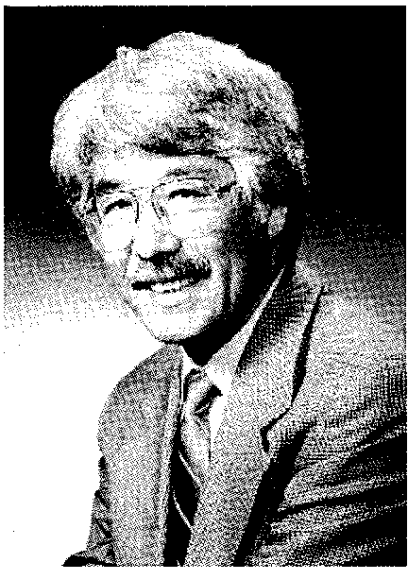
THE GEOCHEMICAL NEWS

Newsletter of The Geochemical Society

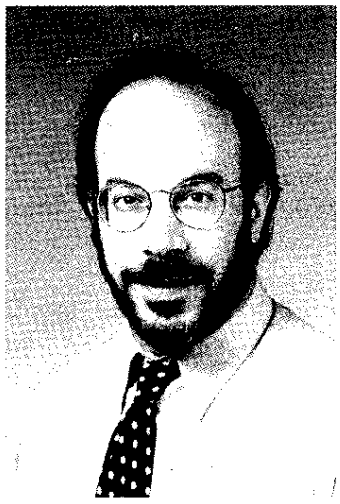
NUMBER 93 **FALL 1997**

In this issue:



Hiroshi Ohmoto Discusses the Evolution of Oxygen in Earth's Atmosphere (page 12)

New Editor's Statement:



It is with honor, excitement, and anxiety that I accept the responsibility of editing *The Geochemical News*. This newsletter in Dave Wesolowski's hands has made significant progress in both quality and quantity during the past two years. I intend to continue this tradition of excellence into the new millenium, with the initiation of some noteworthy new features. The publication rate will increase from biannual to quarterly. In addition to the usual Society-related content, there will be more input from Society members, such as letters to the editor, feature articles, timely news notes, and other miscellaneous information of interest to geochemists. Contributions from any and all Society members will be gladly received, especially from those of you who reside outside of North America. Please feel free to contact me with any suggestions for *The Geochemical News*. This newsletter belongs to all of us; it should reflect more of the vitality of modern geochemistry and its important role in today's world.

Neil C. Sturchio, Environmental Research, ER-203, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439 U.S.A.; Telephone: (630) 252-3986

EDITOR'S NOTE: Neil is Geochemical Processes Group Leader at Argonne, where he has worked since earning his Ph.D. in Earth and Planetary Sciences from Washington University in 1983.

Check out the Society's Brand New Web Site!

http://www.geochemsoc.org

Great Things are Coming (page 19)!

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**, this **Newsletter**, and (jointly with the Meteoritical Society) the journal ***Geochimica et Cosmochimica Acta***; 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 Conferences**, 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 spring meeting of the American Geophysical Union. 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**. 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

The mark of truly great persons is that they do not make lesser individuals feel inferior, but rather enlightened. This can be said of Alex Halliday, whom it has been my great pleasure and honor to serve with over the past two years. The Society owes him a huge debt of gratitude for his creative, energetic and effective leadership as Vice President and then President of the Society.

Lori Warneke and I are delighted that Neil Sturchio has agreed to take over the production of *The Geochemical News*, and to increase its frequency, quality, and interest level. I am looking forward to being able to devote more time to my Secretarial duties, with Lori's continuing help. With all the changes that are coming for GS members (see Alex's letter in this issue) these are exciting times to be involved in this great organization. Thanks to all of you who have sent us materials for the newsletter. Please help Neil to make it a truly useful, informative, and interesting publication.

Dave Wesolowski, Editor
Lori Warneke, Admin. Assist.
Oak Ridge National Laboratory
P.O. Box 2008, MS 6110
Oak Ridge, TN 37831-6110 USA

Phone: 1-423-574-6903
Fax: 1-423-574-4961
Email: dqw@ornl.gov

Geochemical Society Homepage address on the WWW:

http://www.geochemsoc.org/

Letter from the President, Alex Halliday

Dear colleagues,

Well it really is all happening in the Geochemical Society these days. At the Board of Directors Meeting in Tucson a number of important new initiatives were given final approval and are now being enacted. Here is a brief listing of all the things you need to look out for:

1) Werner Stumm (Zürich) will be the 1998 winner of the Goldschmidt Medal, to be bestowed at the Toulouse Goldschmidt Conference, for his fundamental studies in aqueous, surface and environmental geochemistry. (The Clarke Award has not yet been decided).

2) The first Patterson Medal in Environmental Geochemistry, named after the late Clair C. Patterson, will be given at the Goldschmidt Conference in Toulouse next year. Nominations are due May 1st. (See page 15.)

3) We have a new position of Internet Coordinator and Web Site Manager. Mark Bloom will be spearheading efforts to take the Society to new heights of Web outreach and member services, in collaboration with the Mineralogical Society of America (See page 19). Steve Shirey deserves our thanks and a well-earned rest after creating and managing the website over the past two years, following his 6-year term as Secretary.

4) The Business Office is coming under the same organizational structure as the production office of Geochimica et Cosmochimica Acta in Columbus. Lee Mobley has appointed a new Business Manager, Sue Viers. We are very grateful to TinaGayle Osborn for her years of hard work and wish her well in Florida

5) This newsletter will be taken over by a new editor, Neil Sturchio as from the end of this year and we will step up production to four issues per year. Next time you see Dave Wesolowski, thank him for turning the newsletter into something to really read.

6) There will be a major Geochemical Society conference co-sponsored by LPI on The Origin of the Earth and Moon at the end of 1998. (See page 8.)

7) Several changes are taking place in the officers and directors of the Society. Here are the major ones. On January 1, 1998, Mike Drake takes over as President, Michael Hochella becomes Vice President and Ross Taylor will be the new International Secretary, replacing Chris Hawkesworth. Al Hofmann, Mike Lewan, Keith O'Nions, Everett Shock, and Ed Stolper will join the Board of Directors. Everett will be filling the last year of Mike Hochella's Director term, and Al Hofmann will be replacing Karl Turekian on the Board for the remaining two years of his term. The latter change was Karl's idea, since he felt that the GCA Editor should be a servant of the GS Board and Meteoritical Society Council, rather than a voting member of either body. Frank Podosek has agreed to stay on as Chair of the Joint Publications Committee (JPC). The new members of this committee are Everett Shock, Gary Sposito and Grenville Turner. Roberta Rudnick is now in charge of the Nominations Committee. John Hayes has taken over the Fellows Selection Committee. Vala Ragnasdottir and John Jones are the new chairs of the Goldschmidt and Clarke Medal Committees repectively. Finally Bill McDonough is now running the Program Committee.

8) We have decided to offer back issues of our Special Publications Series at a greatly reduced rate to both members and non-members. (See page 30.)

9) In order to promote the involvement of young scientists in the Society, we will heavily subsidize the cost of their membership, and particularly subscription to GCA. The 1998 rates for students will be $5 for membership, and $45 for subscription to the journal. Professionals will pay $25 for membership, and $125 for subscription. (See page 31.) We consider these subscription charges to be very modest for such a high quality, twice-monthly scientific journal. This eliminates the former two tier member-only and member-subscriber dues structure. Benefits of membership in the Society include receipt of this newsletter, reduced registration fees at the spring AGU and GSA annual meetings, and exclusive access to several features now being developed on our new web site, in addition to reduced rates for GS Special Publications and subscription to GCA. Please urge your colleagues and any students to join up!

Over the past 6 months there has been considerable concern expressed about the new shape that Geochimica et Cosmochimica Acta (GCA) is taking. I have received letters from several individuals; one major group has collectively voiced its concern. I want to thank you all for taking the time to express your views. They are being listened to and acted upon. However, GCA does need to change and Karl Turekian was selected as Editor because his scientific breadth and editorial experience were considered essential for this task. Certain sections of the community have become increasingly concerned that the journal is losing impact, quality and interest. We are trying to reverse this damaging trend, now visible in the official "Impact Factors", but it will take a while and it is difficult to accomplish this without declining certain kinds of papers that at one stage may have been published. Karl is surrounding himself with good advisors and the JPC is working with him to try and ensure that the scope of the journal is appropriate. To improve GCA it needs to once again become a journal which is characterized by the very best, most fundamental and interesting papers in geochemistry and cosmochemistry. In some fields this is already the case, in others the papers have to be "attracted in". In pretty much all fields there is probably room for pruning so that the journal does not appear diluted with papers that are considered unimportant or irrelevant. I would urge you to continue communicating with Frank Podosek and with the Karl.

(continued on page 4)

Most important of all, please encourage your colleagues to submit their best geochemistry papers to GCA.

This is my final newsletter as President and probably I should say something about the future of geochemistry. However, most of that is obvious. I feel more inclined to depart with some thoughts about the future of the Society. The Geochemical Society has a phenomenal organizational infrastructure, a great journal, and the most presitigious awards in geochemistry. It offers research and soon, Web-based educational opportunities to you, if you want to take advantage of them. There are many devout members whose enthusiasm and willingness to take on hard work are simply terrific. However, I think the Society is still somewhat under utilized. Nobody wants to turn the Society into an unwieldy bureaucracy but we could expand our influence considerably, and achieve more scientifically, by interfacing to a greater extent with the immediate and vital research concerns of the members and any others whom we wish to involve more in our activities. The Society could easily organize local workshops, review volumes and maybe even form specialized groups, like the highly successful Organic Geochemistry Divsion, if any individuals want to take the initiative.

When I took over the job I was advised that the biggest concern I would have would be handling the contract with Elsevier for GCA. I am happy to say that working with Elsevier has not been a problem at all and I am particularly grateful to Frank Podosek of the JPC, and to Peter Henn and Charles Pallandt of Elsevier for ensuring that the cogs remain well oiled. I have enjoyed excellent cooperation with the European Association for Geochemistry and it has been a pleasure seeing so many joint initiatives come to fruition. Claude Allègre and Chris Hawkesworth have been great collaborators. This has been an unusually busy two years and I would like to acknowledge how much effort the Board of Directors and Committee Members have put into running the Society well. In particular, I very much doubt that there has been another period in the entire history of the Society when the Board has had to work as hard as they have over the past two years. Having a good, responsive and wise team has been essential. There are many to thank, but I have to mention two by name. Dave Wesolowski has been a truly brilliant Secretary, and the Society has no concerns and plenty to feel excited about with Mike Drake taking over as President, accompanied by a most impressive team of Officers, Directors and Committee Members. See you in Toulouse next year!

With best wishes

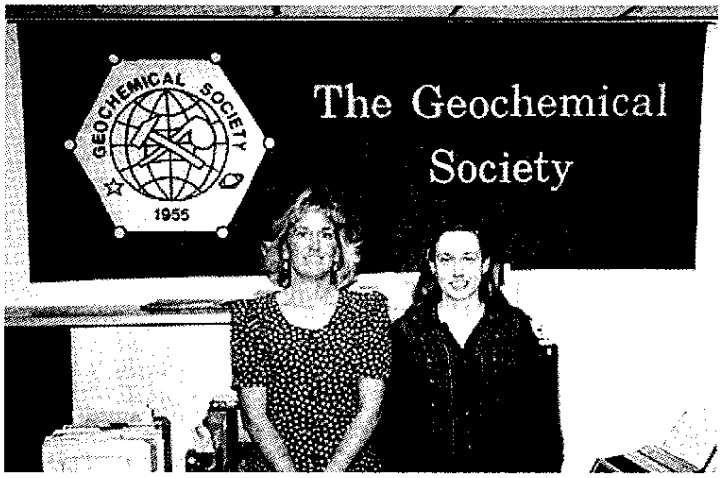
Alex N. Halliday

Notes from the Business Manager

I would like to take this opportunity to introduce myself to the members of the Geochemical Society. My name is Sue Viers (left) and I will be the Business Manager for the society. Prior to this position I handled the patient files and accounts receivable for a busy dental office.

TinaGayle Osborn (right) finished her masters degree in Geology and has relocated to Florida. She hopes to continue teaching an earth science class at a local junior college. I am looking forward to working for the society. If I can be of help in any membership or subscription matters, please feel free to contact me.

Sue Viers
1350 West Fifth Avenue, Suite 219
Columbus, OH 43210 USA
phone: 614-487-8290 fax: 614-486-7065
email: geochsoc@pubcon.com



Renewals Renewal invoices for 1998 were mailed on September 12, 1997. The deadline for making payment or payment arrangements is January 5, 1998. You will notice the new membership number on the renewal invoice. This number is unique for each member and will be used in connection with the new Geochemical Society web site.

Please note that the 1998 renewal costs are, regular membership dues $25 and membership plus subscription to GCA $150; student membership dues $5 and membership plus subscription to GCA $50. Some recipients of the 1998 renewal notice were confused. Membership in the Society is required in order to obtain our special individual GCA subscription rates.

Back issues of GCA If you are having problems with delivery of *GCA*, please contact me immediately.

Claude Allègre Appointed Minister of Education, Research and Technology

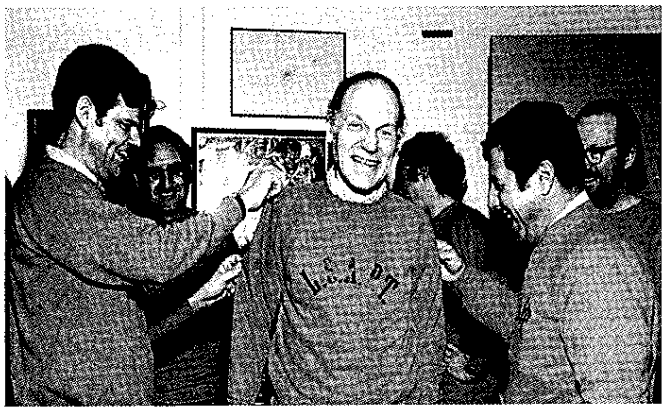
Claude Allègre was appointed French Minister of Education, Research, and Technology by Lionel Jospin, the new socialist prime minister in June. This appointment did not come as a surprise to the French scientific community; in addition to being perhaps the best known Earth Scientist in Europe, Claude Allègre has been known for many years to be an ardent defender of higher education and top quality research. He is well known to the French public; he has been regularly interviewed by the French press and even featured in a public television science series ('Claude Allègre, Géophysicien'). As Minister of Education, Research, and Technology, Allègre will oversee all education from kindergarten to the prestigious Collège de France, including the 'Grandes Ecoles', as well as renowned research agencies such as the CNRS (national center for scientific research) and INSERM (the biomedical research agency).

Few in the geologic community are unfamiliar with his scientific research and accomplishments. He is most closely associated with the field of chemical geodynamics, which he defined as the application of chemical observations in the framework of geodynamics; it is thus the blending of geochemistry and geophysics. For his contributions to this field he was awarded the 1986 V. M. Goldschmidt Award by the Geochemical Society and subsequently, he was awarded the Crafoord prize by the Swedish Royal Academy and the Gold Medal of the CNRS. There are many who personally credit him with the spectacular growth of the French Earth Sciences over the past twenty years.

Claude Allègre has extensive experience in organizing research and participating in the management of French education, having served in numerous academic and administrative posts over the past twenty years. He headed the Institut de Physique du Globe in Paris from 1976 to 1986, and the French Geological Survey (Bureau de Recherches Géologiques et Minières, BRGM) from 1992 to 1997. He was special advisor to Lionel Jospin, then Minister of Education, during the previous socialist government from 1988 to 1993. He also served as a member of the European Parliament from 1989-1994 and as a regional councilor of the French Languedoc-Roussillon region since 1992.

The French press regularly cite Allègre for his progressive new ideas to rejuvenate research and education in France. During his tenure as special advisor to the Education Minister, he launched an ambitious program to expand the French Universities and to give them more autonomy, especially in terms of selecting faculty and students, and in managing their own budgets. This program, which was brought to a halt during the reign of the conservative government of 1993-97 will now be restarted and accelerated. One facet of this program in the near term is the creation of additional posts for young scientists in the Universities and with the CNRS. He wishes to adopt an American-style tenure track system for these posts by changing the current system which virtually guarantees life employment to university faculty and CNRS researchers from the day they are first appointed. He is also addressing the until now unresolved problem of education in the 'banlieues' (impoverished suburbs) by the creation of new educational centers. Over the long term, he hopes to completely rethink the educational system, including for example, bridging the gap between the French Universities and the Grandes Ecoles, which have been traditionally reserved for producing the elite; or changing the long-standing emphasis on using mathematical ability as the primary criteria for student selection in higher education science programs.

Last year, however, in an interview with La Recherche, Allègre said he was extremely doubtful that any government minister would be able to significantly reform the French research and education system. Many in France believe that this may be the first time any of his predictions turn out to be wrong.

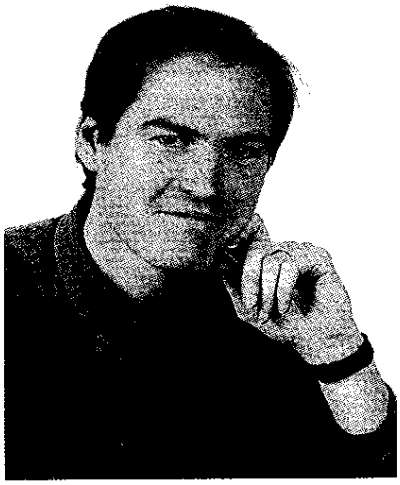


The Geochemical Society honors the memory of its first Goldschmidt Medalist, Paul Werner Gast, with the Gast Lecture series, which will be held each year at the Goldschmidt Conference. Gast is shown wearing the official uniform of NASA's Lunar Sample Analysis Planning Team. At the time of his death in 1973, at just 43 years of age, Gast was professor of geology at Columbia University and chief of the Division of Planetary and Earth Sciences at NASA's Johnson Space Center.

A Brief Extract from the Inaugural Gast Lecture by Edouard Bard, delivered at the 7th V. M. Goldschmidt Conference, June 2, 1997, Tucson, Arizona, USA

Geochemical and geophysical implications of the radiocarbon calibration

Edouard Bard, CEREGE, Université Aix-Marseille III and CNRS, Europole de l'Arbois, 13545 Aix-en Provence cdx4, also at Institut Universitaire de France, e-mail: bard@cerege.fr



The radiocarbon dating method, for which Willard Libby obtained the Nobel Prize in Chemistry in 1960, relies on the beta decay of ^{14}C atoms originally produced in the upper atmosphere by cosmic-rays. This widely used method can be applied to date samples up to 45,000 yr old, but it requires that the initial $^{14}C/^{12}C$ ratio of the sample is known in order to calculate an accurate calendar age. Most samples to be dated by ^{14}C have extracted their carbon directly from the atmosphere (*e.g.* plant remains) or indirectly through the food chain (*e.g.* animal remains). The problem is thus to evaluate the past variations of the atmospheric $^{14}C/^{12}C$ ratio which is very sensitive to previous production changes and, to a lesser degree, to rearrangements within the global carbon cycle.

Past fluctuations of the atmospheric $^{14}C/^{12}C$ ratio are reconstructed by comparing ^{14}C measurements with true ages measured in the same samples by an independent dating technique. The ^{14}C calibration curve is based on tree rings for the Holocene period ($\cup$ the last 10,000 yr; Stuiver, Braziunas, Becker, Kromer, *Quat. Res.* **35**, 1, 1991) and corals which can be cross-dated by high precision ^{14}C and $^{230}Th/^{234}U$ dating using mass spectrometric techniques (Bard, Hamelin, Fairbanks, Zindler. *Nature* **345**, 405, 1990).

The use of corals has been boosted by the development of mass spectrometric techniques which enable to date much smaller samples and to achieve better precisions than traditional techniques of radioactivity counting (beta for ^{14}C and alpha for $^{230}Th/^{234}U$). Accelerator mass spectrometry was developed in the 1970s to determine $^{14}C/^{12}C$ ratios in natural samples ranging between 10^{-12} and 10^{-15} (Nelson, Korteling, Stott. *Science* **198**, 507, 1977; Bennett et al. *Science* **198**, 508, 1977). This revolutionary technique is used to date milligram-size samples allowing thorough screening and cleaning of corals. The same philosophy, counting atoms instead of waiting for them to decay, was applied in the 1980s for the development of $^{230}Th/^{234}U$ dating by thermal ionization mass spectrometry (Edwards, Chen, Wasserburg. *Earth Planet. Sci. Lett.* **81**, 175, 1987). Modern mass spectrometers equipped with ion-counting detectors allow to obtain 2σ errors between 20 to 60 years for ages ranging from 8000 to 14,000 yr BP (Edwards et al., *Science* **260**, 962, 1993; Bard et al., *Nature* 382, 241, 1996) (BP stands for before present and present is year 1950).

Altogether, the different calibration methods led to the reconstruction of significant variations of the atmospheric $^{14}C/^{12}C$ ratio through time expressed as a normalized ratio to the present day value or in term of $\Delta^{14}C$ in ‰. Such data are shown in Figure 1 where the black and thin wiggly line is based on the tree ring calibration (Stuiver & Reimers. *Radiocarbon* 35, 215, 1993) and dots with 2σ error bars stand for corals from Barbados, Mururoa and Tahiti (Bard, Arnold, Fairbanks, Hamelin, *Radiocarbon* **35**, 191, 1993; Bard et al. 1996). This record indicates clearly that the atmospheric $\Delta^{14}C$ was about 400-500 ‰ higher at about 20,000-30,000 yr BP and that it has essentially decreased during the period between 18,000 and 3000 yr BP.

Besides its fundamental use for radiocarbon dating, the atmospheric $^{14}C/^{12}C$ curve provides numerous informations on a variety of geophysical, geochemical and even astronomical phenomena. It has been shown that changes of the atmospheric

$^{14}C/^{12}C$ result mainly from the modulation of the cosmic rays by magnetic fields in the vicinity of the Earth (Lal & Peters, *in* Encyclopedia of Physics **46/2**, 551, 1967). For example, the high frequency excursions observed during the Holocene are probably due to century-scale fluctuations of the solar magnetic activity similar to the so-called Maunder Minimum period of the late 17th century, during which sunspots were almost absent (Stuiver, *J. Geophys. Res.* **66**, 273, 1961; Eddy. *Science* **192**, 1189, 1976; Stuiver & Quay, *Science* **207**, 11, 1980).

A way of checking the solar origin of observed $^{14}C/^{12}C$ variations is to compare these fluctuations with an independent record based on other cosmogenic radionuclides such as ^{10}Be measured in polar ice (Raisbeck et al. *Nature*, **292**, 825, 1981). However, ^{14}C and ^{10}Be time series cannot be compared directly since the fates of these two cosmonuclide are very different after production in the atmosphere. Atmospheric $^{14}C/^{12}C$ follows the average global production but short-term variations are seriously damped by the carbon cycle which requires the use of a mathematical model to quantify this inherent bias (Craig. *Tellus* **1**, 1 1956).

The relative fluctuations of the ^{10}Be concentrations record measured in South Pole ice were recently used as an input to a 12-box numerical model to convert it into a synthetic ^{14}C record (Bard, Raisbeck, Yiou, Jouzel. *Earth Planet. Sci. Lett.* **150**, 453-462, 1997). In Figure 2, the modeled curve (thick grey line) is compared with the decadal ^{14}C data measured in tree rings (dots with 2σ error bars). It is easy to identify periods of maximal $^{14}C/^{12}C$ which correspond to solar activity minima centered at about 120 yr BP (Dalton), 260 yr BP (Maunder), 450 yr BP (Spörer), 630 yr BP (Wolf), 890 and 1040 yr BP. This study confirms the dominance of the solar modulation on the cosmonuclide production variations during the last millenium.

A similar exercise can be performed to evaluate the cause of the long term 400 ‰ decrease of the atmospheric $\Delta^{14}C$. It is possible to use a global ^{10}Be flux curve compiled recently from marine sediments spread at different latitudes (Frank et al. *Earth Planet. Sci. Lett.* **149**, 121, 1997). For the comparison with $\Delta^{14}C$ data based on corals and tree rings, it is again necessary to take into account the secondary effect of ^{14}C mixing within the global carbon cycle which slightly smoothes fast changes and introduces a delay and a memory effect in the system. The resulting thick grey line in Figure 1 clearly shows that a significant part of the 400 ‰ decrease can be accounted for by a long term decrease of the production of cosmonuclides.

By contrast with the high frequency variability solar modulation, it becomes now clear that geomagnetism variations are responsible for the long term decrease of the cosmogenic isotopes production. Indeed, paleomagneticians have been able independently to reconstruct past variations of the geodynamo strength by studying volcanic rocks, lacustrine and marine sediments. As compiled recently (Guyodo & Valet. *Earth Planet. Sci. Lett.* **143**, 23, 1996) the record is mainly characterized by a twofold increase of the geomagnetic field during the period between 30,000 and 5000 yr BP.

This record can be used to make theoretical predictions of the cosmonuclides production through time which must have been

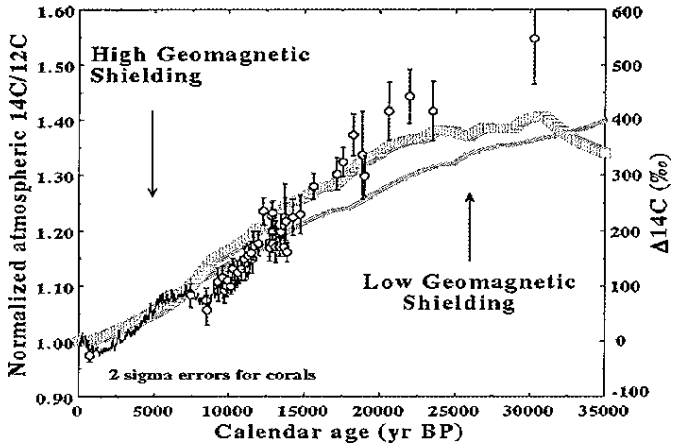


Figure 1

significantly enhanced during periods of weak magnetic shielding. This record shown by the thin grey line on Figure 1, is in good agreement with the theoretical predictions based on the global ^{10}Be flux (thick grey curve) which reinforces the conclusion that the long term decrease of the atmospheric $^{14}C/^{12}C$ ratio is due to an increase of the geomagnetic field.

Between 20,000 and 30,000 yr BP it seems that the atmospheric $^{14}C/^{12}C$ based on measurements in corals (individual dots) are slightly higher than the models based on the paleomagnetic and ^{10}Be records (thin and thick grey curves). However, these modeled curves are not yet precise enough to check that the difference is real: the precision for the thin and thick grey lines on Figure 1 is on the order of ± 100-150 ‰. Furthermore, this period corresponds to the last glacial maximum and major changes in the rate of exchange and reservoir sizes within the carbon cycle probably increased the atmospheric $^{14}C/^{12}C$ (Broecker et al. *Global Biogeochem. Cycles* **4**, 103, 1990).

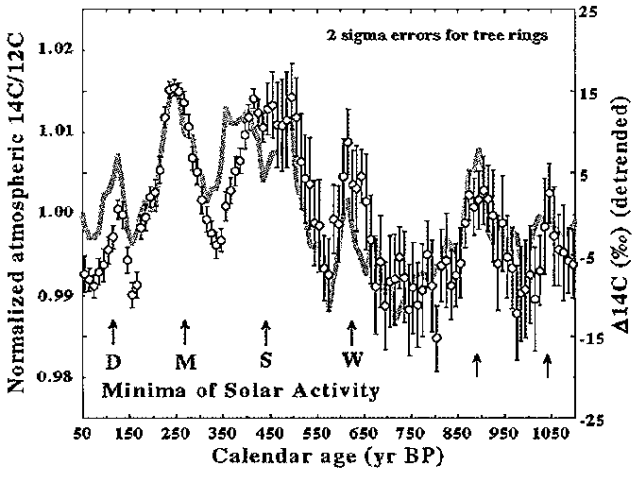


Figure 2

ANNOUNCING A TOPICAL CONFERENCE

The Origin of the Earth and Moon

December 1–3, 1998 Monterey, California

http://cass.jsc.nasa.gov/meetings/origin98/

SPONSORS

Geochemical Society
Lunar and Planetary Institute
National Aeronautics and Space Administration

The 1988 conference *The Origin of the Earth* was an excellent meeting that produced a classic, frequently cited text on the subject. The 1984 conference *The Origin of the Moon* was arguably the most successful conference ever held in planetary geology, bringing together the key players who then and there formulated, debated, refined, and established the giant impact theory of lunar origin. In recent years there have been major advances in these areas, particularly in the fields of geochemistry and petrology. It has become very apparent that a meeting that focuses on the origin of the Earth and Moon, as coupled problems, would be invaluable. For example, discussions about the development of the Earth's atmosphere or hypotheses concerning magma oceans and core formation are esoteric unless constraints on the nature of the interactions that generated the Moon are incorporated. As such, we believe that this conference should focus on the very earliest histories of these bodies, so that nearly everyone present will share a common interest in all aspects of the discussion.

Therefore, this conference is being planned just prior to the 1998 Fall AGU Meeting in San Francisco to encourage interested scientists worldwide to attend and contribute to what we hope will be the third in a series of highly successful topical conferences on origins of planets.

For further information concerning the conference, and to be added to the mailing list for future announcements, please send your request to:

The Origin of the Earth and Moon Conference
Lunar and Planetary Institute
3600 Bay Area Boulevard
Houston TX USA
E-mail: simmons@lpi.jsc.nasa.gov

CONVENERS

Alex N. Halliday
University of Michigan
E-mail: anh@umich.edu

Michael Drake
University of Arizona
E-mail: drake@lpl.arizona.edu

SCIENTIFIC ORGANIZING COMMITTEE

Alan P. Boss
Carnegie Institution of Washington

A. G. W. Cameron
Harvard College Observatory

John H. Jones
NASA Johnson Space Center

H. Jay Melosh
University of Arizona

R. Keith O'Nions
Oxford University

Everett Shock
Washington University

David J. Stevenson
California Institute of Technology

G. Jeffrey Taylor
University of Hawai'i

S. Ross Taylor
Australian National University

The Geochemical Society: Call for Nominations 1998 F.W. Clarke Award

The F. W. Clarke Award, consisting of a silver medal and a certificate, shall be made to a young scientist for a single outstanding contribution to geochemistry or cosmochemistry, published as either a 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 on December 31st of the year in which the award is approved by the Board of Directors. Independence and originality shall be important factors.

1972 D. A. Papanastassiou	1985 E. M. Stolper
1973 H. Ohmoto	1986 M. D. Kurz
1974 L. Grossman	1987 E. Takahashi
1975 D. Walker	1988 F. M. Phillips
1976 J. R. Wood	1989 no award
1977 B. Mysen	1990 R. J. Walker
1978 D. J. DePaolo	1991 D. Sherman
1979 A. C. Lasaga	1992 E. Klein
1980 R. W. Potter	1993 Y. Zhang
1981 J. F. Minster	1994 C. Agee
1982 P. J. Patchett	1995 R. Lange
1983 E. B. Watson	1996 P.M. Dove
1984 A. Mackenzie	1997 J. D. Blundy

Nominations for the 1998 F. W. Clarke Award should be submitted before November 1, 1997 to:

Dr. John Jones
SN4, NASA/Johnson Space Center
Houston, TX 77058 USA
Tel: 281-483-5319
Fax: 281-483-5276
E-mail: jjones2@ems.jsc.nasa.gov

The Goldschmidt and Clarke awards will normally be given annually at the V.M. Goldschmidt Conference, but may be reserved at the discretion of the Board of Directors. Neither award is normally shared, except in highly unusual cases, such as independent discoveries or joint work where the contributions of the co-workers are essentially equal. Members of the Board are ineligible for the duration of their terms. Past medalists are permanently ineligible.

Nominations should specify the name, address, citizenship, 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 few paragraphs summarizing why the candidate is suitable for the award.

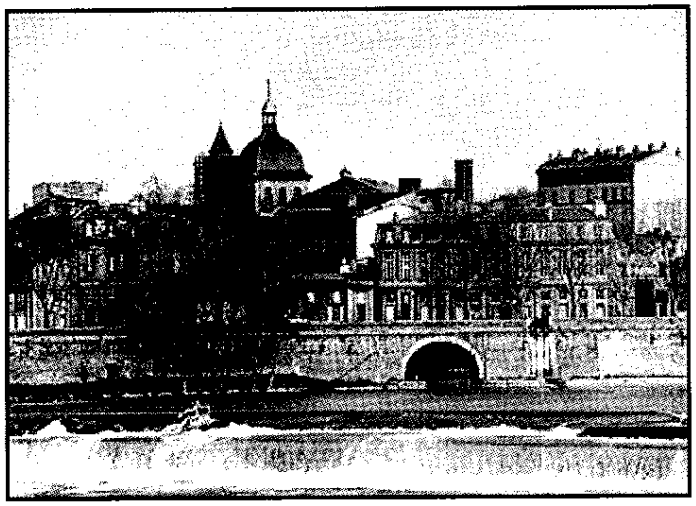
Nominations for the Clarke Award should be accompanied by a copy of the paper(s) for which the nominee is to be considered for the award, together with a statement explaining the significance of the work. Nominators should also specify the nominee's final degree, the degree advisor's name, the year granted, and the name of the granting institution.

All nominations will be considered by the Award Committees and will remain active for three years, unless the candidate becomes ineligible due to time limitations (Clarke), or on grounds of membership on the Board or on one of the Award Committees. Such nominations will then be tabled for the duration of this nominee's term, then reactivated for the balance of the three year period after expiration of the term.

Award winners are chosen by the Board of Directors, normally from between a nominee and an alternate recommended by each Award Committee. The awards are based solely on scientific merit, without regard to citizenship or membership in the Society.

TUREKIAN RECEIVES THE EWING MEDAL

Karl K. Turekian, Executive Editor of Geochimica et Cosmochimica Acta and Benjamin Silliman Professor of Geology and Geophysics at Yale University, has been awarded the 1997 Ewing Medal of the American Geophysical Union, for his outstanding services to the marine sciences (*EOS*, August 26, 1997). In his introduction, Peter G. Brewer of the Monterey Bay Aquarium Research Institute cited Karl's early work with Sr isotope ratio measurements, trace element distributions, U-Th series disequilibrium studies of ocean processes, and his recent use of Os isotope ratios in investigating the K/T boundary and cosmic dust fluxes to the oceans. Peter describes Karl as "...one of the world's most productive, widely known, and best-loved geochemists."



Announcing the Eighth Annual V.M. Goldschmidt Conference

August 30 - September 3, 1998 Toulouse, France

The Eighth Annual V.M. Goldschmidt Conference will be held in Toulouse, France from Sunday August 30 to Friday September 3, 1998. The meeting will be followed by optional field excursions to the neighboring Pyrénées mountains.

This will be the first time that the Goldschmidt will be held in France. The location of the meeting, Toulouse is a university town known for its tradition of culture and 'art de vivre'.

Toulouse, known as 'la ville rose' because of its magnificent brick-based architecture, is the fourth largest city in France. Situated in the south of France, Toulouse is located west of the Mediterranean Sea (90 miles/150 kilometers) and east of the Atlantic Ocean (150 miles/250 kilometers). Summer weather in Toulouse is typically pleasant and sunny, with daytime temperatures ranging from 75° F/24° C to 85° F/30° C.

The Goldschmidt 1998 Conference Venue, Université de Toulouse I, is located in the city center, close to hotels, restaurants, outdoor cafés, shopping, and several historical monuments and museums. The University of Toulouse is the second largest in France ; the campus is surrounded by churches, monasteries, and houses dating from the 11th to 17th centuries.

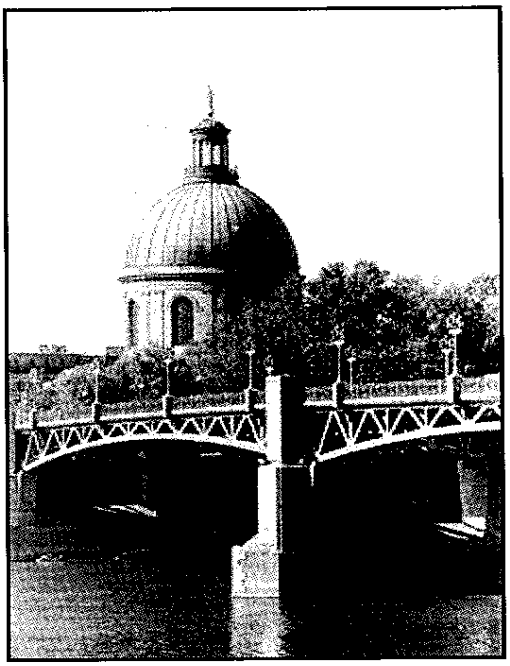
The area surrounding Toulouse is equally interesting. Several exciting touristic destinations are within a very short distance: the medieval city of Carcassone, the Perigord and Dordogne valleys, and the Pyrénées Mountains.

The Conference is organized by the Observatoire de Midi-Pyrénées, an institution dedicated to teaching and research in Earth and Planetary Science, ranging from extra-galactic astronomy to the internal structure of the Earth. If you are interested in obtaining future information regarding the conference, send a request using the Request Information Form or e-mail to goldconf@lucid.ups-tlse.fr.

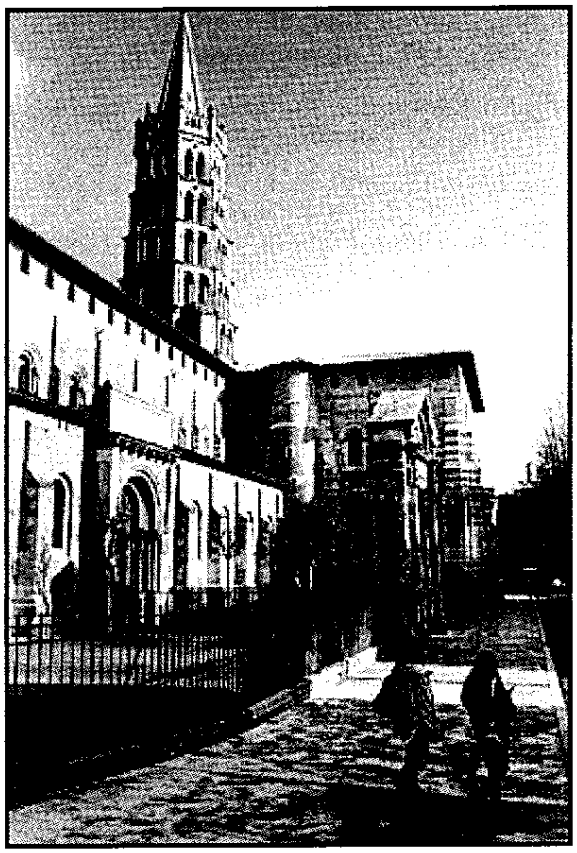
Hosted by
Observatoire de Midi-Pyrénées
Institut des Sciences de la Terre
CNRS/Université Paul-Sabatier

Sponsered by
European Association of Geochemistry
Geochemical Society
Université Paul-Sabatier
CNRS

Contact
Dr. Jacques Schott
Laboratoire de Géochemie
38, rue des 36 Ponts
31400 Toulouse, France
Telephone : (33) 561.55.65.18
FAX : (33) 561.52.05.44
E-mail : goldconf@lucid.ups-tlse.fr



Organizing Committee
Nick Arndt (Rennes)
Ben Harte (Edinburgh)
Laurent Charlet (Grenoble)
Jean-Louis Dandurand (Toulouse)
Robert Delmas (Toulouse)
Bernard Dupré (Toulouse)
Christian Fouillac (Orléans)
Robert Gout (Toulouse)
Alain Huc (Rueil Malmaison)
Catherine Jeandel (Toulouse)
Joel Lancelot (Montpellier)
John Ludden (Nancy)
Jean-François Minster (Paris)
Eric Oelkers (Toulouse)
Mireille Polvé (Toulouse)
Jaques Schott (Toulouse)



Schedule

November 15, 1997	Information Request forms due at Laboratoire de Géochemie
early December 1997	Second announcement, including logistical and registration information
April 3, 1998	Abstract deadline
June 1998	Final announcement/Program
August 30 - September 3, 1998	Eighth Annual Goldschmidt Conference

Information Request Eighth Annual V.M. Goldschmidt Conference August 30-September 3, 1998 Toulouse, France
PLEASE RETURN BY : November 15, 1998

Name _____

Institution _____

Address _____

_____

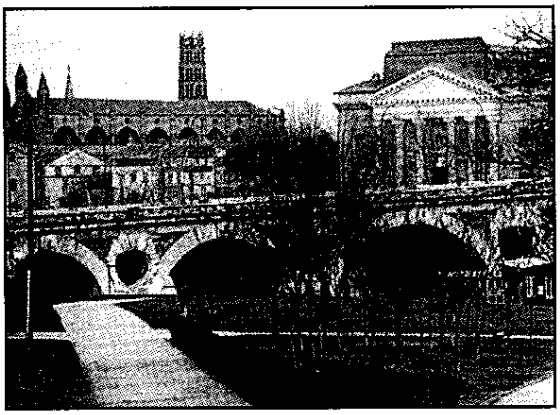
_____

Phone _____

FAX _____

E-mail _____

For future information regarding logistics, registration, and abstract submission, please complete and return this form the address shown at right.
Return by November 15, 1998 to : Goldschmidt Conference, Laboratoire de Géochemie, 38 rue des 36 Ponts, 31400 Toulouse, France FAX : (33) 561.52.05.44



When did the Earth's atmosphere become oxic?

Hiroshi Ohmoto

Dept. of Geosciences, The Pennsylvania State University, University Park, Pa. 16802
and
Research Center for Natural Resources and Environmental Geochemistry,
Graduate School of Science, Tohoku University, Sendai, 980-77, Japan

On today's Earth, photosynthesis, simplified as $H_2O + CO_2 = CH_2O + O_2$, is the dominant mechanism for generating free O_2. Free O_2 accumulates in the atmosphere when the organic matter (CH_2O) is buried in sediments so that the backward reaction is prevented, while the atmospheric O_2 is consumed mostly through weathering of organic matter in sediments. A most controversial issue on the evolution of atmospheric oxygen has been the timing of oxygenation of the atmosphere and ocean. The main purpose of this short article is, therefore, to briefly summarize the specific hypotheses and problems associated with the two contrasting models for the atmospheric evolution (Fig. 1).

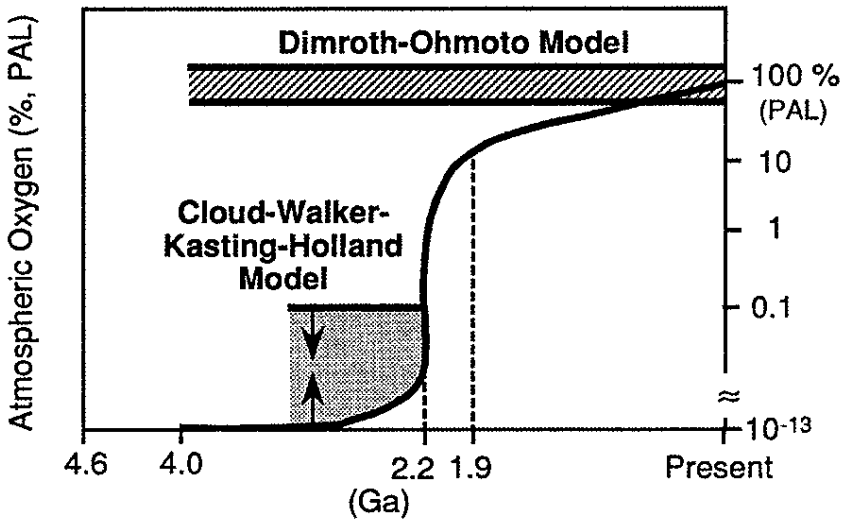


Fig. 1. Two contrasting models for the evolution of atmospheric O_2.

The two models

The currently popular model was first proposed by Preston Cloud[1-3] as "a working model", which was subsequently refined by Walker[4-5], Kasting[6], and Holland[7-9] (i.e., the C-W-K-H model). It postulates an anoxic atmosphere prior to 2.2 Ga with P_{O2} levels between 10^{-13} and 0.1% PAL (the present atmospheric level), a dramatic rise of P_{O2} to >15% PAL between 2.2 and 1.9 Ga, followed by a gradual increase to the present value. An alternative model, proposed by Dimroth and Kimberley[10] and advocated by Ohmoto and his associates[11-17] (the D-K-O model), postulates an essentially constant atmospheric P_{O2} level (probably within ±50 % of PAL) since ~4 Ga.

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

Although it has not been explicitly stated in previous research, the evolution of atmospheric O_2 must have been linked to that of the continental crust. This is because the primary biological productivity in the ocean, linked to the production of O_2, is limited by the flux of nutrients (e.g., phosphate) from the continents. The consumption rate of O_2 through rock weathering also depends on the size of the continental crust. (The other parameters affecting the nutrient flux, such as the atmospheric P_{CO2} level, climate, topography, and geography, may be less important compared to the crustal volume). Furthermore, the extent of crustal growth depends upon the evolution of plate tectonics, involving when plate tectonics began, and how the recycling rate of continental materials through the mantle changed through geologic time.

The C-W-K-H model: Cloud[2-3] proposed that the Archean continental crust was much smaller and thinner than today's crust, and that plate tectonics and the growth of continental crust began around ~2.2 Ga. Knoll[18] suggested that the development of widespread, stable shallow-marine platforms during the early Proterozoic increased the primary biological productivity; the increased O_2 production from burial of organic matter, coupled with the decreased rates of O_2 consumption by volcanic gas, resulted in the rise of atmospheric O_2 level around 2.0 Ga.

Various crustal growth curves[19-21] have been suggested as refinements of Cloud's model. These postulated crustal growth curves, however, do not correlate exactly with the atmospheric O_2 growth curve of the C-W-K-H model.

The D-K-O model: Although Dimroth and Kimberley[10] did not link their atmospheric evolution to crustal evolution, the D-K-O model will become an unrealistic model, if the size of the early continents was much smaller than the present value. The D-K-O model infers that the crustal growth model of Armstrong[22-23] is correct. Armstrong's model, based largely on Pb, Sr, Nd, and Hf isotopic data of igneous and sedimentary rocks of various geologic age, postulates very early differentiation of the Earth into core, depleted mantle, and continental crust, and maintenance of an essentially constant volume for the continental crust by recycling through the mantle (i.e., through plate tectonics) since ~4.5 Ga; the recycling rates, however, decreased with time.

Armstrong's crustal growth model has recently been expanded by some geochemists: for example, by Kröner and Layer[24] on the basis of REE data on Archean sedimentary rocks, P-T data on Archean metamorphic rocks, and paleomagnetic data of Archean and Proterozoic igneous rocks; by Bowring and Housh[25] on the basis of Nd isotopic systematics of the 4.0-3.6 Ga Acasta gneisses; and by Sylvester et al.[26] on the basis of Nb/U ratios of 2.7 Ga basalts from the Yilgarn Craton, Australia.

Banded iron formations (BIFs): products of a globally anoxic ocean or regionally anoxic basins?

C-W-K-H model: The atmospheric evolution model of Cloud[1-3] was based partly on a hypothesis for the origin of the Superior-type BIFs (e.g., the Brockman IF in the Hamersley Basin, Australia) that mostly formed prior to 1.9 Ga. The hypothesis[3] was that the BIFs formed in shallow basins on stable continental platforms where igneous activity was absent or minor; and precipitation of ferric hydroxides occurred when the Fe^{2+}-rich water, originating from a distal deep ocean, was brought to shallow basins and reacted with the O_2 generated locally and seasonally by photosynthetic organisms. To transport Fe^{2+} from a distal deep ocean, the model required a globally anoxic ocean. The Fe^{2+} in the deep ocean was suggested to have been replenished by

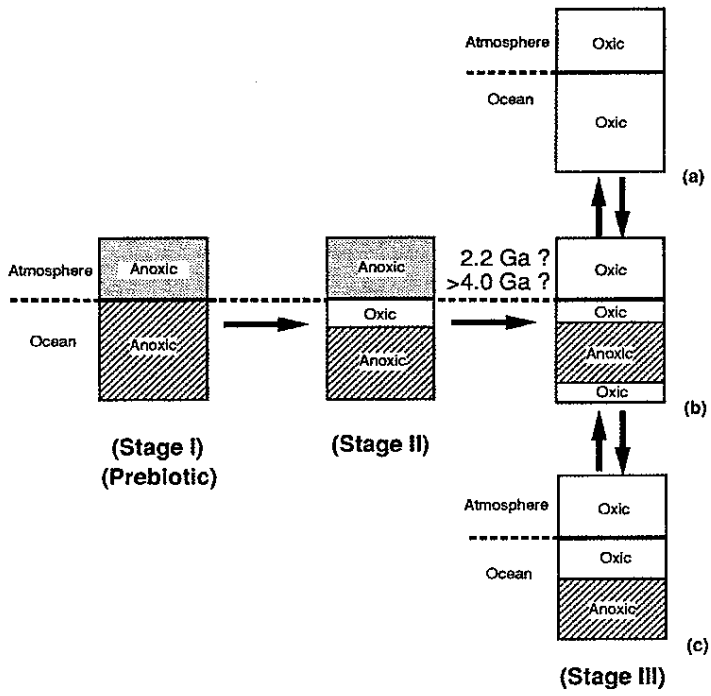


Fig. 2. The proposed sequence of oxygenation of the atmosphere and ocean.

weathering of rocks on land; for this, an anoxic atmosphere was required. The redox conditions for the atmosphere-ocean system prior to 2.2 Ga, therefore, correspond to those of Stage I or II of the evolutional history (see Fig. 2).

Studies of REE and Nd isotopes of the Superior-type BIFs[27] have identified hydrothermal components in the iron oxides and associated minerals. This discovery has led to a modification of Cloud's model, suggesting that the Fe^{2+}-bearing solutions originated as submarine hydrothermal fluids in Mid Ocean Ridges, and that the hydrothermal plumes traveled great distances to shallow basins developed in continental margins. This modified model of BIFs[28] also required a globally anoxic ocean.

D-K-O model: A new model for the tectonic environments and hydrothermal processes for BIFs has been recently developed by our group[12] which postulates that: the environments and processes (textonic, igneous, hydrologic) of mineralization for the Superior-type BIFs were similar to those in the modern Red Sea. The model proposes that the Superior-type BIFs were formed in basins created by the rifting of thick continental crust (i.e., failed rifts), and that the anoxic, Fe^{2+}- and silica-rich hydrothermal fluids were discharged within the basin and accumulated as a brine pool. According to this model, only the bottom water in the basins, rather than the entire ocean, needed to be anoxic; the surface water of the basin (as well as the normal ocean outside of the rift) was probably oxygenated. This model was developed from a variety of geochemical studies[12, 29] that have identified the extensive development of hydrothermal alteration features in the footwall rocks of the Brockman IF.

Pyrite in shales: evidence for an oxic atmosphere?

Modern ocean water is sulfate rich because sulfate was produced by oxidation of SO_2 and H_2S in volcanic gas and sulfides in rocks. Essentially all the pyrite crystals in modern marine sediments are formed by bacterial sulfate reduction[11].

C-W-K-H model: Photochemical reactions involving volcanic gases in the pre-biotic atmosphere may have produced SO_4^{2-} in the ocean with a concentration level of ~1mM (i.e., ~1/30 of the present oceanic level)[5]. Many previous investigators[30-31] suggested that, prior to ~2.2 Ga, sulfate reducing bacteria were absent, ocean water was SO_4^{2-} poor, and pyrites in sediments were formed by magmatic H_2S. This suggestion was largely based on the observation that the *bulk-rock* $\delta^{34}S$ values for pyrite and sulfates in pre-2.2 Ga sedimentary rocks were less variable compared to those in the younger sedimentary rocks, and fall mostly within a narrow range of 0±5 ‰.

D-K-O model: Based on micro-scale $\delta^{34}S$ variations found among individual grains of pyrite in 3.4-2.4 Ga sediments from South Africa, Australia, and Canada, we[15-16] have come to conclude that the pyrite crystals in Archean marine sedimentary rocks were also formed by bacterial sulfate reduction. Furthermore, the magnitude of isotopic fractionation factors accompanying the bacterial sulfate reduction suggests that the SO_4^{2-} content of Archean ocean was greater than ~10 mM. Such a high SO_4^{2-} content would have required a high P_{O2} value for the Archean atmosphere.

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

C-W-K-H model: Uraninite and pyrite crystals occurring in some alluvial conglomerate beds of >2.2 Ga, such as those in the Witwatersrand district, South Africa and in the Elliot Lake district, Canada, have been thought to be detrital minerals[32]. Because both uraninite and pyrite are unstable under oxic conditions, these "detrital" minerals were crucial to the C-W-K-H model that postulated a reduced atmosphere prior to 2.2 Ga. Important evidence for detrital origins for these minerals was the presence of rounded "pyrite pebbles" in the >2.2 Ga gold-uranium deposits in the Witwatersrand district. They appear to be large pyrite crystals that were rounded by abrasion during transportation in stream beds[33].

D-K-O model: Textural evidence was recently discovered that these "pyrite pebbles" were actually rounded pebbles of cherts and shales that were replaced by small aggregates of pyrite crystals during diagenesis and hydrothermal events[34-35]. If the uraninite and pyrite crystals were not detrital in origin, they cannot be used as evidence for a reduced atmosphere.

Hydrothermal alteration of rocks has been thought to be lacking or minor in these deposits[36]. However, from a comprehensive study of paragenesis of minerals, Barnicoat et al.[37] have recognized intense alteration both above and below the mineralized horizon, and concluded that all the gold, uraninite, and pyrite in these deposits are diagenetic and/or of hydrothermal origin. They suggest that U^{6+} was transported through the host rock beds by ground water, and precipitated as UO_2 by reaction with pyrobitumen in the host rocks; the pyrobitumen was derived from petroleum that was generated from deeper parts of the basin and migrated up to the depositional sites. This genetic model for the pre-2.2 Ga uraninite deposits is essentially identical to the one proposed by Gauthier-Lafaye and Weber[38] for the 2.0 Ga uraninite deposits at Oklo, Gabon. The Oklo deposits are famous as "natural fission reactors", and cited by Holland[8] as the first uraninite deposits formed by oxic groundwater. However, the study of Barnicoat et al.[37] suggests that *oxic* ground water was also responsible for the formation of pre-2.2 Ga uraninite deposits.

Sulfides are more abundant than zircon in most igneous rocks, but sulfides are extremely rare detrital minerals in *normal* alluvial sediments of all geologic age, including those of Archean age[10], because they are easily decomposed by oxidation. The absence of sulfides in the Archean rocks is, therefore, compatible with the D-K-O model but not with the C-W-K-H model.

(continued on page 26)

THE GEOCHEMICAL SOCIETY

Call for Nominations for 1998 Joint EAG-GS Geochemistry Fellows

The European Association of Geochemistry (EAG) and the Geochemical Society (GS) established in 1996 the honorary title of Geochemistry Fellow, to be bestowed upon outstanding scientists who have, over some years, made a major contribution to the field of geochemistry. Existing and new Urey, Goldschmidt and Treibs Medal winners become Fellows automatically. In addition, up to 0.5% of the total combined membership of the two societies should be elected as Fellows each year. This corresponds to approximately 15 honorees per year at current enrollment levels, and allows for growth in the societies. Nominations will be sought and recommendations for election made by a committee (Fellows Selection Committee) of 8 persons, 4 from GS, and 4 from EAG.

Any member of either society may nominate Fellows by right. No individual may be elected a Fellow, except as a result of having previously won the Urey, Goldschmidt or Treibs Medal, while they are serving either on the Fellows Selection Committee or as a Council / Board member of EAG / GS. The Selection Committee may not themselves nominate individuals, but may actively solicit nominations from others. Members of the Selection Committee and Council / Board may not vote on any nomination where there is a clear conflict of interest. Final approval of all nominees will be made by the EAG Council and the GS Board of Directors. In the event that the EAG Council and the GS Board differ over the ratification of a nomination, the Executive Committee of the Goldschmidt Forum (the Presidents and Vice Presidents of EAG and GS) will resolve the issue. Fellows will be inaugurated at the 8th V.M. Goldschmidt Conference in Toulouse, France in 1998.

Nominations should include the name, address, and telephone number of the nominee, a citation of no more than two pages describing the contributions the individual has made to geochemistry, and up to three letters of support from members of either society. The nomination should also include the nominator's name, address, telephone number, and signature.

Nominations should be sent no later than November 1, 1997 to:

Dr. John M. Hayes (Chair, Fellows Selection Committee)
WHOI, MS8
Woods Hole, MA 02543 USA

T: 508-289-2585
F: 508-457-2183
E: jhayes@whoi.edu

Geochemistry Fellows (excluding Urey, Goldschmidt and Treibs Medalists)

1996: William Compston, Willi Dansgaard, John Edmond, John M. Hayes, Marc Javoy, Ho-Kwang Mao, Stephen Moorbath, John Reynolds, Jean-Guy Schilling, Nick Shackleton, Mitsunobu Tatsumoto, Werner Stumm, George Tilton, Grenville Turner, Heinrich Wänke, William White

1997: Donald J. DePaolo, Jan Bottinga, Philip Abelson, Gunter W. Lugmair, Tom Krogh, Michael O'Hara, Ikuo Kushiro, Fred T. Mackenzie, Denis M. Shaw, Bruno J. Giletti, George W. Wetherill, Keith O'Nions, Ian Carmichael, Edward M. Stolper, Derek York, Alex Navrotsky

---

1998 GSA and AGU Meetings!

The Geochemical Society is a co-sponsor of the GSA Annual Meeting. Our Organic Geochemistry Division normally organizes an all-day symposium on the Sunday before the meeting, at which it also conducts its Business Meeting. In addition, the Geochemical Society is guaranteed a half-day symposium or theme session slot during the GSA meeting.

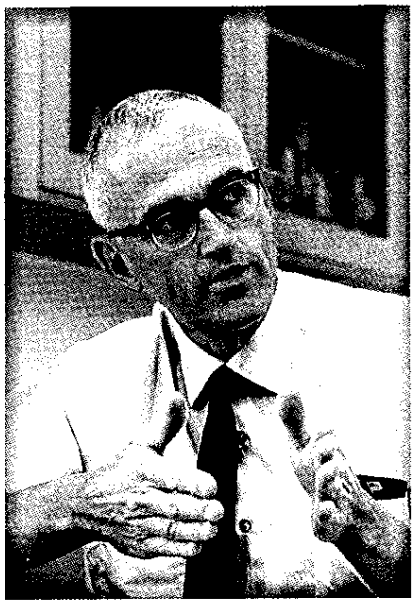
As co-sponsor of the Spring American Geophysical Union Meeting, the Society can submit an unlimited number of symposia and theme sessions. The Society is not allocated any official time at the Fall AGU meetings, but the Volcanology-Geochemistry-Petrology Section of AGU organizes special geochemical sessions at these.

Our Society's special session at the 1997 GSA meeting is described elsewhere in this issue. Now is the time to start thinking about the 1998 meetings. Deadlines for special session proposal submittals generally fall around the first of the year for both GSA and AGU for that year's meetings. If you want more information, or have an idea for GS-sponsored symposia (invited) or theme sessions (volunteered) at these meetings, please get in touch with our 1998 Program Committee Chairperson:

Bill McDonough
Dept. Earth and Planetary Science
Harvard University
20 Oxford Street
Cambridge, MA 02138 USA

T: 617-496-2010
F: 617-496-0434
E: mcdonough@geophysics.harvard.edu

The Patterson Medal in Environmental Geochemistry



The Geochemical Society is establishing the new honorary award of the Patterson Medal, named after the late Clair C. Patterson, to be given for innovative and exciting research in environmental geochemistry. Environmental geochemistry is an important expanding field in which major discoveries are likely to play a societal as well as scientific role. There are few awards in this area. Clair Patterson was a key player in understanding the environment and developing environmental geochemistry. It was clearly the major portion of his life's work and this award will be a fitting tribute to him as well as a way of recognizing creative science and scientists.

The Patterson Medal will be bestowed upon scientists who have recently made a particularly important and innovative breakthrough in environmental geochemistry, considered to be of fundamental significance. The research must be highly original and contribute in a significant fashion to our understanding of the natural behavior of the Earth's environment. Such a contribution must be in the form of a widely recognized important piece of innovative scientific research published in a peer reviewed journal. There is no age limit associated with this honor. The award will be bestowed biennially and is to be distinguished from the Goldschmidt and Treibs Medals and the Geochemistry Fellows. Such awards reflect a longer term of achievement and are generally bestowed upon senior individuals, whereas the Patterson Medal is for a single accomplishment, irrespective of age or career stage. The closest parallel is with the Clarke Medal but this is reserved for early-career scientists. A Clarke Medal awardee cannot receive the Patterson Medal for the same accomplishment (and vice versa). The awardee does not have to be a member of the Geochemical Society. If the scientific discovery is clearly a joint effort then the award may be shared in a given year.

Nominations will be sought, and a recommendation for the awardee plus an alternate, made by a committee (Patterson Medal Committee) of 6 persons. The first Patterson Medal Committee will comprise Joel Blum (Dartmouth College), Ed Boyle (M.I.T.), Alex Halliday (University of Michigan), Malcolm McCulloch (A.N.U.), Judy McKenzie (ETH Zürich) and Lee Silver (CalTech). Any member of the Geochemical Society can nominate an individual, with the exception that the Patterson Medal Committee cannot nominate any individual themselves, unless no suitable nomination is received from the membership. Nobody is permitted to be selected for this award while they are serving on the Patterson Medal Committee or on the Board of Directors of the Geochemical Society. Members of the Patterson Medal Committee and Board of Directors cannot vote on a nomination where there is an obvious conflict of interest. If none of the nominees are judged to have made a sufficiently distinctive contribution, the award will not be made in that particular year.

Nominations will only be considered if accompanied by the same critical mass of supporting material as follows:

1 A citation of no more than two pages describing the contribution the individual has made to geochemistry.

2 A two page condensed resume that includes education and employment history together with details of service to national and international scientific and educational organizations. Personal details and funding record are not required.

3 A list of no more than 10 peer-reviewed publications relevant to the accomplishment being recognized, with full references.

4 Up to three letters of support.

Nominations for the first Patterson Medal should be sent to Alex Halliday, Department of Geological Sciences, The University of Michigan, 2534 C.C. Little Building, Ann Arbor, MI 48109-1063, by May 1, 1998.

7th V.M. Goldschmidt Conference

Mike Drake (left) and Joaquin Ruiz (right) with LPI Conference Coordinator LeBecca Simmons.

The Seventh Annual V.M. Goldschmidt Conference was held at the Westin La Paloma Resort in Tucson, Arizona, USA from June 1-6, 1997. It was organized by Michael J. Drake and Joaquin Ruiz, ably assisted by the Program Committee composed of Jon Patchett, Jay Quade, Marek Zreda, George Gehrels, Tim Swindle, Jiba Ganguly, and Mark Barton. The Conference was sponsored by the Geochemical Society, the European Association of Geochemistry, the Lunar and Planetary Institute, the Department of Planetary Sciences/Lunar and Planetary Laboratory and the Department of Geosciences of the University of Arizona, and the U.S. National Aeronautics and Space Administration. Official Exhibitors were Cameca Instruments Inc., JEOL USA Inc., Depths of the Earth Co., LLC, Finnigan Corporation, Elsevier Science Ltd., and the Geochemical Society. The Goldschmidt Conference ran extremely smoothly and professionally thanks to the expert assistance of LPI and the highly professional staff of the Westin La Paloma.

Approximately 450 people from all continents attended. Delegates were welcomed with Sunday evening registration and a pool-side welcoming party. Topics discussed in technical sessions included Isotopic Studies of Early Earth; Fluxes in Subduction Zones; Isotope Exchange in Crustal and Mantle Processes; Hydrothermal Systems; Carbon Cycling in Soils; Links between Ocean Chemistry, Climate, and Tectonics; Experimental Trace-Element Geochemistry; Mineral Growth Kinetics and Reactivity; Large Igneous Provinces and their Relation to Plumes; Planetary Geochemistry; Tectonics and Igneous Petrology; Thermodynamics; Evolution of Mantle Geochronology and Thermochronology; Weathering; Analytical Trace-Element Geochemistry; Accretion and Core Formation; Archean Geochemistry; Records of Climate Change; and Comparative Chemistry of Earth and Mars.

Devendra Lal (right) accepts the Goldschmidt Medal from Alex Halliday

In addition, three Symposia in honor of Prof. Bart Nagy, Prof. Paul Damon, and Dr. M. Tatsumoto were held. The Conference was also the site of the inaugural Gast Lecture, given by Edouard Bard after an introduction about the life of Paul Gast by Jerry Wasserburg. The Geochemical Society Presidential Lecture was given by Alex Halliday. The Presidential Lecture of the European Association of Geochemistry was canceled because the change of government in France resulted in Claude Allegré becoming a minister in the new government, apparently a more important task than giving a lecture in Tucson.

Jon Blundy accepts the Clarke Award

An Awards Banquet was held on Monday evening, June 2. In between being serenaded with a southwestern Mariachi band, several important awards were made. The Geochemical Society's highest medal, the Goldschmidt Award was given to Devendra Lal following a citation by Wally Broecker. The Clarke Medal was awarded to Jon Blundy, following a citation by Bernie Wood. And the Houtermans medal of the European Association of Geochemistry was given to Ken Farley following a citation by Thure E. Cerling. The following scholars were made Geochemistry Fellows: Philip Abelson, Yan Bottinga, Ian Carmichael, Donald DePaolo, Bruno Giletti, Tom Krogh, Ikuo Kushiro, Gunter Lugmair, Fred Mackenzie, Alexandra Navrotsky, Michael O'Hara, Keith O'Nions, Denis Shaw, Edward Stolper, George Wetherill, and Derek York.

The meeting concluded with a pool-side Farewell Party. Attendees judged the Conference a great success. The Tucson organizers strongly encourage you to attend the Eighth Annual V.M. Goldschmidt Conference in Toulouse, France from August 30 to September 3, 1998.

Calendar of Meetings

Oct. 4-9, 1997: Natural Waters and Water Technology: Microorganisms & Chemistry in Aquatic Systems, San Feliu de Guixols - Girona, near Barcelona (Spain). Contact: Dr. Josip Hendekovic, Executive Director, European Research Conferences, Fondation Europeenne poour la Science, 1, Quai Lezay-Marnesia, 67080 Strasbourg Cedex; Tel: 33 (0) 388 767 135; Fax: (0) 388 366 987; Email: euresco@esf.org; WWW: http://www.esf.org/euresco

Oct. 5-10, 1997: Fourth International Symposium on Environmental Geochemistry, Vail, CO USA. Contact: 4th ISEG,C/O USGS/CEGG, Federal Center, Box 25046, MS 973, Denver, CO 80225; Fax: 303-236-3200; Email: iseg@helios.cr.usgs.gov

Oct. 8-10, 1997: Fourth International Conference on Rare Gas Geochemistry, Rome, Italy. Contact: Conference Secretariat, W. Plastino, 4th ICRGG, Physics Dept., University of Roma III, Via della Vasca Navale, 84, I-00146 Rome, Italy; Tel: + 39 6 49914200; Fax: + 39 6 4957697; Email: 4ICRGG@uniroma3.it

Oct. 10-13, 1997: MIT-Harvard Workshop on Continental Roots, Hoffman Laboratory, Harvard University, Cambridge, MA USA. Contact: Bill McDonough; Email: mcdonough@eps.harvard.edu

Oct. 12-16, 1997: The Estuarine Research Federation's 14th International Conference to Explore the State of Our Estuaries, Providence, RI USA. Contact: Estuarine Research Federation, 490 Chippingwood Drive #2, Port Republic, MD 20676 USA; Tel: 410-586-0997; Fax: 410-586-9226; Email: jbarth@cbl.ceed.edu; WWW: http://cbl.cees.edu/erf/erf97.html

Oct. 13-16, 1997: International Conference on Earth Observation and Environmental Information, Alexandria, Egypt. Contact: B. Saleh, Arab Academy for Science and Technology and Maritime Transport, P. O. Box 1029, Miami, Alexandria, Egypt; Tel: 203-5602578; Fax: 203-5602915; Email: rugsd@rusys.eg.net; WWW: http://www.frcu.eun.eg/www/conference/aast.html

Oct. 14-16, 1997: East Sea Oceanography Conference (ESOC), Pusan, KOREA. Contact: Dr. Seok-Yun Kim, Secretariat, ESOC, KIOS, Pukyong National University, 599-1, Daeyon-dong, Nam-ku, Pusan 608-737, KOREA; Tel: + 82-51-620-6218; Fax: + 82-51-624-5387; Email: ksyun@dolphin.pknu.ac.kr

Oct. 15-17, 1997: Monitoring the Oceans in the 2000s: An Integrated Approach, Biarritz, France. Contact: C. Saintpaul, Capitole Tourisme Affaires/Ocean97, 22 avenue de Purpan, 31700 Blagnac, France; Tel: 33-5-61-71-55-71; Fax: 33-5-61-71-44-37; Email: Corinne.Saintpaul@PYRENET.fr

Oct. 15-17, 1997: Symposium on Molecular Sciences for the Environment, Richland, WA USA. Contact: T. A. Zinn, Symposium Administrator, K4-99, Pacific Northwest National Laboratory, P.O Box 999, Richland, WA 99352; Tel: 509-375-2797; Email: teresa.zinn@pnl.gov

Oct. 17-18, 1997: Ore Genesis and Exploration: The Roles of Organic Matter, Salt Lake City, UT USA. Contact: Richard M. Kettler, Dept. Of Geology, University of Nebraska, Lincoln, NE 68588-0340 USA; Tel: 402-472-0882; Fax: 402-472-4917; Email: rkettler@unlinfo.unl.edu or Thomas Giordano, Dept. Of Geological Sciences, Box 3AB, New Mexico State University, Las Cruces, NM 88003-8001 USA; Tel: 505-646-2511; Fax: 505-646-1056; Email: tgiordan@nmsu.edu

Oct. 18-22, 1997: Water Environment Federation's Annual Meeting (WEFTEC '97), Chicago, IL USA. Contact: Water Environment Federation, 601 Wythe Street, Alexandria, VA 23214-1994; Tel: 800-666-0206 (USA and Canada) or 703-684-2452; Fax: 703-684-2492; Email: confinfo@wef.org; WWW: http://www.wef.org/docs/weftec.html

Oct. 19-23, 1997: American Water Resources Association Annual Conference and Symposium, Long Beach, CA USA. Contact: American Water Resources Association, 950 Herndon Parkway, Suite 300, Herndon, VA 20170-5531 USA; Tel: 703-904-1225; Fax: 703-904-1228; Email: awrahq@aol.com; WWW: http://www.awra.org/~awra

Oct. 19-24, 1997: Chapman Conference: Applications of GIS, Remote Sensing, Geostatistics, and Solute Transport Modeling to the Assessment of Non-Point Source Pollutants in the Vadose Zone, Riverside, CA USA. Contact: AGU Meetings Dept., 2000 Florida Ave., Washington, DC 20009; Tel: 202-462-6900

Oct. 20-23, 1997: 1997 GSA Annual Meeting, Salt Lake City, UT USA. Contact: GSA, 3300 Penrose Place, Boulder, CO 80301; Tel.: 303-447-2020; Fax: 303-447-1133; WWW: http://www.geosociety.org/meetings/97/index.htm

Oct. 22-24, 1997: 5th International Conference on Estuarine and Coastal Modeling, Alexandria, VA USA. Contact: A. F. Blumberg, HydroQual, Inc., 1 Lethbridge Plaza, Mahwah, NJ 07430; Tel: 201-529-5151; Fax: 201-529-5728

(Continued on page 24)

Geochemical Society-sponsored Sessions at 1997 GSA Annual Meeting
Salt Lake City, Utah, USA
October 19-24, 1997

Title	Location	Date	Time	Presiding
Low Temperature Inorganic and Organic Geochemistry	Ballroom D	Oct. 22	AM	Carl Steefel and Peggy Ostrom
S16. Geochemical Records of Hydrologic Response to Climate Change (see page 24)	Ballroom E	Oct. 21	PM	Emi Ito and Jay Banner
S02. Organic Perspectives on Geochemical Processes I (see page 25)	150 G	Oct. 19	AM	John Hedges, Stu Wakeman, and Cindy Lee
S02. Organic Perspectives on Geochemical Processes II	150 G	Oct. 19	PM	
T05. Trace Metals in the Environment: Sources, Transport, and Fate--A Tribute to Ernest E. Angino	151 A-G	Oct. 21	AM	David T. Long and Gunter Faure
T33. Theoretical Molecular Methods in Earth Sciences	259	Oct. 22	AM	Antonio C. Lasaga
T41. Natural Background Chemistry and Environmental Decision-making	Ballroom H	Oct. 23	AM	Donald D. Runnells and Georgia A. Doyle
Groundwater, Surface Water, and Environmental Geochemistry	Ballroom D	Oct. 22	PM	Simon Poulson and William Holden
Geochemistry Posters	Hall C	Oct. 21	AM	
Geochemistry of Soils and Weathering	257	Oct. 20	PM	Rob Rye and Carey Gazis
Hydrothermal to High Temperature Geochemistry	Ballroom H	Oct. 23	PM	Elizabeth Warner Holt and Gregory J. Holk
Experimental and Theoretical Aqueous Geochemistry	251 AB	Oct. 20	AM	David Cole and John Walther
S02. Organic Perspectives on Geochemical Processes III (Posters)	Hall C	Oct. 19	PM	

The Mineralogical Society of America and The Geochemical Society will again host a reception at GSA, Tuesday evening, Little America Hotel, Grand B, from 5:30 to 7:30 pm. Tickets ($10 regular, $5 student) available at GSA registration and at the reception.

Editor's Note: The Geochemical Society Board of Directors recently approved an annual contract with Dr. Mark Bloom as the Coordinator of Internet Resources for the Society. Please join me in welcoming Mark to the Society's business and scientific operations.

Mark is an accomplished geochemist. He holds a B.Sc. and M.Sc. in geology from The New Mexico Institute of Mining and Technology, and a Ph.D. in geochemistry from The University of British Columbia. He was a Lecturer and Senior Lecturer in Economic Geology and Geochemistry at The Victorian Institute of Earth and Planetary Sciences, Monash University (Australia) from 1979 until 1993. His research at Monash focused on the geochemisty of hydrothermal ore deposits and experimental hydrothermal geochemistry.

In 1993, Mark joined a consulting firm in Boulder, Colorado specializing in the environmental geochemistry of mineral deposits. He began an independent consulting practice in 1996, which quickly evolved to supply Internet database connectivity for environmental service providers.

Mark's mandate from the Society is to develop membership services and content, and educational outreach for the K-12 community. He will be responsible for building and deploying the Society's web presence, and for maintaining the servers that deliver these services to our membership and the public. Mark isn't working alone in these efforts. He holds a similar position with the Mineralogical Society of America and is collaborating with the Geological Society of America on the educational outreach initiative.

From the Coordinator of Internet Resources

These are indeed exciting times for the Geochemical Society. We are about to embark on a new era of services for our members and an initiative to develop educational outreach for the K-12 community. I'd like to take this opportunity to acknowledge the outstanding efforts of Steve Shirey in keeping the GS Home Page alive, and to thank Alex Halliday, Mike Hochella, and Dave Wesolowski for their unfailing support while this project was in gestation. I hope the vision I share with the Board for the GS web presence and describe in this letter to our members, in some small way communicates the excitement I feel for increasing public awareness of the geochemical sciences.

The Geochemical Society web site has migrated to its new home, which is located in the Business Office of the Mineralogical Society of America. The new URL for our web site is **http://www.geochemsoc.org/**. There are also two new Internet services on our domain: **ftp://ftp.geochemsoc.org/** for file transfers and **gs-talk@lists.geochemsoc.org**, the first of several email talk lists. You won't see anything vastly different at our new URL, but development of a new look and feel for the web site is nearing completion. ***The new Home Page will at first be a facade, with our existing web resources lurking behind the new look and gradually being replaced as work proceeds.*** The ftp and list serves are not on-line at the time of this writing, but should be live by the time this issue hits the press.

For those interested in the specifics, the GS web presence is on a distributed array of Apple 8550/200 and 8550/225 Workgroup Servers with a dedicated T-1 connection to the Internet. There's Bullwinkle (the primary web server and auxiliary servers for graphics, load balancing and e-commerce), Boris (a dedicated SQL database server), and Natasha (ftp and list servers, site logging and statistics). Rocky stayed at home in Colorado and is the development platform.

The Geochemical Society has joined forces with the Mineralogical Society of America and the Geological Society of America to develop a collaborative educational outreach effort via the Web. The goal is to provide engaging education materials that would be effective in a classroom setting as well as to the public at large. There are many possible forms this may take, including on-line activities with real data, student-professional mentoring relationships, data sharing and other technology-enhanced classroom activities. Our initial efforts will focus on topics that are of interest to all three professional groups, particularly those which lend themselves to a systems approach to understanding earth processes and resources.

This area of the our web site will be the container for society business and information links in the present GS home page. Visitors will be able to obtain general information about the Geochemical Society, the names and contact addresses for officers and committees, a description of awards and nomination procedures, ballots, by-laws, the minutes of board meetings, and forms for membership renewals and applications. There will also be instructions to authors for manuscripts submitted to *Geochimica et Cosmochimica Acta* and *The Geochemical News* and, in the not-too-distant future, interactive ballots for on-line voting and forms for nominations for the general membership.

A pet project for the GS web presence, the databag will be a searchable database of thermochemical information for solids, gases, and aqueous species. It will operate in conjunction with the extensive mineralogical and crystallographic database planned by the Mineralogical Society of America. Our vision for the databag is to key searches to one or more fields including (but not limited to) name(s), phase, component(s), composition, structure, and charge. Ancillary information such as adsorption constants and surface complexation may be included. The databag will be an ambitious undertaking that will require the cooperation and assistance of researchers, as well as the blessing of publishers for compliance with copyright constraints.

Work is in progress to bring on-line a searchable GS membership directory. A member will be able to update his/her records in the database, interactively from the web site, using the new membership number and password that will be assigned in the upcoming round of membership renewals. Visitors to the web site will be able to search the membership directory by name, geographic location, institution or employer, and key research or interest areas. There are likely to be two or more levels of information returned from a directory search, depending on whether a search request is submitted by a non-member, a member, or one of the society executive or business office representatives.

We're fortunate to have licensed a non-commercial, proprietary calendaring system that works together with our database software. The Events FYI will provide our membership with a calendar of meetings and other events similar to what is presently available in the Geochemical News. But, like the membership directory, the calendar system can be searched by date, sponsoring organization, venue, and keywords. We'll be encouraging the membership to give Events FYI a local flavor by allowing interactive addition of events, and hope that geoscience and chemistry departments will use this facility to announce seminars and other events of interest to the geochemical community and the public.

Many GS members may not actively participate in the talk lists. But, with the advent of on-line discussion forums, there's an easier, interactive way to keep abreast of the latest ideas and to discuss topics of mutual interest. The GS Forums area will kick off soon with a threaded discussion group focused on general feedback, and on suggestions for expanding the available forums into topical areas. There will also be an open forum, Ask-a-Geochemist, to engage the public audience in question-and-answer type activities in the geochemical sciences. Ask-a-Geochemist will be a spotlighted feature on the GS home page that's easily accessible from most search robots, and can be hot-linked directly from other web sites.

The web pages of professional societies typically provide a static list of links to higher education institutions. Ordinary. With cooperation of university departments and research organizations, the GS plans to take this public service the extra mile, by serving dynamic information about undergraduate and graduate degree programs, teaching and research facilities, and faculty and research staff. We can't hope to achieve this goal alone so, as with the other database-driven areas of the site, we'll encourage participation by universities worldwide by providing an annotated summary for each respondent and search options for specific faculty, institutions, and key research programs.

The job board will be a valuable resource for recent graduates and seasoned professionals who are seeking opportunities for career advancement in the geochemical sciences. Using the global reach and immediacy of the internet, the job board will feature employment listings sorted by date, location, employer, or keyword. In future editions of the job board we'll add interactive forms that will facilitate on-line resumes for job hunters, and employer entry of job details for inclusion in the employment listings. We'll also be opening a careers talk list that can be used by employers to announce their career opportunities to registered talk list users (you'll be able to sign up for the career talk list at the job board).

An important objective of the new GS web presence is to increase the public awareness of geochemical sciences. The educational outreach initiative that I've described above will provide engaging educational activities for the K-12 audience, but it's scope will be limited to teaching modules earmarked for development by the outreach committee. The effort of locating and reviewing existing resources on the web undoubtedly will uncover a wealth of information that has merit but won't be incorporated into an educational module. The Learning Links pages will be devoted to providing these additional teaching resources for K-12 educators in the form of links to resources elsewhere on the web.

RESORCERER

The resorcerer will be our repository of resources for teaching and research. The obvious candidate for inclusion in the resorcerer is an eclectic collection of computer software together with brief annotation. Software that is public domain or shareware can be made available for download from our ftp server or mirrored with the author's permission. We can link to commercial software solutions. A long-range vision is to make available on-line calculations for some software packages, especially those that produce output amenable to graphic display. The resorcerer may also be the logical choice for links to NSF, CREDA, and other research grants and activities in the geochemical sciences.

SPONSORS

The GS will be exploring alternatives for generating revenue from our web presence. The Geochemical News accepts paid advertisements, and this is one method of partial cost recovery if it can be done in an unobtrusive manner. A variation on this theme would be to secure corporate sponsorships and benefactors. Another option, and the one that I prefer, is to develop a searchable directory of geochemical products and services, in which vendors pay and nominal fee to the GS for their cross-referenced listing(s) in the directory. This alternative is attractive because it also provides a valuable free service to our membership and the public, and is capable of drawing non-members into the society.

GS SHOP

The GS intends to enter the age of electronic commerce, although it remains to be seen when, and to what degree, we'll make the leap. Our options vary from maintaining the status quo (with the addition of interactive forms) to a complete e-commerce solution, with automatic credit authorization and debiting, from the web site. We have the technology! In addition to on-line sales of the Special Publications series, we can ease the annual renewal process in the business office by creating on-line membership renewal and application. Registration fees for the Goldschmidt Conference and other GS-sponsored events can also be processed on-line, and we're exploring other possible ways to use e-commerce from our web presence.

CALL FOR VOLUNTEERS

We're in need of a few good men and women. Quite a few. Once on-line, parts of our web site will need to be updated on a regular basis. We'll need to locate content for our professional audience and connect with members who will contribute regularly. The most challenging task for all of the GS membership will be to identify and develop Internet resources for more general outreach to the public and the K-12 community. We need to determine what types of web-based materials will be useful for these groups, and what is already out there. When we do identify good web approaches and needs, we'll need to contribute to their creation by locating or developing content that can be translated into web resources.

Here are just a few of the possible tasks where a little of your time could make a big difference:

- moderators for Ask-a-Geochemist
- moderators for GS threaded discussion groups
- marketing specialists for finding sponsors and benefactors
- points of contact for the events calendar, job board, and higher education
- wannabe graphic artists who can create engaging caricatures - the GS wizards for K-12 outreach

If you're interested in participating in any aspect of locating, creating, or maintaining content for the Geochemical Society web presence please contact Mark Bloom, the Coordinator of Internet Resources, at **msbloom@geochemsoc.org**. Suggestions for ways to improve services to GS members and feedback about these services as they come on-line are always welcome.

Tracy Neil Tingle

January 29, 1957 to October 19, 1996

It is particularly painful when a young person, in the prime of their life and the picture of health and vitality, is suddenly lost. Such was the case when friend and colleague Tracy Neil Tingle died last year at the age of 39 from cancer. Although we memorialize his life here to the scientific community, we cannot do this story justice. Tracy transcended conventional personal and scientific boundaries, and we can only hope to give the reader glimpses of his varied and fascinating years.

Tracy was raised in the small, rural town of Garland, North Carolina. His father was a machinist and inventor, his mother, the town clerk. From a very young age, influenced by his father's independence and creativity, Tracy showed a gift for building and tinkering, skills that would be honed during his formative years by spending hours in his father's shop. He also was deeply influenced by his mother's strong love, intelligence and interest in everyone around her. Almost from the very beginning, Tracy showed the personal characteristics that anyone who knew him as an adult immediately recognized. He was a free spirit, yet at the same time possessed a charming and magnetic personality. And he never got involved with anything that he did not push to the limit. No tale is more appropriate and representative of these traits than the time he took it upon himself to direct traffic in front of a factory that had just let out for the day. The drivers actually obeyed his directions, even though he was only 5 years old at the time! By the time he left for the University of North Carolina at Chapel Hill, he had long since fallen in love with the outdoors and with rocks. Four years later, he was voted the outstanding senior in his geological sciences graduating class.

Tracy's graduate career was spent at the University of California at Davis, first with Philip Fenn for his M.S., and later with Harry Green for his Ph.D., completed in 1987. Given someone with Tracy's inherent talents, it was not surprising that during these years he developed his superior knowledge of and exceptional versatility with a wide range of analytical techniques and instrumentation, high temperature and pressure apparatuses, and computers. His primary contribution as a graduate student was to achieve a far better understanding of carbon solubility and diffusivity in olivine at high pressure and temperature than had ever been possible before. A significant amount of confusion and misinformation was coming into the literature on this subject in the 1980's. It was Tingle and Green (1988) that put definite and reliable limits on carbon solubility and diffusivity in olivine, and allowed for reasonable speculation on the role of carbon in the upper mantle to start once again.

It was also during these years at UC Davis that Tracy took up cycling, and then kayaking, as a hobby. True to Tracy's immense drive, he developed into a national-class rider in the years to follow, and he eventually earned a spot on a top San Francisco-based racing team. In addition, he advanced to be a class V white water kayaker. These are remarkable achievements considering the effort required to reach such a level of athleticism, and at the same time remaining, first and foremost, a truly dedicated and productive scientist.

After his Ph.D., one of us (MFH) hired Tracy as a postdoc, a position that lasted into the fall of 1990. It was during those years that Tracy developed highly successful methods for analyzing the surface of minerals using SALI (surface analysis by laser ionization) along with Christopher Becker, the principal developer of the instrument, at SRI International. This was a new and complex technique that combined single- or multiphoton ionization of desorbed neutral atoms and molecules with analysis by time-of-flight mass spectrometry. Tracy and Chris set up this instrument to be able to measure exceptionally low concentrations of organic molecules on mineral surfaces. Tracy then made the important and surprising discovery that trace concentrations of organic molecules were present on some of the surfaces of minerals from mantle xenoliths. He further determined to a very high confidence level that they did not originate from laboratory or field biogenic contamination, nor did they originate from the mantle itself. Instead, the organics may have originated from assimilation of volcanic gases prior to eruption. However, Tracy also conclusively showed that there was a distinct (and fascinating!) possibility that they could have been the product of abiotic heterogeneous catalysis of volcanic gases on new, chemically active mineral surfaces formed by fracturing during cooling.

Tracy's love for upper mantle mineral physics and chemistry continued when he returned to UC Davis in 1990 as a lecturer and research associate. There, he teamed up once again with Harry Green, this time to contribute to Green's development of the anticrack theory of deep-focus earthquakes. At the same time, Tracy also continued his work using SALI, this time with an intriguing project involving the fate of organic matter within Murchison meteorite fragments after experimental shocking. In collaboration with Jim Tyburczy (now at Arizona State University) and Tom Ahrens at Caltech, he used these results to speculate on the fate of organic molecules during planetary accretion.

Tracy's last professional stop was Stanford's Center for Materials Research (CMR) where he accepted the position of Director of Chemical Characterization Laboratories in 1993. He inherited a somewhat complex situation with balky and out-of-date analysis software and computers on the microprobe, and a dwindling user base at Stanford. Over the next two years he completely turned the facility around with new software and hardware, making it one of the most popular within CMR. Tracy also began to realign his research interests with programs already underway at CMR and the Department of Geological and Environmental Sciences. Thus, he began his studies of arsenic provenance and characterization in mine tailings and other sources within the California gold country. He was part of a program being developed by Dennis Bird to do further studies of arsenic migration and placement, and was particularly interested in chemically and structurally characterizing arsenic-containing pyrite, the weathering process of this and other arsenic-bearing sulfides, and their role as a source of arsenic in natural waters.

Tracy also developed a capability, with the help of John Donovan from UC Berkeley, for accurately determining the thicknesses of multilayer metallic and oxide thin films with the use of the electron microprobe. The determination was based on precise calculation of the x-ray absorption, electron beam penetration depth, and x-ray fluorescence from thin film samples as a function of varied electron beam energy. This method has promise of greatly extending the utility of electron microprobe measurements on thin film samples, which now comprise most of the samples under study by CMR staff, students and faculty.

During these final years Tracy's office was just down the hall from one of us (GAW), and his non-conforming personality was a refreshing change from the typical hard-grinding single-purpose academic clone. Tracy often wore wooden shoes without socks, so his approach from quite a way down the hall was immediately recognizable. His office door was always open, resulting in strong coffee aromas wafting up and down the hall, and an inviting and somewhat used-looking couch was located just inside the doorway. Tracy was always available to enthusiastically discuss scientific problems, and it never mattered whether the project was his, yours, or somebody elses. He had innovative ideas for interesting work in a variety of directions. Tracy preferred to keep his fluorescent room lights off all of the time. This kept his office illuminated only by natural lighting, and with the diversity of mineral and materials science samples about on desks and tables, it felt to the visitor as a distinctive oasis amidst an otherwise cold and character-less building.

Tracy's cancer started as a melanoma lesion on his back that was discovered and surgically removed. Cancer was rediscovered in his body 13 months later, having spread to several vital organs. Tracy spent much of the last year of his life in a heroic battle with a tremendously aggressive form of this disease, using highly promising but still experimental forms of treatment in combination with alternative diet and vitamin therapy. Martha, his wife for less than a year, was heroic in her support. Through these last months, Tracy never lost his love of life, his flair, and especially his hope.

Tracy's great love of the outdoors, punctuated by his many camping excursions, kayaking expeditions, and field geology trips, affected and tempered his outlook on life and science. Coupled with his outgoing nature, ability to develop passion for any enterprise, and striking friendliness and warmth, Tracy had, and continues to have, a very positive influence on many of us. To his family, friends and colleagues, his loss still seems unimaginable. But in his life's wake, he leaves behind an amazingly vivid and lasting memory of his unquenchable spirit. He is, and will remain, dearly missed.

Michael F. Hochella, Jr.
Virginia Polytechnic Institute and State University

Glenn A. Waychunas
Stanford University

Selected Bibliography of Tracy N. Tingle

Tingle T. N. and Fenn P. M. (1984) Transport and concentration of molybdenum in granite molybdenite systems: Effects of fluorine and sulfur. Geology 12, 156-158.

Tingle T. N. and Green H. W. (1987) Carbon solubility in olivine: Implications for upper mantle evolution. Geology 15, 324-326.

Tingle T. N. (1987) An evaluation of the carbon-14 beta track technique: Implications for solubilities and partition coefficients measured by beta track mapping. Geochim. Cosmochim. Acta 51, 2479-2488.

Tingle T. N. (1989) More on the mantle carbon flux. EOS 70, 1513-1514. (Forum article.)

Tingle T. N., Hochella M. F., Jr., Becker C. H. and Malhotra R. (1990) Organic compounds on crack surfaces in olivine from San Carlos, Arizona and Hualalai Volcano, Hawaii. Geochim. Cosmochim. Acta 54, 477-485.

Tingle T. N., Mathez E. A. and Hochella M. F., Jr. (1991) Carbonaceous matter in peridotites and basalts studied by XPS, SALI and LEED. Geochim. Cosmochim. Acta 55, 1345-1352.

Tingle T. N., Becker C. H. and Malhotra R. (1991) Organic compounds in the Murchison and Allende carbonaceous chondrites studied by photoionization mass spectrometry. Meteoritics 26, 117-127.

Tingle T. N., Tyburczy J. A., Ahrens T. A. and Becker C. H. (1992) The fate of organic matter during planetary accretion: Preliminary studies of the organic chemistry of experimentally shocked Murchison meteorite. Origins of Life 21, 385-397.

Tingle T. N. and Hochella M. F., Jr. (1992) Formation of reduced carbonaceous matter in basalts and xenoliths: Reaction of C-O-H gases on olivine crack surfaces. Geochim. Cosmochim. Acta 57, 3245-3249.

Tingle T. N., Green H. W., II, Scholz C. H. and Koczynski T. A. (1993) The rheology of faults triggered by the olivine-spinel transformation in Mg2GeO4 and its implications for the mechanism of deep-focus earthquakes. J. Struct. Geol. 15, 1249-1256.

Tingle T. N., Green H. W., II, Young T. E. and Koczynski T. A. (1993) Improvements to Griggs-type apparatus for mechanical testing at high pressures and temperatures. Pure Appl. Geophys. 141, 523-543.

"Geochemical Record of Hydrologic Response to Climate Change"

GSA Annual Meeting, Salt Lake City, Utah, October 20-23, 1997

Convenors: Emi Ito, University of Minnesota; Jay L. Banner, University of Texas at Austin

These tools are being increasingly applied to geologic records of paleohydrologic processes, such as lacustrine sediments, cave deposits, weathering products, and biota. This approach is essential for improving our understanding of the connections between climate variability and the evolution of natural waters. This symposium will examine the types of geologic records and geochemical tracers of coupled hydrologic-climatic variability, and the prospects for 1) advancing chronologic and spatial resolution of such variability, and 2) integrating continental records with marine and ice-core records.

Tuesday, October 21, 1997

1:30	Introductory Remarks
1:40	Kerry R. Kelts and Emi Ito, "Isotopic composition of paleo-precipitation for mid-Cretaceous high-latitude Kerguelen Plateau from diagenic siderite crystals"
2:00	Thure E. Cerling, Zachary D. Sharp, John M. Harris, and Bruce J. MacFadden, "Tooth enamel as a recorder of hydrologic and climate change"
2:20	Jay L. Banner and MaryLynn Musgrove, "Speleothems and cements as recorders of groundwater response to climate variability"
2:40	Alison J. Smith, "Tracking solute changes in fresh to low salinity waters: ostracodes as geochemical indicators"
3:00	Emi Ito, "Effect of groundwater on the geochemical records of aridity in closed basin lake sediments"
3:20	Julia Cole, David Rind, Jean Jouzel, and Richard Healy, "Interannual variability of stable isotopes in precipitation simulated by a general circulation model: relative impacts of temperature, precipitation, and source region changes"
3:40	Peter J. Fawcett, Alfred M. Ziegler, Michael L. Hulver, and Eric J. Barron, "Global precipitation minus evaporation (P-E) over the last 280 Myr: a comparison of climate model results with the geologic record"
4:00	Suzanne Prestrud Anderson, "Glacial sediment production and chemical weathering"
4:20	Svante Björck (keynote speaker), "Paleoclimatic consequences of synchronized atmospheric and terrestrial records of the last termination"

(Meetings, cont. from page 17)

Oct. 26-29, 1997: Symposium on Climate Variability, Climate Change and Water Resource Management, Colorado Springs, CO USA. Contact: B. Neal, Hagler Bailly Services, Inc., P.O. Box 3524, Eagle, CO 81631; WWW: http://civil.colorado.edu/climate

Oct. 27-31, 1997: Volatile Organic Compounds in the Troposphere, Institute for Atmospheric Chemistry, Juelich Research Center, Juelich, Germany. Contact: Dr. Ralf Koppmann, Institut fuer Atmosphaerische Chemie, Forschungszentrum Juelich, D-52425 Juelich, GERMANY; Tel: + 49-2461-615118; Fax: + 49-2462-618190; Email: r.koppmann@fz-juelich.de

Oct. 27-31, 1997: WCRP First International Conference on Reanalysis, Silver Spring, MD USA. Contact: International GEWEX Project Office, Suite 1210, 1100 Wayne Ave., Silver Spring, MD 20910; Tel: 301-427-2089; Fax: 301-427-2222; Email: gewex@cais.com; WWW: http://www.cais.com/gewex/gewex.html

Oct. 28-Nov. 1, 1997: Mining and Geology Forum-Mineral Raw Resources of the CIS, St. Petersburg, Russia. Contact: Tatiana Perepetch, RESTEC, St. Petersburg; WWW: http://www.spb.su/restec.

Nov. 2-5, 1997: 28th Underwater Mining Institute, Seattle, WA USA. Contact: K. Chong Morgan, Underwater Mining Institute, c/o Marine Minerals Technology Center, 811 Olomehani Street, Honolulu, HI 96813-5513 USA; Tel: 808-522-5611; Fax: 808-522-5618; Email: 70673.534@compuserve.com

Nov. 3-5, 1997: International Conference and Sino-American Symposium on the Tectonics of East Asia, Chungli, Taiwan. Contact: C.-H. Lo, Dept. Of Geology, National Taiwan University, Taipei Taiwan, Fax: 886 2 3636095; Email: lo@suno3.gl.ntu.edu.tw; WWW: http://fermat.geol.uconn.edu/info/taiwan

Nov. 3-7, 1997: Annual Meeting, Mexican Geophysical Union, Puerto Vallarta, Jalisco Mexico. Contact: Victor Manuel Frias C.; Email: ugm@cicese.mx; WWW: http://www.ugm.org.mx

Nov. 8-9, 1997: Structural Controls and Genesis of Economic Resources (Mineral and Hydrocarbon Deposits), The Dave Johnson Memorial Meeting, Trinity College, Dublin, Ireland. Contact: Dr. Ken McCaffrey, Kingston University, Tel: + 44 181 547 2000; Email: k.mccaffrey@kingston.ac.uk

Nov. 9-13, 1997: 43rd Annual Conference on Bioassay, Analytical, and Environmental Radiochemistry, Charleston, SC USA. Contact: N. Slater, 43rd Bioassay Conference, P. O. Box 30712, Charleston, SC 29417; Tel: 803-556-8171; Email: nancy.slater@lims.gel.com; WWW: http://mwanal.lanl.gov/bioassay/bioassay.html

"Organic Perspectives on Geochemical Processes"

GSA Annual Meeting, Salt Lake City, Utah, October 19, 1997

(Co-chaired by John Hedges, Cindy Lee and Stuart Wakeham)

This day-long symposium will highlight organic-based geochemical measurements as complements to inorganic characterizations in studies of environmental processes. The OGD "Sunday Symposium" is designed to bring together a diverse set of geochemists working with modern and ancient environments on land and in the ocean. Eleven invited speakers will cover such diverse processes as soil formation, biodegradation, sorption, sedimentary preservation, and thermal alteration. Speakers will emphasize outstanding questions in their topic areas and assess how new organic measurements and concepts might lead to scientific advances. Generous discussion periods will follow each talk and a parallel poster session will occur. A schedule for the day is given below.

Topic	Time	Speaker	Institution
Introduction	8:00-8:10 am	Cindy Lee	SUNY, Stony Brook
Organic Carbon Cycling	8:10-8:45 am	Rick Jahnke	Skidaway
Weathering/Soil Formation	8:45-9:20 am	Jeff Baldock	CSIRO Soils, Adelaide, OZ
Aging/Dynamics	9:20-9:55 am	Ellen Druffel	UC Irvine
Coffee Break	9:55-10:15 am		
Preservation	10:15-10:50 am	Susan Henrichs	University Alaska Fairbanks
Particle Transport	10:50-11:25 am	Rick Keil	University of Washington
Advection/Diffusion	11:25-12:00 am	Dennis Hansell	Bermuda Biological Station
OGD Business Meeting	12:00-12:30 pm	John Hedges	University of Washington
Lunch	12:30-1:30 pm		
Aggregation/Disaggregation	1:30-2:05 pm	George Jackson	Texas A&M
Sorption/Desorption	2:05-2:40 pm	Baohua Gu	Oak Ridge
Biodegradation	2:40-3:15 pm	Ron Benner	University Texas, Port Aransas
Coffee Break	3:15-3:35 pm		
Photolysis	3:35-4:10 pm	Mary Ann Moran	University of Georgia, Athens
Thermal Alteration	4:10-4:45 pm	Mike Lewan	USGS, Denver
Overview	4:45-5:00 pm	Stuart Wakeham	Skidaway
Poster Session	5:00-6:00 pm		

Nov. 10-16, 1997: Marine Benthic Habitats and their Living Resources, Noumea, New Caledonia. Contact: J.-M. Auzende, IFREMER, c/o ORSTOM, BPAS, 98848, Noumea Cedex Nouvelle Caledonie; Tel: 687 26 07 59; Fax: 687 26 43 26; Email: auzende@noumea.orstom.nc

Nov. 11-14, 1997: International Conference on Isotopes in the Solar System, Ahmedabad, India. Contact: Professor J. N. Goswami, Chairman, Local Organizing Committee, Physical Research Laboratory, Ahmedabad 380 009, INDIA; Tel: 91-79-462129; Fax: 91-79-6560502; Email: isotope@prl.ernet.in

Nov. 11-15, 1997: Comparative Evolution of PeriTethyan Rift Basins, Cairo, Egypt. Contact: William Cavazza, Dept. Earth and Geoenvironmental Sciences, University of Bologna, Bologna, Italy; Fax: 39-51-243-336; Email: cavazza@geomin.unibo.it

Nov. 12-13, 1997: The Rates and Timescales of Magmatic Processes, Geological Society of London, Burlington House, London, UK. Contact: Nick Rogers, Tel: 1908-653013; Fax: 1908-655151; Email: n.w.rogers@open.ac.uk

Nov. 16-19, 1997: International Conference on Advances in Groundwater Hydrology, A Decade of Progress, Tampa, FL USA. Contact: AIH, 2499 Rice St., Suite 135, St. Paul, MN 55113 USA; Tel: 612-484-8169; Fax: 612-484-8357; Email: AIHydro@aol.com

Nov. 17-19, 1997: Applied Geologic Remote Sensing Twelfth International Conference, Denver, CO USA. Contact: Robert Rogers, ERIM, Box 134001, Ann Arbor, MI 48113-4001; Tel: 313-994-1200 ext. 3234; Fax: 313-994-5123; Email: raeder@crim.org

Dec. 8-12, 1997: Fall AGU Meeting, San Francisco, CA USA. Contact: AGU Meetings Dept., 1997 Fall Meeting, 2000 Florida Ave. NW, Washington, DC 20009 USA; Tel: 202-462-6900 or 800-966-2481; Fax: 202-328-0566; Email: meetinginfo@kosmos.agu.com; WWW: http://www.agu.org/meetings/fm97call.html--(Special Session--V11 Geochemical Earth Reference Model (GERM); Contact: Cecil H. or Ida M. Green, Institute of Geophysics and Planetary Physics, Scripps Institution of Oceanography, University of California, San Diego, -0225, La Jolla, CA 92093-0225 USA; Tel: 619-534-8764; Fax: 619-534-8090; WWW: http://www-ep.es.llnl.gov/germ/germ-home/html)

(continued on page 27)

(continued from page 13)

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

C-W-K-H model: Loss or retention of Fe from paleosols has been used as a guide to distinguish whether the soil formed under a reduced or oxic atmosphere, because Fe^{2+}-bearing silicates may be easily dissolved in O_2-free water but are converted to insoluble Fe^{3+}-hydroxides (goethite) in O_2-bearing water. Many investigators[7-8, 39] have suggested that most paleosols older than 2.2 Ga have lost Fe, but essentially all paleosols younger than 2.0 Ga have retained Fe. This was the most important reason for Holland[8-9] to suggest a dramatic rise of P_{O2} between 2.2 and 2.0 Ga.

D-K-O model: Ohmoto[14] has reexamined the behavior of Fe in paleosols using depth profiles of Fe^{2+}/Ti and Fe^{3+}/Ti ratios. Essentially all paleosols, both pre- and post 2.2 Ga in age, have retained some characteristics of soils formed under an oxic atmosphere, such as Fe^{3+}/Ti ratios which increase upward in the soil sections. Also recognized is that many paleosols, both pre- and post 2.2 Ga, have lost some Fe^{3+} as well as Fe^{2+} during and/or after soil formation. Based on available experimental data, Ohmoto[14] suggested that the losses of Fe^{3+} and Fe^{2+} were caused either by organic acids at T < 100°C or by hydrothermal fluids at T > 200 °C, rather than by organic-free, anoxic water during soil formation. Our preliminary $\delta^{18}O$ analyses of the 2.22 Ga Hekpoort paleosols, considered as the best example of paleosols formed under a reduced atmosphere by Holland[7-8], suggest that the loss of Fe was caused by submarine hydrothermal fluids (Ohmoto, in prep.).

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

$\delta^{13}C$ values of organic carbon ($\delta^{13}C_{org}$) in sedimentary rocks may indicate the type of dominant organisms and the redox conditions of the water and sediment columns. The $\delta^{13}C_{org}$ values for Precambrian sedimentary rocks exhibit a larger variation (-50 to -10 ‰) compared to those for modern marine sediments (-35 to -15 ‰ with an average of -25 ‰)[40]. Such a large variation has been found even in 3.8 Ga metasedimentary rocks from the Isua district, Greenland[41].

C-W-K-H model: Hayes and his associates[42-43] have discarded the $\delta^{13}C_{org}$ values higher than ~-30 ‰ as those altered by diagenesis and metamorphism, and suggested that the primary $\delta^{13}C_{org}$ values for >2.2 Ga marine sediments fell in a range between -60 to -30 ‰. Based on these values, they have suggested that the organic carbon cycle in the Archean oceans was strongly influenced by methanogenic bacteria and methanotrophic bacteria, as well as oxygenic photosynthesising organisms, and that, except for a shallow surface layer, the entire ocean was anoxic. His model implies that the atmosphere-ocean system prior to 2.2 Ga was in Stage II of the evolutional history (Fig. 2).

D-K-O model: Based on studies of the effects of thermal maturation of organic matter, Watanabe et al.[17] have concluded that the increase in the $\delta^{13}C_{org}$ value is typically less than 2 ‰ even during intense alteration. Therefore, the large $\delta^{13}C_{org}$ variation (-50 to -10 ‰) suggests that a variety of organisms and redox environments already existed in the Archean oceans, such as the environments dominated by normal marine phyto-organisms (O_2-producers) and those supporting the activity of methanogenic and methanotrophic bacteria. Watanabe et al.[17] also recognized large fluctuations with time in the $\delta^{13}C_{org}$ values, as much as ~25 ‰, within a period of less than 100 Ma, during the 3.0-2.0 Ga history of several sedimentary basins. Such fluctuations only would have been possible when the ocean was basically oxic, with anoxic bottom water conditions developing episodically during the period between 3.0 and 2.0 Ga (Stage III in Fig. 2).

Positive $\delta^{13}C$ shifts in carbonates: evidence for dramatic rises in P_{O2}?

$\delta^{13}C$ values of marine carbonates ($\delta^{13}C_{carb}$) are similar to the $\delta^{13}C$ of HCO_3^- in the ocean, and they may reflect the relative proportions of organic C (f_{org}) and carbonate C (f_{carb}) removed from the ocean. The $\delta^{13}C_{carb}$ values are essentially constant at ~0 ‰ for carbonates of all geologic ages, from ~3.9 Ga to the present, with a few stratigraphically limited exceptions[40].

C-W-K-H model: Karhu and Holland[9,44] have suggested that the carbonates of 2.22-2.06 Ga are characterized by large positive $\delta^{13}C_{carb}$ values, up to ~+10‰, and calculated the f_{org}/f_{carb} ratio during that period to be between 0.6 and 1.2, compared to the present ratio of 0.25. Based on these values, they have concluded that the O_2 production rate during the 2.2-2.06 Ga period was ~2 to ~3 times greater than the present O_2 production rate, and that this is strong evidence for a dramatic rise in atmospheric oxygen. Similar arguments were previously made by Des Marais et al.[42] based on the $\delta^{13}C_{org}$ values of shales of ~2.3 and ~2.1 Ga in age.

Karhu and Holland[9,44] (and also Des Marais et al.[42]) face a dilemma in the method of computing the burial flux of organic carbon (and thus the O_2 production rate) from the f_{org}/f_{carb} ratio. The adopted assumption was that the burial rate of total carbon, which is essentially the same as the total carbon flux from continent to ocean, has been constant at the present value throughout geologic time. This assumption, conflicting with Cloud's model of crustal growth, actually implies that the size of the continental crust has remained constant throughout geologic time. In fact, their ways of calculation will result in a conclusion that the O_2 production rates (and O_2 consumption rates) during most of geologic time when the $\delta^{13}C_{carb}$ values were ~0 ‰ (including the period prior to 2.2 Ga) have been similar to today's values. This, in turn, would necessiate the conclusion that the P_{O2} level has been similar to the present level throughout most of geologic time.

D-K-O model: As discussed above, the positive $\delta^{13}C_{carb}$ shift at ~2.2 Ga may not have been related to increased rates of C_{org} burial. The f_{org}/f_{carb} ratio would increase, if (a) the total carbon flux from the continent to ocean was decreased and/or (b) the precipitation rate of carbonate from ocean was decreased, even if the burial rate of C_{org} remained the same. (A similar suggestion was made by Kump[45] to explain the positive $\delta^{13}C_{carb}$ shifts in the Phanerozoic). It is interesting to note that global glaciation, even at low latitudes, took place just prior to 2.22 Ga[46]. Global glaciation could have caused a decrease in the total carbon flux from continent to ocean and also a decrease in the carbonate precipitation rate, because of combined effects of decreases in the average global surface temperature, rainfall, continental area exposed for weathering, and the ocean-shelf area.

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

D-K-O model: A more direct method of estimating the O_2 production rates is from the organic carbon contents of sedimentary rocks. Watanabe et al.[17] have shown that the organic carbon contents of shales of 3.0-2.0 Ga in the Kaapvaal Craton, when corrected for the losses due to metamorphism, were around 2 wt. %, which are essentially identical to those in Phanerozoic shales. This is probably the best evidence that the O_2 production rates have been constant throughout geologic time, provided that the size of continental crust has been constant. The constancy in the organic carbon contents of sediments and in the crustal size will further imply that the consumption rates of atmospheric O_2 have been constant throughout geologic time.

Conclusions

Cloud's working model for the chemical evolution of the Earth was an excellent synthesis of available geochemical and biological data prior to the development of the theory of plate tectonics and the discovery of submarine hydrothermal systems. As outlined in this article, lines of evidence in favor of the Dimroth-Kimberley-Ohmoto model appear to be accumulating. (Because of the constraint in space, I have deleted other lines of evidence supporting the D-K-O model, such as the mineralogical and isotopic data of volcanogenic massive sulfide deposits, the occurrences of >2.2 Ga red beds, and the trace element and Fe^{3+}/Fe^{2+} data of shales). However, it is still too early to declare that the D-K-O model is correct. I will be pleased if some of the examples given here have created a little doubt about the existing theories (including ours) on the chemical and biological evolution of the Earth, and prompt new investigations by young geochemists with fresh approaches to solve some of the most fundamental problems in geological sciences.

References

1. Cloud, P. *Science* **160**, 729-736 (1968).
2. Cloud, P. *Am. J. Sci.* **272**, 537-548 (1972).
3. Cloud, P. *Econ. Geol.* **68**, 1135-1143 (1973).
4. Walker, J.G.G. *Evolution of the Atmosphere* (Macmillan, New York, 1977).
5. Walker, J.G.G. and Brimblecombe, P. *Precamb. Res.* **28**, 205-222 (19850.
6. Kasting, J.F. *Precamb. Res.* **34**, 205-229 (1987).
7. Holland, H.D. in *The Proterozoic Biosphere* (eds Schopf, J.W. and Klein, C.) 153-155 (Cambridge Univ. Press, 1992).
8. Holland, H.D. in *Early Life on Earth. Nobel Symposium No. 84* (ed Bengston, S.) 237-244 (Columbia University Press, New York, 1994).
9. Karhu, J.A. and Holland, H.D. *Geology* **24**, 867-870 (1996).
10. Dimroth, E. and Kimberley, M. M. *Can. J. Earth Sci.* **13**, 1161-1185 (1976).
11. Ohmoto, H. in *Early Organic Evolution: Implications for Mineral & Energy Resources* (eds Schidlowski, M., Golubic, S., Kimberley, M.M., Mckirdy, D.M., and Trudinger, P.A.) 378-397 (Springer-Verlag, 1992).
12. Ohmoto, H. *Abst. with Programs Geol. Soc. Amer. Ann. Mtgs., Boston, MA* A89 (1993).
13. Ohmoto, H. *Ore Geology Rev.* **10**, 135-177 (1996a).
14. Ohmoto, H. (1996b) *Geology* **24**, 1135-1138.
15. Ohmoto, H., Kakegawa, T., and Lowe, D.R. *Science* **262**, 555-557 (1993).
16. Kakegawa, T. *Unpub. Ph.D. thesis, Penn State Univ* (1997).
17. Watanabe, Y., Naraoka, H., Wronkiewicz, D.J., Condie, K.C., and Ohmoto, H. *Geochim. et Cosmochim. Acta* **61**, 3441-3459 (1997).
18. Knoll, A.H. *Origins of Life* **9**, 313-327 (1979).
19. Taylor, S.R. and McLennan, S.M. *The continental Crust: its Composition and Evolution* (Blackwell Scientific Publications, 1985).
20. Condie, K.C. *Plate Tectonics and Crustal Evolution, third edition* (Pergamon Press, New York, 1988).
21. Veizer, J. in *Early Life on Earth. Nobel Symposium No. 84* (ed Bengston, S.) 208-219 (Columbia University Press, New York, 1994).
22. Armstrong, R.L. *Phil. Trans. R. Soc. Lond.* A **301**, 443-472 (1981).
23. Armstrong, R.L. *Australian J. of Earth Sciences* **38**, 613-630 (1991).
24. Kröner, A. and Layer, P.W. *Science* **256**, 1405-1411 (1992).
25. Bowring, S. A. and Housh, T. *Science* **269**, 1535-1540 (1995).
26. Sylvester, P.J., Campbell, I.H., and Bowyer, D.A. *Science* **275**, 521-523 (1997).
27. Jacobsen, S.B. and Pimentel-Klose, M.R. *Earth and Planet. Sci. Lett.* **87**, 29-44 (1988).
28. Beukes, N.J. and Klein, C. in *The Proterozoic Biosphere* (eds Schopf, J.W. and Klein, C.) 147-151 (Cambridge Univ. Press, 1992).
29. Alibert, C. and McCulloch, M.T. *Geochim. et Cosmochim. Acta* **57**, 187-204 (1993).
30. Hattori, K., Campbell, F.A., and Krouse, H.R. *Geochem. Int.* **22**, 97-114 (1985).
31. Lambert, I.B. and Donnelly, T.H. in *Stable Isotopes and and Fluid Processes in Mineralisation* (eds Herbert, H.K. and Ho, S.E.) 260-268 (Univ. West. Aust. Pub. **23**, 1992).
32. Grandstaff, D.E. *Econ. Geol.* **71**, 1493-1506 (1976).
33. Saager, R. *Geol. Soc. of S. Africa Trans.* **73**, 29-46 (1970).
34. Myers, R.E., Zhou, T., and Phillips, G.N. *Mineral. Magazine* **57**, 395-405 (1993).
35. Phillips, G.N. and Dong, G. *Int. Geol. Rev.* **36**, 65-71 (1993).
36. Sutton, S.J., Ritger, S.D., and Maynard, J.B. *J. Geol.* **98**, 329-341 (1990).
37. Barnicoat, A.C., Henderson, I.H.C., Knipe, R.J., Yardley, B.W.D., Napier, R.W., Fox, N.P.C., Kenyon, A.K., Muntigh, D.J., Strydom, D., Winkler, K.S., Lawrence, S.R., and Conford, C. *Nature* **386**, 820-824 (1997).
38. Gauthier-Lafaye, F. and Weber, F. *Econ. Geol.* **84**, 2267-2285 (1989).
39. Maynard, J.B. *J. Geology* **100**, 279-289 (1992).
40. Schidlowski , M. and Aharon, P. in *Early Organic Evolution* (eds Schidlowski, M. et al.) 147-175 (Springer, Berlin, 1992).
41. Mojzsis, S.J., Arrhenius, G., McKeegan, K.D., Harrison, T.M., Nutman, A.P., and Friends, C.R.L. *Nature* **384**, 55-59 (1996).
42. Des Marais, D.J., Strauss, H., Summons, R.E., and Hayes, J.M. *Nature* **15**, 605-609 (1992).
43. Hayes, J.M. in *Early Life on Earth. Nobel Symposium No. 84* (ed Bengston, S.) 220-236 (Columbia University Press, New York, 1994).
44. Karhu, J.A. *Geol. Surv. Finland Bull.* **371**, 87p (1993).
45. Kump, L.R. in *Biogeochemical Cycles and Global Changes. NATO ASI Series, Vol. 14* (eds Wollast, R., Mackenzie, F.T., and Chou, L.) 475-490 (Springer-Verlag, Berlin Heidelberg, 1988).
46. Evans, D.A., Beukes, N.J., and Kirschvink, J.L. *Nature* **386**, 262-266 (1997).

Acknowledgements

Comments and suggestions on an earlier manuscript from the following colleagues and friends have significantly contributed to the improvement of this article: Y. Watanabe, H. Naraoka, T. Kakegawa, K. Hayashi, K. Yamaguchi, S. Ono, L. & M. Whitfield, R. Mock, R. Hotinski, T. Frank, P.B. Barton, Jr., L.M. Kump, J.F. Kasting, D.H. Eggler, A.W. Rose, M.E. Patzkowsky, K.H. Freeman, M.A. Arthur, and H.L. Barnes. Research on the Archean and Proterozoic systems by my research groups at Penn State and Tohoku has been supported by the National Science Foundation and the Japanese Ministry of Science, Culture, and Education.

(Meetings, cont. from page 25)

Dec. 16-18, 1997: Minerals Management Service 17th Information Transfer Meeting. New Orleans, LA USA. Contact: Office of Conference Services, University of New Orleans, Metropolitan College, ED 122, New Orleans, LA 70148; Tel: 504-280-6680; Fax: 504-280-7317; Email: confmc@uno.edu; WWW: http://www.mms.gov

1998: Canadian Institute of Mining, Metallurgy and Petroleum, 100th Annual General Meeting, Quebec, Canada. Contact: John Gaydos, Meetings Manager, Canadian Institute of Mining and Metallurgy, 1 Place Alexis Nihon, 1210-3400 de Maisonneuve Boulevard West, Montreal, Quebec H3S 3B8, Canada; Tel. 514-939-2710; Fax 514-939-2714.

1998: 10th IAGOD Symposium, Australia. Contact: Professor I. R. Pliner, University of Melbourne, Parkville, VIC 3052, Australia; Tel. 613 3446520; Fax 613 3447761.

Jan. 19-21, 1998: Minerals Colloquium, Ottawa, Ontario, Canada. Contact: Geological Survey of Canada; Tel. 613-992-1600; Fax: 613-996-9820; Email: colloq98@gsc.nrcan.gc.ca; WWW: http://www.nrcan.gc.ca/gsc/mrd/colloq98.htm

Jan. 26-29, 1998: Tailings and Mine Waste '98, Fort Collins, CO USA. Contact: L. Hinshaw, Dept. Of Civil Engineering, Colorado State University, Fort Collins, CO 80523-6081 USA; Tel: 970-491-6081; Fax: 970-491-3584; Email: lhinshaw@vines.colostate.edu

Feb. 12-15, 1998: Tucson Gem and Mineral Show, Tucson, AZ USA. Contact: Tucson Gem and Mineral Society Show Committee, P. O. Box 42543, Tucson, AZ 85733 USA; Tel: 520-322-5773; Fax: 520-322-6031

Feb. 17-20, 1998: 6th International Zonenshain Conference on Plate Tectonics, Moscow, Russia. Contact: E. Pristavakina, Institute of Oceanology, Nakhimosky prosp. 36, Moscow 117851, Russia; Tel: 007-095-124 7396; Fax 007-095-124 5983; Email: prist@sbg.geol.msu.su

(continued on page 28)

(Meetings, cont. from page 27)

Mar. 10-13, 1998: Geochemical Earth Reference Model (GERM) Workshop, Institute for Geophysics and Planetary Physics, Scripps Institution for Oceanography, University of California, San Diego, La Jolla, CA 92093-0225 USA. Contact: Hubert Staudigel, UCSD-IGPP, UCSD-0225, La Jolla, CA 92093-0225; Tel. 619-534-8764; Fax: 619-483-7708; Email: hstaudigel@igpp.ucsd.edu; WWW: http://www-ep.es.llnl.gov/germ/lajolla.html

Mar. 10-13, 1998: Oceanology International '98, Brighton, United Kingdom. Contact: Spearhead Exhibitions Ltd., Ocean House, 50 Kingston Road, New Malden, Surrey KT3 3LZ, UK; Tel: + 44 (0) 181-949-9222; Fax: + 44 (0) 181-949-8186/93; Email: oi98@spearhead.co.uk

Mar. 16-20, 1998: Lunar and Planetary Science Conference, Houston, TX USA. Contact: LeBecca Simmons, Conference Administrator, LPI Publications and Program Services Dept., 3600 Bay Area Blvd., Houston, TX 77058-1113 USA; Tel: 281-486-2158; Fax: 281-486-2160; Email: simmons@lpi.jsc.nasa.gov

Mar. 30-Apr. 3, 1998: 18th Annual Hydrology Days, Fort Collins, CO USA. Contact: J. Montera, Dept. Of Civil Engineering, Colorado State University, Fort Collins, CO 80523-1372; Tel: 970-491-7425; Email: jmontera@engr.colostate.edu

Mar. 30-Apr. 4, 1998: International Association of Geochemistry and Cosmochemistry, Water Rock Interaction-9, Taupo, New Zealand. Contact: B. W. Robinson; Tel. 64-7-374-8211; Fax: 64-7-374-8199; Email: wri-9@gns.cri.nz, WWW: http://www.ruamoko.gns.cri.nz/wri-9.html

Apr. 13-16, 1998: Experimental Mineralogy, Petrology & Geochemistry, Orleans, Cedex, France. Contact: EMPG-VII Organising Committee, CNRS-CRSCM, 1A Rue de la Ferollerie, 45071 Orleans Cedex 2, France; Tel: + 33 02 38 25 53 96; Fax: + 33 02 38 63 64 88; Email: empg@cnrs-orleans.fr

Apr. 13-17, 1998: Seventh International Kimberlite Conference, University of Cape Town, Rondebosch, South Africa. Field trips between April 6-12 and 19-24, 1998. Contact: James Gurney, Secretary/Treasurer, 7IKC, Dept. Of Geological Sciences, University of Cape Town, Private Bag, Rondebosch, 7700, South Africa; Tel: + 27 21 531 3162 or + 27 82 550 2004; Fax: +27 21 650 3783; WWW: http://www.uct.ac.za/depts/geolsci/7ikc/

Apr. 14-18, 1998: Geoscience '98, Keele University, Staffordshire, UK. Contact: Conference Dept., Tel: 44-171-4349944; Fax: 44-171-4398975; Email: conf@geolsoc.cityscape.co.uk

Apr. 20-23, 1998: Eighth Symposium on Environmental Toxicology and Risk Assessment, Atlanta, GA USA. Contact: D. S. Henshel, Indiana University, SPEA 340, Bloomington, IN USA; Tel: 812-855-4556; Fax: 812-855-7802; Email: dhenshel@indiana.edu

Apr. 27-30, 1998: International Conference on Modern Preparation and Response Systems for Earthquake, Tsunami, and Volcanic Hazards, Santiago, Chile. Contact: B. Bolt, Dept. Of Geology and Geophysics, University of California, Berkeley, CA USA; Fax: 510-845-4816; Email: boltuc@socrates.berkeley.edu

May 3-7, 1998: 34th Forum on the Geology of Industrial Minerals, Norman, OK USA. Contact: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 E. Boyd St., Room N-131, Norman, OK 73019 USA; Tel. 405-325-3031 or 800-330-3996; Fax: 405-325-7069

May 5-8, 1998: Fractal Scaling, Non-Linear Dynamics, and Chaos in Hydrologic Systems, Anderson, SC USA (Clemson University). (Abstract deadline: Jan. 8, 1998) Contact: AGU Meetings Dept., 2000 Florida Avenue, NW, Washington, DC 20009 USA ; Tel: 202-462-6900 or 800-966-2481 (North America only) ; Fax: 202-328-0566; Email: meetinginfo@kosmos.agu.org; WWW: http://www.agu.org

May 13-15, 1998: Advances in Fluid Mechanics (AFM 98), Udine, Italy. Contact: P. Doughty-Young, AFM 98, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, 2040 7AA UK; Tel: 44-1703-293-223; Fax: 44-703-292-853; Email: paula@wessex.ac.uk; WWW: http://www.wessex.ac.uk/

May 14-18, 1998: Linking Spatial and Temporal Scales in Paleoecology and Ecology, Annapolis, MD USA. Contact: A. Cohen, Dept. Of Geosciences, University of Arizona, Tucson, AZ 85721 USA; Tel: 520-621-4691; Fax: 520-621-2672; Email: acohen@geo.arizona.edu

May 18-20, 1998: Quebec Canada Joint Meeting Geological Association of Canada, Mineralogical Association of Canada, and Association Professionnelle des Geologues et des Geophysiciens du Quebec. Contact: Agathe Morin, Dept. Of Geology, Universite Laval, Pavillon Adrien-Pouliot, Sainte-Foy Quebec G1K 7P4, Canada; Tel: 418-656-2193; Fax: 418-656-7339; Email: quebec1998@ggl.ulaval.ca; WWW: http://www.ggl.ulaval.ca/quebec1998.html

May 18-21, 1998: First International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, USA. Contact: J. Purvis, The Conference Group, Inc., 1989 West Fifth Ave., Suite 5, Columbus, OH 43212-1912 USA; Tel. 800-783-6338 or 614-424-5461; Fax 614-488-5747

May 22-27, 1998: European Research Conference on the Geochemistry of Crustal Fluids: Reactive Transport in Natural Systems, Aghia Pelaghia, Crete, GREECE. Contact: Eric H. Oelkers, Laboratoire de Geochimie, Universite Paul Sabatier, 31000 Toulouse FRANCE; Tel: 33 5.61.55.87.85; Fax: 33 5.61.52.05.44; Email: oelkers@cict.fr

May 26-29, 1998: Spring AGU Meeting, Boston, MA USA. Abstract Deadline: Feb. 19, 1998 (by mail) or Feb. 26, 1998 (via WWW). Contact: AGU Meetings Dept., 2000 Florida Ave. NW, Washington, DC 20009; Tel: 800-966-2481 or 202-462-6910, ext. 215; Fax: 202-328-0566; Email: meetinginfo@kosmos.agu.org (subject: 1998 Spring Meeting); WWW: http://earth.agu.org/meetings/sm98top.html

June 1-4, 1998: The Oceanography Society and IOC Meeting on Coastal and Marginal Seas, UNESCO Headquarters, Paris, France. Contact: J. Rhodes, The Oceanography Society, 4052 Timber Ridge Drive, Virginia Beach, VA 23544; Tel: 757-464-0131; Fax: 757-464-1759; Email: rhodesj@exis.net; WWW: http://www.tos.org

June 4-12, 1998: Evolution of Ocean Island Volcanoes, Galapagos Islands, Ecuador. (Abstract deadline: Jan. 15, 1998) Contact: Dennis Geist, Dept. Of Geology, University of Idaho, Moscow, ID 83844; Tel: 208-885-6491; Fax: 208-885-5724; Email: dgeist@uidaho.edu

June 16-20, 1998: 8th Pacific Congress on Marine Science and Technology, Seoul, Korea. (Abstract deadline: Jan. 15, 1998) Contact: PACON International, P. O. Box 11568, Honolulu, HI 96828; Tel: 808-956-6163; Fax: 808-956-2580.

June 23-27, 1998: 7th International Conference on Permafrost, Yellowknife, Canada. Contact: J. A. Heginbottom, Geological Survey of Canada, 601 Booth St., Ottawa, Ontario, Canada K1A 0E8; Tel. 613-992-7813, Fax 613-992-2468; http://www.ncrcan.gc.ca/gsc/permaf_e.html

June 29-July 15, 1998: 8th International Platinum Symposium (IAGOD/CODMUR), Johannesburg, South Africa. Contact: Dr. C. A. Lee, P.O. Box 68108, Bryanstown, SOUTH AFRICA; Tel: + 27 1127 373 2580; Fax: + 27 1127 836 0371; Email: clee@amplats.co.za

July 4-11, 1998: Processes of Crustal Differentiation (Geological Society of America), Verbania, Italy. Contact: Tracy Rushmer, Dept. Of Geology, University of Vermont, Burlington, VT 05405 USA; Tel: 802-656-8136; Fax: 802-656-0045; Email: trushmer@zoo.uvm.edu

July 7-14, 1998: Coupled Ocean-Atmosphere Response Experiment '98 (COARE98), Boulder, CO USA. Contact: B. Jackson, University Corporation for Atmospheric Research/ Joint Office for Science Support Program Support Group, P.O. Box 3000, Boulder, CO 80307-3000 USA; Tel: 303-497-8663; Fax: 303-497-8633; Email: bjackson@ucar.edu; WWW: http://www.joss.ucar.edu/joss_psg/project/coare98/

July 11-17, 1998: IAVCEI International Volcanological Congress '98, Rondebosch, South Africa. Contact: Secretariat, IAVCEI 1998, Dept. Of Geological Sciences, University of Cape Town, Rondebosch, South Africa; Fax: + 27 21 650 3783; Email: ivc98@geology.uct.ac.za; WWW: http://www.uct.ac.za/depts/geolsci/ivc98/

July 21-24, 1998: 1998 Western Pacific Geophysics Meeting, Taipei, Taiwan. Contact: Tel: 800-966-2481 or 202-462-6900; WWW: http://www.agu.org (Click on Meetings, Click on 1998 Western Pacific Geophysics Meeting)

Aug. 5-8, 1998: Eighth International Symposium on Solubility Phenomena, Niigata, Japan. Contact: Kiyoshi Sawada, General Secretary of the 8th ISSP, Dept. Of Chemistry, Faculty of Science, Niigata University, Niigata 950-21, Japan; Tel: + 81 25 262 6265; Fax: + 81 25 262 6116; Email: issp@sc.niigata-u.ac.jp

Aug. 9-12, 1998: 4th International Symposium on Environmental Geotechnology and Global Sustainable Development, Boston, MA USA. (Abstract deadline: Nov. 15, 1997) Contact: H. I. Inyang, Center for Environmental Engineering and Science Technologies, James B. Francis College of Engineering, University of Massachusetts-Lowell, One University Avenue, Lowell, MA 01854 USA; Tel: 508-934-2285; Fax: 508-934-3092; Email: inyangh@woods.uml.edu

Aug. 9-14, 1998: International Mineralogical Association: IMA '98, 17th General Meeting, Toronto, Canada. Contact: Professor A. J. Naldrett, Dept. Of Geology, University of Toronto, Canada M5S 3B1; Tel: 461-978-3030; Fax: 416-978-3938; Email: ima98@quartz.geology.utoronto.ca

Aug. 10-16, 1998: International Ophiolite Symposium and Field Excursion; Generation and Emplacement of Ophiolites Through Time, Oulu, Finland. Contact: Jouni Vuollo, Dept. Of Geology, University of Oulu, FIN-90570 Oulu, Finland; Fax: + 358-81-5531484; Email: vuollo@sveka.oulu.fi or Eero Hanski, Geological Survey of Finland, P.O. Box 77, FIN-96101 Rovaniemi, Finland; Fax: + 358-60-3297289; Email: eero.hanski@gsf.fi

Aug. 15-20, 1998: Sixth International Congress on History of Oceanography, Qingdao, China. (Abstract deadline: Nov. 30, 1997) Contact: G.-K. Tan, First Institute of Oceanography, SOA, 3A Hongdao Branch Road, Qingdao 266003. P. R. China; Tel: + 86-532-2883127; Fax: + 86-532-2879562; Email: fiokjc@ns.qd.sd.cn

Aug. 17-20, 1998: The Second International Conference on Climate and Water, Espoo, Finland. Contact: N. Helenius, Helsinki University of Technology, Water Res. Eng., Tietotie 1, FIN-02150 Espoo, Finland; Tel: + 358 9 275 3835; Fax: + 358 9 451 3827; Email: nheleniu@ahti.hut.fi; WWW: http://ahti.hut.fi/wr/caw2

Aug. 19-25, 1998: Global Atmospheric Chemistry and Climte, Seattle, WA USA. Contact: Patricia Quinn, CACGP/ICAG Meeting - 1998, NOAA/PMEL OCRD, Bldg. 3, 7600 Sand Point Wa NE, Seattle, WA 98115 USA; Fax: 206-526-6744; Email: quinn@pmel.noaa.gov

Aug. 20-26, 1998: World Congress of Soil Science, Montpellier, France. Contact: Agropolis- Avenue, Agropolis-34394, Montpellier, Cedex 5, France; Tel: 33 6704 7538; Fax: 33 6 7549

Aug. 30-Sep. 3, 1998: 8th Annual V.M. Goldschmidt Conference, Toulouse, France. WWW: http://www.obs-mip.fr/omp/umr5563/goldconf98.html

Aug. 30-Sep. 4, 1998: Clay Mineralogy and Petrology Conference and Workshop, Brno, Czech Republic, by International Geological Correlation Programme Project No. 405. Contact: Petr Sulovsky, Dept. Of Mineralogy, Petrology, and Geochemistry, Faculty of Science, Masaryk University, Kotlarska 2, CZ 611 37 Brno, Czech Republic; Fax: + 420 541211214; Email: clays@sci.muni.cz

Sep. 21-25, 1998: GQ '98: International Conference and Special Workshops on Groundwater Quality: Remediation and Protection, Tubingen, Germany. Contact: Conference Secretariat GQ '98, c/o Lehrstuhl fur Angewandte Geologie, Sigwartstrasse 10, D-72076 Tubingen, Germany; Tel: + 49-7071-2974692; Fax: + 49-7071-5059; Email: mike.herbert@uni-tuebingen.de

Oct./Nov. 1998: Physical, Chemical and Biological Aspects of Aquifer—Stream Sediment Interrelations, 28th IAH Congress. Contact: Dr. J. Rosenschein, USGS, MS 414, National Center, Reston, VA 22092, USA; Fax 703-648-5722.

Oct. 26-29, 1998: 1998 GSA Annual Meeting, Toronto, Canada. Contact: GSA, 3300 Penrose Place, Boulder, CO 80301 USA; Tel: 303-447-2020; Fax: 303-447-1133; WWW: http://www.geosociety.org/meetings/index.htm

Nov. 14-19, 1998: Ninth International Symposium on Recent Crustal Movements (CRCM '98), Luxor, Egypt. Contact: A. Tealeb, National Research Institute of Astronomy and Geophysics, Helwan, Cairo, Egypt; Tel: 00202-780645; Fax: 00202-78683; Email: gad@Frcu.eun.eg

Dec. 6-10, 1998: Fall AGU Meeting, San Francisco, CA USA. Contact: AGU Meetings Dept., 2000 Florida Ave. NW, Washington, DC 20009; Tel: 800-966-2481 or 202-462-6910, ext. 215; Fax: 202-328-0566; Email: meetinginfo@kosmos.agu.org (Subject: 1998 Fall Meeting)

THE GEOCHEMICAL SOCIETY SPECIAL PUBLICATION SERIES

Volume	Title	Year	Institutions & Non-member Price	Member Price
1	Magmatic Processes: Physiochemical Principles Edited by B.O. Mysen	1987	US$20.00	
2	Fluid-Mineral Interactions: A Tribute to H.P. Eugster Edited by R.J. Spencer and I-Ming Chou	1990	US$20.00	
3	Stable Isotope Geochemistry: A Tribute to Samuel Epstein Edited by H.P. Taylor, J.R. O'Neil, I.R. Kaplan	1991	US$20.00	
4	Victor Moritz Goldschmidt: Father of Modern Geochemistry by Brian Mason	1992	US$15.00	
5	Mineral Spectroscopy: A Tribute to Roger C. Burns Edited by M. D. Dyar, C. McCammon, and M. W. Schaefer	1996	US$65.00	US$35.00

Prepayment in U.S. dollars is required. Please remit the proper amount by check, money order, or credit card (Mastercard and Visa only). All payments must be made to the Geochemical Society. Price includes postage (bookrate/foreign surface). Please send payment to:

The Geochemical Society
c/o Dr. Donald Elthon
Department of Chemistry
University of Houston
Houston, TX 77004

FAX: USA (713) 743-8281

E-Mail: elthon@uh.edu

Name & Address

☐ **Check here if GS member**

Phone: _____
Fax: _____
e-mail: _____

ORDER: Special Publication Volume(s): please specify quantity

1 _____ 2 _____ 3 _____ 4 _____ 5 _____ Please total: $ _____

If paying by credit card, please provide the necessary information below:
(circle one)
Mastercard
Visa

Number: _____ Exp. _____

Signature _____

GEOCHEMICAL SOCIETY MEMBERSHIP APPLICATION 1998

The Geochemical Society, Inc. and *Geochimica et Cosmochimica Acta*

In order to process your application for membership in the Geochemical Society and begin your subscription to *Geochimica et Cosmochimica Acta* for 1998, please fill out this form and mail it with your payment to:

Sue Viers, Business Manager
The Geochemical Society
1350 W. Fifth Ave., Suite 219
Columbus, OH 43212 USA

To assure proper credit and to provide us with accurate records, please fill in the following information **(please print or type)**:

LAST NAME, First Name _____

Department _____

Institution _____

Street Address _____

City _____

State _____ Zip Code _____ Country _____

Telephone _____ FAX _____

E-Mail _____

Would you like to be affiliated with the Organic Geochemistry Division?

Yes _____ No _____

(There is no extra charge for membership in the Organic Geochemistry Division)

What is your main area of interest?

_____

***Please make checks and money orders payable to The Geochemical Society.**

Regular membership & subscription to GCA: $150.00 ____
Student membership & subscription to GCA: $50.00 _____
Regular Membership only: $25.00 _____
Student Membership only: $5.00 _____
*Gift Memberships are available at the same prices (below)

If you selected Membership only, why did you decide not to subscribe to *Geochimica et Cosmochimica Acta*?

_____

_____

***Payment must be made in U.S. Currency and may be made by check (drawn on a U.S. Bank and it must have account tracking numbers), money order, or credit card (Mastercard/Visa only).**

Payment by: Check_____ Money Order _____
Mastercard_____ Visa_____

Credit card account number _____

Expiration Date _____

Signature _____

STUDENT MEMBERSHIP/SUBSCRIPTION: (Department chair must sign to certify that student is enrolled in a degree granting institution of higher learning).

I certify that _____ is enrolled at my institution _____ and that s/he is a candidate for a degree.

Signature of Department Chair:

_____

***GIFT MEMBERSHIP/SUBSCRIPTION (Please provide the recipient's name and address below).**

LAST NAME, First Name _____
Department _____
Institution _____
Address _____
City _____ State _____ Zip Code _____
Country _____ Telephone _____

Do you wish to be identified as a donor?
Yes _____ No _____

Thank you for your support!

New From Elsevier Sciences Ltd.!

FREE access to EPSL-online* until January 1999

EPSL Online: Earth and Planetary Science Research made easy!

The online version of Earth and Planetary Science Letters

http://www.elsevier.nl/locate/epsl
http://www.elsevier.com/locate/epsl

** Provided your institution subscribes to the paper version of EPSL*

With EPSL Online you can enjoy the following extra services and conveniences:

- 24-hour-a-day access to full text articles (HTML and PDF), including 1996 back issues
- access to full abstracts of the articles in the reference list
- keyword thesaurus
- sophistocated search and browse options for full-text articles
- datasets and colour figures

How to register?

The easiest way to register is via the electronic registration form on the homepage. This electronic form will automatically generate your IP address and/or the domain name of your server. By registering your site all the people working at your institution may obtain desk top access to EPSL Online.

Articles available in EPSL Online:

EPSL Online contains everything published in Earth and Planetary Science Letters since January 1996, and is updated simultaneously with the monthly publication of the paperbound issue.

CHEMICAL AND ANALYTICAL SCIENCES DIVISION
c/o D. J. Wesolowski
Oak Ridge National Laboratory
P.O. Box 2008, 4500S, MS 6110
Oak Ridge, TN 37831-6110