory of Washington, Institute for Study of the Earth's Interior of Misasa and ETH Zürich. Web Site: http://btgix5.bgi.uni-bayreuth.de/verbania/

Sept. 6-10, 1999: 19th International Meeting on Organic Geochemistry, Istanbul-Turkey, Contact: Conference Chairman: Prof. M. Namik Yalcin (TUBITAK Marmara, Research Center, Gebze-Kocaeli, 41470 Turkey); Conference Secretariat: Mr. Cengiz Soylu (TPAO Research Center, Mustafa Kemal. Mah. 2. cad. No. 86, Esentepe-Ankara, Turkey. Tel: +90 (312) 2843490; Fax: +90(312)2843491; E-mail: ogc99@petrol.tpao.gov.tr); Web Site: http:// www.nemrut.mam.gov.tr

Sept. 11-16, 1999: European Research Conference The Deep Earth: Theory, Experiment and Observation, Acquafredda di Maratea, Italy. Contacts: John Brodholt (UCL, London, UK), George Helffrich (U. Bristol, Bristol, UK). To receive first circular, register at URL: http://slamdunk.geol.ucl.ac.uk/~brodholt/euroconference.html See http://www.edinet-gdp.com/villadelmare/vdm.htm for hotel information.

Sept. 12-15, 1999: Third International Workshop on Orogenic Lherzolites and Mantle Processes, Pavia, Italy. Web Site: http://www_crystal.unipv.it/LherzoliteWorkshop.html

Sept. 13-15, 1999: Symposium devoted to the 100th anniversary of Prof. D.S. Korzhinski: Physico-chemical aspects of endogenic geological processes, Moscow, Russia. Contact: Dr.V.L.Rusinov, Institute of Geology,Petrography,Mineralogy and Geochemistry(IGEM), Russ.Acad.Sci., Staromonetnyi, 35 Moscow, 109017,Russia; Fax: 007-095-2302179; Tel: 007-095-2308479; e-mail: rusinov@igem.msk.su

Sept. 19-22, 1999: NAMS: North Atlantic Minerals Symposium, TrinityCollege, Dublin, Ireland. Web Site: http://www.gov.nf.ca/nams/

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Sept. 21-25, 1999: 3rd International Symposium on Applied Isotope Geochemistry (AIG-3), Orléans, France. Abstract and registration deadline, April 30, 1999. Contacts: Jean-Pierre Girard, Phone: 33 (0)2 38 64 32 15, Fax: 33 (0)2 38 64 39 25; Marie-Odile Gérault, Phone: 33 (0)2 3864 3707; Fax: 33 (0)2 3864 3990, BRGM, 3, avenue Claude Guillemin, BP 6009, F-45060 Orléans Cedex 02, France, E-mail: aig3@brgm.fr.

Sept. 26- 30, 1999: The Society for Organic Petrology (TSOP), 16th Annual Meeting, Salt Lake City (Snowbird Resort), Utah, USA.; Information: Jeff Quick, Utah Geological Survey, 1594 West North Temple, Suite 3110, Salt Lake City, Utah 84114-6100 USA. Phone 801-537 3372; fax: 801-537-3400, e-mail: nrugs.jquick@state.ut.us; http://www.tsop.org

Sept. 26 - Oct. 1, 1999: XIVth International Symposium on Environmental Biogeochemistry (ISEB). Earth System Interfacial Processes from Molecular toGlobal Scale. Huntsville, Ontario, Canada. Contact: Prof. Grant Ferris, Dept. of Geology, Univ. of Toronto, 22 Russell Street, Toronto, ON, M5S 3B1,Canada; E-mail: ferris@quartz.geology.utoronto.ca; http://opal.geology.utoronto.ca/ISEB_XIV/

Sept. 26 - Oct. 1, 1999: Migration '99: Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere, Incline Village, Lake Tahoe, CA USA; Contact: Migration '99, Dr. Cynthia Palmer, Lawrence Livermore National Laboratory, P.O. Box 808, L-231, Livermore, CA 94551-9989, USA; Phone: +1-925-422-5693; FAX: +1-925-422-2105; e-mail: palmer2@llnl.gov; WWW: http://www.aer.wsu.edu/migration/migration.html

Oct. 3-6, 1999: Workshop on Alkenone-Based Paleoceanographic Indicators, Woods Hole, MA, USA. Contact: Ms. Virginia (Gini) McKinnon, Dept. of MarineChemistry and Geochemistry, WHOI, MS #4, Woods Hole, MA 02543-2164, USA.; Tel: +1-508-289-2394; Fax: +1-508-457-2164; E-mail: vmckinnon@whoi.edu

Oct. 4 - 6, 1999: 22nd Annual Meeting of the German Working Group of Stable Isotopes (ASI), Gottingen, Germany; Contact: Dr. A. Reineking and R. Langel, Isotopenlaboratorium für biol. u. med. Forschung, Georg-August-University of Göttingen, Burckhardtweg 2, D-37077 Göttingen, Germany; e-mail: areinek@gwdg.de or rlangel@gwdg.de; Tel.: 0049-551-398113 or 398104; Fax: 0049-551-398110

Oct. 11-14, 1999: Carpathian Geology 2000, Smolenice Castle near Bratislava (Slovak Republic),An international geological conference held on the occasion of the 45th anniversary of the Geological Institute of the Slovak Academy of Sciences, and of the 50th anniversary of the international geological journal Geologica Carpathica. Contact: RNDr. Igor Broska, Csc., Geological Institute of the Slovak Academy of Sciences, Dúbravská cesta 9, 842 26, Bratislava, Slovak Republic; Phone: +42 17 373 961; Fax +42 17 377 097; E-mail: geolbros@savba.savba.sk

Oct. 14-15, 1999: Fluid-Mineral Interactions in the Crust, Ecole Normale Supérieure, Paris (France), 14-15 October 1999. Workshop, organised by the SFMC and the ENS in honour of Martine Lagache.

Oct. 25-28, 1999: GSA Annual Meeting, Denver, CO, USA, Contact: Becky Martin, GSA Meetings Department, Box 9140, Boulder, CO 80301-9140 USA. Tel: +1-303-447-2020, ext. 164; Fax: +1-303-447-1133

Nov. 7-9, 1999: First Latin American Workshop on Reservoir and Production Geochemistry, La Habana, Cuba. Sponsor: The Latin American Association of Organic Geochemistry (ALAGO). Abstract deadline: April 30,1999 Contact: Dr. Jose Orlando Lopez Quintero, Centro de Investigaciones del Petroleo, Washington 169, Cerro - CP 12000 La Habana, Cuba. Tel: +53-7-577309; Fax: +53-7-666021; E-mail: ceinpet@ceniai.inf.cu

Dec. 13-17, 1999: AGU Fall Meeting, San Francisco, Calif., U.S.A. Sponsor: AGU. Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA. Tel: +1-202-462-6900; Fax: +1-202-328-0566; E-mail: meetinginfo@kosmos.agu.org; Web Site: http://www.agu.org

March 26-31, 2000: Organic Solids in Petroleum Production, ACS Spring Meeting, Geochemistry Divisision Symposium, San Francisco, CA, USA. Contact: Dr. B.Artur Stankiewicz, Shell E&P Tech Co., 3737 Bellaire Blvd., Houston, TX 77025, USA; E-mail: artur@shellus.com. Dr. Erik Tegelaar, Baseline Resolution, Inc., 2000 Avenue G, Suite 810, Plano, TX 75074, USA; E-mail: ETegelaar@brilabs.com. Web Site: http://www.acs.org/meetings/future/newsanfran.htm.

March 26-31, 2000: The Integration of Organic Geochemistry and PVT Studies in Petroleum Exploration and Production, ACS Spring Meeting, GeochemistryDivision Symposium, San Francisco, CA, USA. Contact: Dr. Gordon Macleod, Shell E&P Tech Co., 3737 Bellaire Blvd., Houston, TX 77025, USA; E-mail: gmac@shellus.com. Dr. Peter Meulbroek, Woods Hole Oceanographic Institute, 360 Woods Hole Rd, MS#4, Woods Hole, MA 02543, USA; E-mail: pmeulbroek@whoi.edu . website: http://www.acs.org/meetings/future/newsanfran.htm

April 16-19, 2000: Eighth International Symposium on Experimental Mineralogy, Petrology and Geochemistry (EMPG VIII), Bergamo, Italy; Web Site: http://imiucca.csi.unimi.it/~spoli/empg.html

April 24 -29, 2000: 5th International Symposium on Environmental Geochemistry, University of Cape Town, South Africa. Pre- and post-conference technical tours available. Abstract deadline 30th September 1999. Registration and other details on the web site: http://www.uct.ac.za/depts/geolsci/menviro/main.html

May 7-11, 2000: Salt Symposium, The Netherlands Congress Centre, The Hague,The Netherlands. Contact: Secretariat Organizing Committee 8th World Salt Symposium, P.O. Box 25, NL-7550 GC Hengelo (Overijssel), The Netherlands; Phone: +31 74 244 3908; Fax: +31 74 244 272; E-mail:Salt.2000@inter.NL.net. Web Site: http://www.salt2000.nl/

May 8-11, 2000: 2nd International Conference on Applications of Stable Isotope Techniques to Ecological Studies, Braunschweig, Germany. Dr. Anette Giesemann, Institute of Agroecology, Federal Agricultural Research Centre, Bundesallee 50, D-38116 Braunschweig Tel.:++49 531/596-217; FAX: ++49 531/596-366; e-mail: anette.giesemann@fal.de; http://www.pe.shuttle.de/slater/anette

May 15-20, 2000: 2nd EMU School and Symposium on Environmental Mineralogy, Eötvös University, Budapest, Hungary. Contact: EMU Secretariat, Department of Mineralogy, Eötvös University Múzeum krt. 4/A, H-1088 Budapest, Hungary: Fax: +36 1 266 4992; E-mail: emu@ulixes.geobio.elte.hu. Web Site: http://ulixes.geobio.elte.hu/emu.htm

May 30-June 3, 2000: AGU Spring Meeting, Washington, D.C., U.S.A. Sponsor: AGU. Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA. Tel: +1-202-462-6900; Fax: +1-202-328-0566; E-mail: meetings@kosmos.agu.org; Web Site: http://www.agu.org/meetings

June 21-24, June 2000: GREEN3, 3rd International Symposium on Geotechnics Related to the European Environment, Federal Inst. for Materials Research and Testing (BAM), Berlin, Germany; Contact: Dr. Paul H. McMahon, Civil and Environmental Engineering Subject Group, Faculty of Technology, Bolton Institute, Deane Road, Bolton BL3 5AB; E-mail: pm4@bolton.ac.uk; Web Sites: http://www.acs.bolton.ac.uk/~pm4 and http://www.technology.bolton.ac.uk/civils/

July 9-12, 2000: Catastrophic Events and Mass Extinctions: Impacts and Beyond, Institute of Geochemistry, University of Vienna, Austria. Co-sponsored by the Lunar and Planetary Institute, ESF-IMPACT Programme, Austrian Federal Ministry of Science and Transport, Geological Survey of Austria, Vienna Convention Bureau, City of Vienna. Web Site: http://cass.jsc.nasa.gov/meetings/impact2000/

July 11-12, 2000: 1st International Professional Geology Conference,Universidad de Alicante, Spain. Web Site: http://www.ua.es/sri/1IPGC.htm

July 12-14, 2000: ACCURACY 2000 - 4th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences, Amsterdam, The Netherlands. Email: accuracy@frw.uva.nl; http://www.gis.wau.nl/Accuracy2000

July 16-22, 2000: ICAM 2000: 6th International Congress on Applied Mineralogy, Gottingen & Hannover, Germany. Sponsors: International Council for Applied Mineralogy, German Mineralogical Society, Commission for Applied Mineralogy, others. Abstract Deadline: September 1, 1999. Contact: ICAM 2000 Office, P.O. Box 510153, D-30631 Hannover, GERMANY. Tel: +49-511-643-2298; Fax: +49-511-643-3685; E-mail: ICAM2000@bgr.de; Web Site: http://www.bgr.de/ICAM2000

July 18-22, 2000: International Association of Volcanology and Chemistry of the Earth (IAVCEI) General Assembly 2000, Bandung, INDONESIA. Abstract Deadline: February 29, 2000. Sponsor: IAVCEI. Contact: Secretariat, Volcanological Survey of Indonesia, Jalan Diponegoro 57, Bandung 40122, INDONESIA. Tel: +1-62-22-772606; Fax: +1-62-22-702761; E-mail: iavcei@vsi.dpe.go.id; Web Site: http://www.vsi.dpe.go.id/iavcei.html

Aug. 6-17, 2000: 31st International Geological Congress, Rio de Janeiro, BRAZIL. Sponsors: International Union of Geological Sciences (IUGS), Brazilian Geological Society, The Brazilian Ministry of Mines and Energy, others. Abstract Deadline: September 1, 1999. Contact: Secretariat Bureau, 31st International Geological Congress. Av. Pasteur, 404, Anexo 31 IGC, Urca, Rio de Janeiro, RJ, CEP 22.290-240, Brazil. Tel: +1 55 21 295 5847; Fax: +1 55 21 295 8094; E-mail: 31igc@31igc.org.br

Sept. 3-8, 2000: Goldschmidt 2000, Oxford, UK. Sponsors: Geochemical Society, European Association for Geochemistry, The University of Oxford. Contact: P. Beattie, Cambridge Publications, Publications House, PO Box 27, Cambridge UK CB1 4GL. Tel: +44 -1223 -333438; Fax: +44- 1223-333438; E-mail: Gold2000@campublic.co.uk; Web Site: www.campublic.co.uk/science/conference/Gold2000/

Nov. 13-16, 2000: GSA Annual Meeting, Reno, NV USA. Contact: GSA Meetings, Box 9140, Boulder, Colo. 80301-9140. Tel: +1-303-447-2020, ext. 164; Fax: +1-303-447-1133; Web Site: http://www.geosociety.org/meetings/index.htm

Dec. 15-19, 2000: AGU Fall Meeting, San Francisco, Calif., U.S.A. Sponsor: AGU. Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 USA. Tel: +1-202-462-6900; Fax: +1-202-328-0566; E-mail: meetins@kosmos.agu.org; Web Site: http:/www.agu.org/meetings

June 10-15, 2001: 10th Water-Rock Interaction Symposium, Tanka Village Congress Centre, Villasimius, Sardinia, Italy. Organized by the University of Cagliari in cooperation with the Working Group on Water-Rock Interaction of the International Association of Geochemistry and Cosmochemistry. Contact: WRI-10 Scientific Committee Secretariat (Prof. L. Fanfani, secretary general), Department of Earth Sciences, University of Cagliari, Via Trentino 51, I-09127 Cagliari, Italy; Phone.: +39 070 6757724; Fax: +39 070 282236; E-mail: wri10@unica.it. Web Site: http://www.unica.it/wri10/

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