THE GEOCHEMICAL NEWS

Quarterly Newsletter of The Geochemical Society

NUMBER 105 *ISSN 0016-7010* **OCTOBER 2000**

Living With Cyanide

- page 16

Goldschmidt 2001

May 20-24, 2001
Roanoke, Virginia, U.S.A.

(see page 8 for information)

http://cass.jsc.nasa.gov/meetings/gold2001/gold2001.1st.html

In this issue:

OFFICERS - 2000

President
Michael F. Hochella, Jr., Virginia Polytechnic Institute

Vice President
Judith McKenzie, ETH, Zurich

Past President
Michael J. Drake, University of Arizona

Secretary
David J. Wesolowski, Oak Ridge National Laboratory

International Secretary
S. Ross Taylor, Australian National University

Treasurer
Rebecca Lange, University of Michigan

Chair, Organic Geochemistry Division
Mike Engel, University of Oklahoma

Secretary, Organic Geochemistry Division
Peggy Ostrom, Michigan State University

DIRECTORS

Thure Cerling, University of Utah
Jochen Hoefs, Universität Göttingen
Albrecht W. Hoffman, Max Planck Institut f. Chemie
Alexandra Navrotsky, University of California - Davis
R. Keith O'Nions, Oxford University
K. Vala Ragnarsdottir, University of Bristol
Everett L. Shock, Washington University

EDITORS

GEOCHIMICA ET COSMOCHIMICA ACTA
Frank Podosek, Washington University

GEOCHEMICAL NEWS
Neil C. Sturchio, University of Illinois at Chicago

INTERNET COORDINATOR
Bob Nichols, Washington University

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

THE GEOCHEMICAL SOCIETY

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

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

Editor's Corner *(Note our new address)*

Neil C. Sturchio, Editor
Earth & Environmental Sciences
University of Illinois at Chicago
845 West Taylor St. (M/C186)
Chicago, IL 60607-7059 U.S.A.

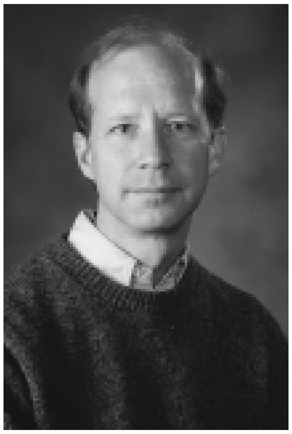
Phone: 312-355-1182
Fax: 312-413-2279
Email: Sturchio@uic.edu

ASSOCIATE EDITORS
Janne Blichert-Toft, Lyon(France)
Yoko Furukawa, Naval Research Laboratory(USA)
John M. Hanchar, University of Notre Dame (USA)
Mitch Schulte, NASA Ames Research Center (USA)
Angelina W. M. G. Souren, Armadillo Research, Amsterdam(Netherlands)

ASSISTANT EDITOR
Dolores Sturchio, Naperville, Illinois (USA)

From the President

The 2000 Goldschmidt meeting -


Mike Hochella

The Goldschmidt meeting in Oxford last month was a great experience for me. Despite extensive travels in England over the years, I had never been to this place that seems to be synonymous around the world with teaching and learning. After all, they have been doing it there since the 12th century (at least), in more or less a form that we would recognize today. I must admit that I spent a good deal of time between and after sessions in bookstores, museums, musical performances, and more historical points of interest than I can remember.

A number of conferees were unfortunately caught up in administrative and housing problems, but I did not hear any complaints about the science presented. It was indeed impressive, and the biggest problem that I had was trying to figure out how to be at two sessions at the same time. Over 800 abstracts were submitted to the meeting on geochemical subjects ranging from the biogeochemistry of microbes to the weathering of continents to the formation of planets. After a full week in Oxford, I was not burned out, but energized. Thanks to Max Coleman, Chris Hawkesworth, and Keith O'Nions, as well as Cambridge Publications, for putting on quite a show, and for doing the best they could under very difficult organizational constraints and limitations imposed by, well, let's just say centuries of history and tradition. That's Oxford.

Board of Directors meeting in Oxford -

All day on the Saturday before the Goldschmidt Conference began, the Board of Directors of the Geochemical Society met in a magnificent room in the Oxford college of Christ Church. I was nominally in charge, although I wonder about that with Henry VIII keeping watch over our meeting from a grand and historic portrait above. The meeting minutes as compiled by Dave Wesolowski are included in this issue of the GN. I will only briefly summarize here some highlights of our annual meeting.

- GS membership has dropped over the last few years, while all other indicators of GS activities (GCA, Goldschmidt meetings, GN, G-cubed, RiM&G, etc.) are strongly up. We are going to put our finger in the membership dike now, and I am confident that the GS membership will stabilize and perhaps even grow in each of the next few years.
- For the third straight year, GS membership rates will remain exactly the same, that is dues of only $25 (professionals) and $5 (students). GCA subscriptions rates will also remain the same for the third year in a row ($122 for professionals and $45 for students). At over 4,000 pages per year, GCA is a bargain, and is actually less expensive than some society-published journals on a cost per page basis.
- The Treibs medal, awarded by the Organic Geochemistry Division of the GS every other year, will now be awarded each year. In addition, I appointed an *ad hoc* committee (Judith McKenzie, Peggy Ostrom, Vala Ragnarsdottir, and Dave Wesolowski) to look into expanding the number of medals presented each year by the GS.
- Finally, we agreed to initiate a GS Meetings Assistance Program (or GS MAP). The idea is for GS to invest $20K per year in supporting the Goldschmidt and other geochemically relevant meetings. More details on this program, and how to apply for funding, appear in this GN.

Future Goldschmidt Conference locations -

For those who like to plan ahead, or if you are just curious, here are the locations that have been approved for future Goldschmidt meetings beyond next year's Virginia meeting:

- 2002 Goldschmidt, Davos, Switzerland, August 17-23
- 2003 Goldschmidt, Kurashiki, Japan, September 7-12.
- 2004 Goldschmidt, Copenhagen, Denmark

Note that 2003 is normally a North American "year" for the Goldschmidt Conference. However, the GS sponsors and organizes major portions of GSA and AGU meetings in the States each year. In this context, we felt that we could skip a North America Goldschmidt meeting by going with a generous offer from Japan. Japanese geochemistry is alive and well, to say the least (the Geochemical Society of Japan has 800 members!). Going to Japan in 2003 will be a great opportunity for the GS to become more international in both our membership and science.

Best regards to all,
—*Mike*

Geochemical Society Business

Please address all inquiries and correspondence concerning memberships, subscriptions, address changes, and charitable contributions to:

Seth Davis
Earth & Planetary Sciences
Washington University
One Brookings Drive, Box 1169
St. Louis, MO 63130, USA
Tel. 314-935-4131; Fax. 314-935-4121
e-mail: office@gs.wustl.edu

Letters

Dear Editor:

I write about an article that appeared in the previous issue (#104) of *The Geochemical News* that dealt with a cyanide spill in NW Romania. There were a few inaccuracies in that article and it would be better if the matter was corrected. Baia Mare is a city founded in the 12th Century; it was a major gold mining center and for a few hundred years it yielded the most gold in Europe. The word "Baia" means pan - as in panning for gold, and the same applies to Baia Sprie, Baia Borsa, and Baia de Arama. Baia Mare was not a spa. In Hungarian, the name of the city is "Nagybanya" which means "the large mine". I was born there and my father was the engineer who built the largest flotation station. I hope this will shed some light on the matter.

Monica C. Dumitrescu

Dear Dr Dumitrescu:

Thank you very much for adding your personal input about Baia Mare. The translation 'large spa' of the name 'Baia Mare' was given by an Eastern Europe editor of a rather 'serious' and renown Dutch radio station. I had no reason to think that it might be incorrect, but am truly sorry to learn that it was. I was aware of the fact that Baia Mare has a very long mining history, but I did not know that it was actually built in the 12th century.

Angelina Souren

Dear Editor,

I write concerning the article entitled "Weeping rivers: Cyanide spills in Romania" published in volume 104 (July 2000) of *The Geochemical News*. The subject matter of this article is very contentious, and is the focus of several international lawsuits. The author, Angelina Souren, whose address and credentials are not provided in the article, sets out to review the events surrounding this disaster, indicating in the first paragraph that key questions such as "What happened where and when" (doubtless of great interest to the lawyers involved in the case) will be addressed. Unfortunately, what follows is a totally unreferenced, unattributed, and unverifiable account of events. For example, quotations and comments are given with no or vague attribution ("A WHO report," "A worker...," "Other reports," p. 14; "'Unbelievably huge quantities of dead fish' [no source]," "...commented someone," p.15). As a scientist, I therefore reject this as an authoritative account of these events, and was surprised to read it in our society newsletter.

Clearly something went disastrously wrong at Baia Mare in January of this year, and the company involved, whether culpable or not, was quick to respond in stopping the spill. Accidents will happen, and no doubt the courts will decide whether negligence, the taking of unacceptable risks, or simply bad luck were to blame for the spill. The benefits of the Aural S.A. plant operation are easily forgotten, however: wealth creation aside, modern reprocessing of old mine tailings sites is designed not only to extract valuable metals left behind from the first processing, but renders the tailings less contaminated and less hazardous to the environment. Thus, an alternative view to the media's wholly negative portrayal of the operators is that they were actually attempting to do an environmental service, but were overtaken by events. After lessons have been learned about local containment requirements, I hope that the Romanian government encourages more companies to tackle the issue of tailings reprocessing and clean-up. Otherwise, as noted in this article, the people of Baia Mare can look forward to many more decades of lead poisoning and low life-expectancy.

Jeremy P. Richards
Department of Earth & Atmospheric Sciences
University of Alberta, Edmonton, T6G 2E3 Canada
Jeremy.Richards@UAlberta.CA

Dear Dr. Richards:

Thank you very much for your letter, which was forwarded to me and which I have read with great interest.

I fully agree with your comment that my article cannot be regarded as an authoritative account. The article did not claim to be an authoritative account and was not intended as such either. Perhaps I should have made that clearer. At the time, I expected that the use of thoroughly unscientific expressions like 'weeping rivers' and 'the river smiled again' would make that sufficiently clear. The item was only a backdrop for the next article, particularly aimed at those who are not familiar with the case at all. I used the phrase 'appetizer'. I intended to communicate some of the impact of geochemical issues on society, nothing more.

You wonder who I am and what my credentials are. I am one of the Associate Editors for *The Geochemical News* and that information, as well as my affiliation (and contact details) was listed elsewhere in the issue, as usual. I am not involved in any way with the situation in Eastern Europe, but am in touch with Hanneke Vreugdenhil who is.

You write that you missed literature references and felt that they should have been included with the article. Again, I agree with you. I had planned to supply them at the end of the two-part series, but had mentioned to a colleague that I really should have added them to the first part, only a few days before I received your comment. The article was written in a great hurry (also evident in typos and style errors). I had been tied up in a different project, but I had promised copy for the GN. I felt that, while the item certainly would not go down in history as an example of my best writing, it had sufficient 'entertainment value' to be submitted. Indeed, not everyone disliked it.

You express your disapproval of the use of expressions such as 'a worker' and 'someone commented'. Frankly, I don't think that details such as the names of the worker, who discovered the spill, and of the person who said that Esmeralda's claim that the fish were killed by the low temperatures was like claiming that a kangaroo involved in a road kill was killed by the sun, would have improved the article. The official UNEP/OCHA report did not list the name of the worker either and used similar expressions as I did. I am sure that the name of the worker who discovered the spill will be mentioned in the law suits, but I didn't consider these details of any geochemical significance, and not fitting in with the overall 'loose' style either.

It also appears to me that you feel that I was blaming the Aurul plant for the disaster. I did imply that it looks as if the Esmeralda company made mistakes in how they handled the matter (public relations) and I did write that apparently there were delays at the local authority level. I also wrote that the Aurul plant stopped its operations soon after it became aware of the problem and promptly informed the authorities. I assure you that I am not blaming anyone for the disaster and certainly not the Aurul plant.

Perhaps the real issue here is: What do our readers expect from *The Geochemical News*? Can we provide it? Are we willing to provide it? I am saying this because I am very much aware of the facts that the cyanide article in the present issue will have done some legwork for anyone wanting to write a grant proposal in that area and that ISI won't give me any brownie points for it. Should the newsletter become a scientific journal with only 'proper' scientific articles? Or should it only carry interviews and meeting announcements, but stay away from scientific matters? Or could it be something in between, a communication medium with room for discussion, between geochemists all over the world?

Obviously, last time I wrote about a topic that greatly interests you and about which you feel very strongly. I'm inviting you to write an article for the GN. Shed more light on issues that concern us all, as geochemists! You clearly have something to offer and I'm sure that most readers would love to hear more. I certainly do.

Angelina Souren
Armadillo Research Services
Angie@armadillo-research.com

Molecular Modeling Theory and Applications in the Geosciences

Geochemical Society and Mineralogical Society of America

Short Course

Randall T. Cygan and James D. Kubicki, Organizers

May 19 and 20, 2001
(precedes Goldschmidt Conference)
Hotel Roanoke and Conference Center
Roanoke, Virginia, USA

The course will focus on techniques and applications for modeling a wide variety of problems in mineralogy and geochemistry. Those interested in using molecular modeling in research or understanding papers in computational chemistry should attend.

www.sandia.gov/eesector/GScourse.htm

2001 Membership Drive

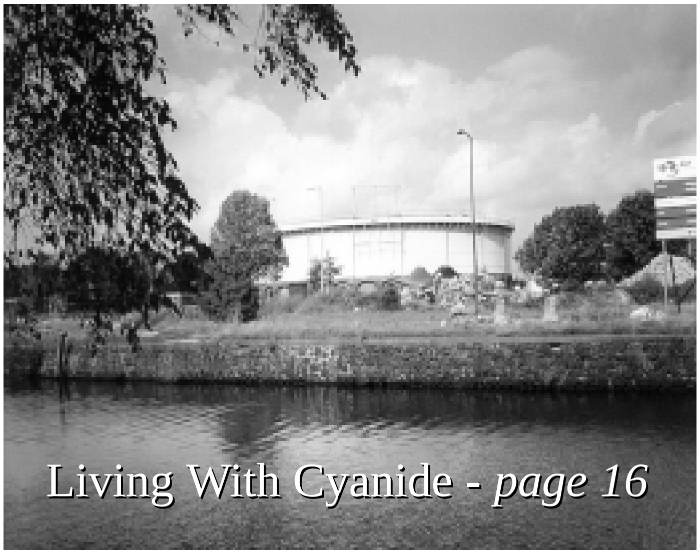
Renew your membership for 2001 now, quickly and easily!

The Geochemical Society can save a tremendous amount of money if we do not have to send you a renewal notices by mail. Just find your renewal type below, and follow the simple directions. Thank you!

1) **Renewal by credit card** - If paying by credit card (Visa, MasterCard, or American Express), you have multiple options available.
   A) Fill out the renewal form on page 31 of this issue and either mail to the address on the form or fax it to us (314-935-4121).
   B) You may e-mail your data to gsoffice@gs.wustl.edu. A text file of the renewal form is available at http://gs.wustl.edu/join/#HowJoin.
   C) Simply call the Business Office and renew over the phone (314-935-4131).

2) **Renewal by check or money order** - Please fill out the renewal form on page 31 of this issue and send it to the Business Office. The mailing address is on the form.

3) **Students** - Please fill out the renewal form on page 31 of this issue and send it to the Business Office. The mailing address is on the form. Please remember that you must obtain either a signature on the order form, or a letter of certification from a faculty member in your department. You may either mail to the address on the form or fax it to us (314-935-4121).



Living With Cyanide - *page 16*

From the Geochemical Society Business Office

Seth Davis
The Geochemical Society
Earth & Planetary Sciences
Washington University
One Brookings Drive
St. Louis, MO 63130, USA

Phone: 314-935-4131
Fax: 314-935-4121
gsoffice@gs.wustl.edu
http://gs.wustl.edu

2001 Membership Drive

The membership drive for 2001 has begun! Professional Members may renew by e-mail, mail, fax, or phone. Student Members must include a faculty member's signature from their department, so may renew by mail or fax. As I get a tremendous volume of renewals in a short period of time, *please* process your membership as early as possible.

Thank you for your continued support to the Geochemical Society!

Back Issues

Sometimes there are isolated problems with the mail delivery of *GCA*. If this happens to you, please contact me and I will make sure that you eventually receive all your issues. I can order issues of Volume 64 (2000) from Elsevier for paid subscribers of the Geochemical Society or the Meteoritical Society. If you have been a new member for longer than three months and still have not received your back issues, please contact me.

Special Publications

In March 2000, I assumed the task of processing GS Special Publication orders. Included in this newsletter is the current order form. Please note that this order form supercedes previously published forms.

The Geochemical Society's Web Site

Please check out the web site at http://gs.wustl.edu. It has been undergoing considerable changes and updates. I strongly encourage members to offer suggestions or comments that will make the site most effective.

INTRODUCING:

The Geochemical Society Meetings Assistance Program (GS MAP)

The Geochemical Society wishes to help support geochemically-oriented meetings. GS MAP has been created to this end. This program is divided into two parts.

Part I: This is a $10K award given each year from the Treasurer of the GS to the organizers of the Goldschmidt Conference that year. This award is automatic, that is, no application is required. The money is to be used exclusively for assistanceships to graduate students attending Goldschmidt Conferences. It is the responsibility of the conference organizers to distribute the money as they think best. However, it is also the responsibility of the organizers to report to the GS Treasurer how the money was distributed in a brief report after the meeting takes place.

Part II: This is a $10K sum per year that is to be used by GS members to financially support geochemistry sessions/symposia at any scientific conference of geochemical relevance. The following guidelines will be enforced.

1) Individual GS members who are symposium/session organizers can apply for such a MAP award.

2) Proposals should be between 1 and 2 pages in length and should describe the overall conference, the session(s) for which funds are required along with the session(s) speaker list, and exactly how the requested funds will be spent.

3) The amount requested cannot exceed $2,000 per proposal.

4) Only one proposal from the same individual or group can be submitted in a 12 month period.

5) Proposals are reviewed and awarded/rejected by the Program Committee of the Geochemical Society. Submission is made to the Chair of the Program Committee (see the GS website for current chair by clicking on About the GS, then Governance, then GS Personnel). Although the proposals are judged primarily on merit and funds available, grants will be distributed as widely as possible across the board range of disciplines and geographical areas represented by the GS, and also as evenly as possible throughout the calendar year.

6) There is no submission deadline, but it would be wise to submit a proposal as early as one can be put together. If the proposal is rejected because that year's funds have already been assigned, the organizers will still have time to seek funding elsewhere.

Call for Symposia for the 2001 Boston GSA

As an associated society of the GSA the Geochemical Society will be helping select special symposia for the 2001 GSA in Boston. We strongly encourage Society members to consider proposing symposia for the meeting. There are two types of symposia - Pardee Keynote Symposia and Topical Sessions. Pardee Symposia are special events that should be of broad interest to the geoscience community. Topics should be on the leading edge in a scientific discipline or area of public policy, address broad fundamental problems, be interdisciplinary, or focus on global problems. Selection is on a competitive basis with only four to eight half day, non-concurrent (one per half day; minimum of one per day) sessions being offered. All speakers will be invited.

Topical sessions should be topically focused with a mix of invited and volunteered papers and designed to promote the exchange of timely or state-of-the-art information. Organizers (advocates) may invite specific papers to ensure a successful and excellent session and are encouraged to solicit volunteered contributions. A maximum of four invited speakers is automatically allowed, but an advocate may request more invitations with a justification for the larger number. The deadline for submission of symposia and topical sessions is January 8, 2001, midnight, Mountain Standard Time. Any Geochemical Society members wishing to submit Pardee Symposia or Topical Sessions for the 2001 GSA, please contact Pat Brady (pvbrady@sandia.gov) at (505) 844-7146 for application materials and further information.

Call for papers

Biogeochemical consequences of the dynamic interactions between benthic infauna, microbes, and aquatic sediments

221st ACS National Meeting, San Diego, CA, April 1-5, 2001. On-line abstract deadline: Nov.15, 2000; hard-copy abstract deadline: Nov. 1, 2000. http://membership.acs.org/g/geoc/upcoming.htm

Biogeochemical processes in the vicinity of water-sediment interface in marine, estuarine, and fresh-water environments play a crucial role in large-scale biogeochemical cycles of carbon and nutrients, as well as in degradation and preservation of contaminants. Benthic infauna introduce temporal and spatial heterogeneity to aquatic sediments through processes such as burrow irrigation and sediment ingestion/egestion. Mega-, macro-, and meiofauna actively participate in the sedimentary biogeochemical cycles by their metabolic consumption and production of oxygen, sedimentary organic carbon, and metabolites. This symposium will be a forum for those who study physical, chemical, and biochemical interactions between benthic infauna, microbes, and sediments.

Yoko Furukawa
yoko.furukawa@nrlssc.navy.mil

GeoProc2002

March 4 to 7, 2002

Bremen, Germany

Geochemical processes with long-term effects in anthropogenically affected seepage and groundwater.

Program and Organisation:

Fachbereich 5 – Geowissenschaften, Universität Bremen
Postfach 330 440, D-28 334 Bremen, Germany.
www.geochemie.uni-bremen.de

Prof. Dr. Horst D. Schulz Phone / Fax: +49 (421) 218 3393 / 4321 Email: hdschulz@uni-bremen.de

Dr. Astrid Hadeler Phone / Fax: +49 (421) 218 3950 / 4321 Email: ahadeler@uni-bremen.de

Sulfate Minerals

GSA sessions/MSA short course

Annual GSA meeting
Reno, Nevada, November 13-16, 2000

Theme Session T-37
Sulfate Minerals 1. Hydrothermal Systems
(A tribute to Robert O. Rye)
Theme Session T-38
Sulfate Minerals 2. Low Temperature Environments

Invited speakers for session T-37 are: Bob Rye, Alfred Truedell, Virgil Lueth, and Barney Poole. Topics will include acid-sulfate hydrothermal systems, related mineralization, stable isotopes, radiometric dating, aqueous sulfate in active geothermal systems, and sedimentary-exhalative deposits.

Invited speakers for session T-38 are: Alexandra Navrotsky, I-Ming Chou, Jerry Bigham, and Clare Robinson. Topics will include thermodynamic properties of sulfate minerals, acid mine drainage, geochemical modeling, metal cycling in the environment, stable isotopes, radiometric dating, and paleoclimate studies.

For more information contact Charlie Alpers (cnalpers@usgs.gov; tel. 916-278-3134).

A related short course on “SULFATE MINERALS: CRYSTALLOGRAPHY, GEOCHEMISTRY, AND ENVIRONMENTAL SIGNIFICANCE,” sponsored by the Mineralogical Society of America, The Geochemical Society, andthe Society of Economic Geologists will be held Nov. 11-12, 2000, at the Granlibakken Resort, Tahoe City, CA. Co conveners are Charlie Alpers (cnalpers@usgs.gov), John Jambor (jlj@wimsey.com), and Kirk Nordstrom (dkn@usgs.gov). For more information see: <http://www.minsocam.org/MSA/SC_SO4.html>.

The Eleventh Annual Goldschmidt Conference (Goldschmidt 2001)

May 20-24, 2001
Roanoke, Virginia, USA

Conference Website:
http://www.lpi.usra.edu/meetings/gold2001/

Important dates:

- November, 2000: Second circular mailed with prices and other specifics.
- February 8, 2001: Last day for submission of mailed abstracts.
- February 21, 2001: Last day for submission of electronic abstracts.
- March 30, 2001: Last day to register without paying late fee.
- mid-April: Meeting program mailed to all registrants.
- May 20-24: Eleventh Annual Goldschmidt Conference

Sponsors as of this writing (in alphabetical order):

- European Association of Geochemistry
- Geochemical Society
- Mineralogical Society of America
- NASA
- Oak Ridge National Laboratory
- Virginia Polytechnic Institute and State University

Student support:

All students that come to Roanoke to present a talk or poster will receive a monetary conference grant. The amount of the award will be dictated by the number of students that present and the final amount of funds raised. Before the abstract submission deadline, the conference website will have an estimate of the size of these student grants.

General and topical sessions:

The following general and topical sessionshave been organized for Goldschmidt 2001. At the time of abstract submission, you will be directed to request one of these sessions for oral or poster presentation.

Goldschmidt 2001 - General Sessions

Aqueous Geochemistry: Kathy Nagy (kathryn.nagy@colorado.edu)
Metamorphic and Igneous Processes: Robert Tracy (rtracy@vt.edu)
Mineralogy and Crystallography: Nancy Ross (nross@vt.edu)
Ore Deposits: James Craig (jrcraig@vt.edu)
Organic Geochemistry: Simon Brasell (simon@imap4.indiana.edu)
Planetary Geochemistry: Gretchen Benedix (gbenedix@vt.edu)

Goldschmidt 2001 - Topical Sessions

Genomics Meets Geochemistry: Christopher H. House (chouse@geosc.psu.edu), Eric J. Gaidos (gaidos@gps.caltech.edu)
Molecular Biogeochemistry: Kate Freeman (kate@essc.psu.edu), Linda Jahnke (ljahnke@mail.arc.nasa.gov)
Mineral-Organic Interactions in Aqueous Systems: Jon Chorover (jdc7@psu.edu), Patricia Maurice (pmaurice@nd.edu), Richard Keil (rickkeil@u.washington.edu)
Of Earth and Microbes: Active Participation of Microorganisms in Geochemical Processes: Katrina Edwards (kedwards@whoi.edu), Terry Beveridge (tjb@uoguelph.ca)
Organic Geochemical Applications to Freshwater and Estuarine Systems: Elizabeth Canuel (ecanuel@vims.edu), Stephen Macko (sam8f@virginia.edu), Teofilo Abrajano (abrajt@rpi.edu), Tom Bianchi (tbianch@mailhost.tcs.tulane.edu)
Secular Variations in the Stable Isotope Composition of Organic Matter and Carbonates: Mike Engel (ab1635@ou.edu) Ethan Grossman (grossman@geo.tamu.edu), K. C. Lohmann (kacey@umich.edu)
Astrobiology: Martin Schoonen (MSCHOONEN@notes.cc.sunysb.edu), Hiroshi Ohmoto (ohmoto@geosc.psu.edu)
In Situ Geochemical Analysis on Planets and Asteroids: William. V. Boynton (wboynton@lpl.arizona.edu), Patricia Beauchamp (patricia.m.beauchamp@jpl.nasa.gov)

Extraterrestrial Water - Its Origin, Evolution, and Effects: Hap McSween (mcsween@utk.edu), Laurie Leshin (laurie.leshin@asu.edu)

Chronology of Early Solar System Processes: Frank Podosek (fap@isochem.wustl.edu), Alex Halliday (halliday@erdw.ethz.ch)

Mineralogy, Geochemistry and Geodynamics of Planetary Interiors: Tom Duffy (duffy@princeton.edu), Steve Haggerty (haggerty@geo.umass.edu)

Microanalytical Techniques for Earth and Planetary Samples: Mike Zolensky (michael.e.zolensky1@jsc.nasa.gov), David Vanko (dvanko@gsu.edu), Jill Pasteris (pasteris@levee.wustl.edu), Kazumasa Ohsumi (ohsumik@kekvax.kek.jp)

Melting and Melt Transfer in the Mantle - Thermodynamic and Transport Models: Glenn Gaetani (gaetag@rpi.edu), Paul Asimow (asimow@gps.caltech.edu)

Ultra-High Pressure Metamorphism - Mineralogy, Geochemistry, and Petrology: “Louie” Liou (liou@pangea.stanford.edu), Brad Hacker (hacker@geol.ucsb.edu), Doug Rumble (rumble@gl.ciw.edu)

Volatiles in the Mantle: Eric Hauri (hauri@dtm.ciw.edu), Chris Ballentine (Ballentine@erdw.ethz.ch), Max Schmidt (max@opgc.univ-bpclermont.fr)

Abiotic Formation of Organic Species in Hydrothermal Systems - Catalytic and Mineral-Fluid Equilibria Effects: Bill Seyfried (wes@tc.umn.edu), Jeff Seewald (jseewald@whoi.edu)

Fluid Phase Separation in Subaerial and Submarine Geothermal Systems: Mike Berndt (mberndt@tc.umn.edu), Stuart Simmons (sf.simmons@auckland.ac.nz)

Advances in the Development and Application of In-Situ Techniques for the Investigation of Geochemical Systems: I-Ming Chou (imchou@usgs.gov), Alan Anderson (aanderso@stfx.ca), Rus Hemley (hemley@gl.ciw.edu)

Mechanisms of Mineral Growth and Texture Formation in Rocks - Measurements and Theory: Bill Carlson (wcarlson@mail.utexas.edu), Frank Spear (spearf@rpi.edu)

Reactive Fluid Flow During Metamorphism - Field Studies and Modeling: Greg Roselle (roselle@mpi.unibe.ch), Jay Ague (jay.ague@yale.edu)

Geochemistry of Fluids from Sedimentary Systems: Max Vityk (movityk@upstream.xomcorp.com), Robert Goldstein (gold@ukans.edu)

Accessory Minerals - Equilibrium and Kinetic Properties and Applications: Bruce Watson (watsoe@rpi.edu), Roberta Rudnick (rudnick@eps.harvard.edu), Sorena Sorenson (sorena@volcano.si.edu)

Physics and Chemistry of Earth Materials: Ross Angel (btgil7@uni-bayreuth.de), Joe Smyth (joseph.smyth@spot.colorado.edu)

Molecular Modeling in Geochemistry: James Kubicki (kubicki@geosc.psu.edu), Randy Cygan (rtcygan@sandia.gov)

The Felsic Magma-Ore Deposit Link: Phil Candela (candela@geol.umd.edu), Jake Lowenstern (jlwnstrn@usgs.gov)

The Mafic Magma-Ore Deposit Link: Jim Brenan (brenan@zircon.geology.utoronto.ca), Jim Mungall (mungall@zircon.geology.utoronto.ca), Alan Boudreau (boudreau@eos.duke.edu)

Partitioning of Elements in Mineral/Melt/Volatile Systems: Jim Webster (jdw@amnh.org), John Hanchar (jhanch@gwu.edu), Roger Nielsen (rnielsen@oce.orst.edu)

Radiogenic Geochemistry/Geochronology of Ore Systems: Joaquin Ruiz (jruiz@geo.arizona.edu), David Lambert (dlambert@nsf.gov)

Recent Advances in U/Pb Goechronology: Session Dedicated to T. Krogh: Ken Ludwig (kludwig@bgc.org), Bob Tucker (tucker@levee.wustl.edu)

Recent Advances in Stable Isotope Analysis and Interpretation: John Eiler (eiler@gps.caltech.edu), Ed Young (ed.young@earth.ox.ac.uk)

Geochemistry of Contaminated Aquifers: Janet Herman (jsh5w@virginia.edu), Maddy Schreiber (mschreib@vt.edu), Laura Toran (ltoran@nimbus.temple.edu)

Link between the Chemical and Isotopic Evolution of the Atmosphere and the Rock Record: James Farquhar (jfarquha@ucsd.edu), Huiming Bao (hbao@ucsd.edu)

Controls on Chemical Weathering - Small and Large Scale Views: Suzanne Anderson (spa@earthsci.ucsc.edu) Alex Blum (aeblum@usgs.gov), Lisa Stillings (stilling@usgs.unr.edu)

Metals in the Weathering Environment: Don Rimstidt (jdr02@vt.edu), Philip Jardine (jardinepm@ornl.gov)

Environmental Mineralogy: David Bish (bish@lanl.gov), Martine Duff (Duff@srel.edu)

Advances in Oxide and Sulfide Mineral Surface Chemistry: Kevin Rosso (Kevin.Rosso@pnl.gov), Udo Becker (ubecker@uni-muenster.de)

Crystal Structures and Mineral Behavior: Jeffrey Post (post.jeffrey@nmnh.si.edu), Dave Veblen (dveblen@jhu.edu)

The Geochemistry and Mineralogy of Gemstones: Peter Heaney (heaney@geosc.psu.edu), George Harlow (gharlow@amnh.org)

Geochemical Aspects of Sustainable Energy Utilization: David J. Wesolowski (dqw@ornl.gov), David R. Cole (coledr@ornl.gov)

A special session dedicated to Roland Wollast at Goldschmidt 2000

During the symposium on Biological Geochemistry held at the recent Goldschmidt conference in Oxford from 3 to 8 September 2000, a one-day special session devoted to "Biogeochemical Cycles: From Local to Global Scales" was organized in honor of Roland Wollast. It was a tribute to his pioneering activities in the field of mineral weathering, nutrient cycles, chemical oceanography and biogeochemistry. Emphasis of the session was on recent advances in our understanding of material fluxes at the Earth surface. About 20 multidisciplinary contributions addressing the role of biological activity in the cycling of elements and the integration of observations at various spatial scales were presented. The importance of local and regional studies for the understanding of global biogeochemical cycles was also stressed.

An opening speech entitled: Roland Wollast: "A Man for All Seasons" of Coastal Oceanography was given by his colleague and friend, Fred Mackenzie, of the University of Hawaii. The following is an extract of Fred's introductory address to the session:

> *"Theory is when one knows everything but nothing works.*
> *Practice is when everything works but no one knows why.*
> *Here, theory and practice are joined, nothing works*
> *and we do not know why.*

This is a small sign that appeared in Roland's laboratory some years ago—it may still be there? In my mind, it symbolizes Roland's approach to being a scientist-reflecting an individual with the highest standards of hard work and dedication but also a person who has a sense of humor and recognizes that what we do as scientists should be fun and contribute to the betterment of the society.

Roland Wollast is one of my best friends and a research collaborator for nearly four decades. We first met in Bermuda in the 1960s when Roland came to the island paradise to work with Bob Garrels and myself on various aspects of seawater chemistry. At that time and for many summers thereafter, Roland, Bob Garrels, Michèle Loijens, Lei Chou, Bob Berner, Hal Helgeson, Owen Bricker, Neil Plummer, Don Thorstenson, John Morse, Bernie Boudreau, Don Canfield, and many others collaborated in research and teaching at the Bermuda Biological Station for Research. Roland's and my first paper co-authored with Owen Bricker in 1968 on the experimental precipitation of sepiolite and its significance in low-temperature environments was a result of our initial meeting and research collaboration in Bermuda. This was the first of 12 journal articles and one book that Roland and I have co-authored over the years. During our Bermuda sojourns, Roland was part of BBSAC, the Bermuda Biological Station Athletic Club, immortalized in the drawing of "The Compleat Bermuda Man", made by Bob Garrels, a close friend, mentor, and research colleague of both Roland and myself (Figure 8 of the preface, the Robert M. Garrels Memorial Issue, *Geochimica Cosmochimica Acta* **56**, number 8).

Bob Garrels was very influential in Roland's career. Other than Bob being Roland's best and dearest friend, I believe Bob was also influential in encouraging Roland to use his exceptional talents in thermodynamics and kinetics for investigation and solution of problems dealing with the geochemistry of the environment. Their friendship and research cooperation started in 1962 when Roland was an Assistant and "Chef de Travaux" in the "Laboratoire de Chimie des Solides" and Bob was a Senior Post-doctoral Fellow at the Université Libre de Bruxelles, and lasted until Bob's untimely death in 1988. Roland translated Bob's and Charlie Christ's book on *"Solutions, Minerals and Equilibria"* into French in 1966. Their first co-authored paper was that dealing with the diffusion coefficient of silica in seawater published in *Nature* in 1971 and still recognized and cited as the best estimate of this important parameter.

Roland has spent his whole career at the Université Libre de Bruxelles. In the United States, this would be unusual (and certainly different from Bob Garrels), but for Roland it was to be a continuous progression from undergraduate student to professor and director. Roland received the equivalent of his Bachelor of Science degree in 1956 and his Doctorate in 1960, both in the field of Chemistry. He was an Assistant and "Chef de Travaux" in the "Laboratoire de Chimie des Solides" in the 1960s and became an Associate Professor at the university in 1972. He then went on to develop and direct the Water Treatment and Pollution Laboratory and the Oceanography Laboratory and became a full Professor in 1991. Roland also holds or has held appointments at Paul Pasteur University, Ecole Superieure du Verre, University of Liege, Luxembourg University Foundation, University of South Florida, and the University of Hawaii. Roland is now retired but for Roland this status has little meaning (except he does not have to teach), and he continues to be as productive as ever.

Roland is one of a small cadre of geochemists (now more popularly in the United States called biogeochemists) who is truly holistic and global in approach to scientific research. He employs whatever physical, chemical, biological, and mathematical skills are necessary to attack and solve a scientific problem. Roland has the uncanny and unusual ability to develop field and experimental programs that initially have regional significance but eventually contribute to an understanding of the global Earth surface system. Perhaps even more importantly, Roland is able to take his laboratory and field observations and interpret them in the context of a sound theoretical foundation. I have yet to read a paper of Roland's in which there is not an equation or a model describing quantitatively the results of his work.

Roland is not simply an oceanogapher, a geologist, or a geochemist. As the title of my talk implies, Roland's work in coastal oceanography has had substantial impact on the field. He is probably the world leader in studies of the geochemistry of carbon, nitrogen, and heavy metals in coastal and estuarine environments. However, this is not his only forte. His contributions to the field of geochemistry span a range of subject matter. These include fundamental experimental studies of mineral-solution reaction thermodynamics and kinetics; modeling and interpretation of the global biogeochemistry of nutrient and other element cycles, including, and perhaps most importantly, human impacts on these cycles; the geochemistry of carbon and carbonates; and yes, even fundamental phase equilibria studies dealing with the formation of the alkaline silicon oxides.

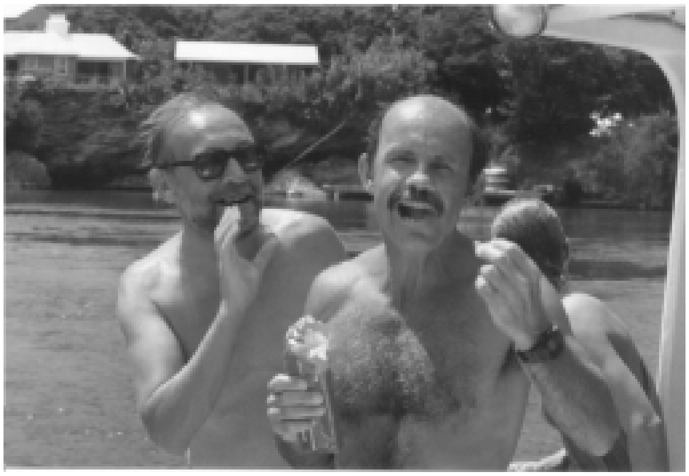
Aside from being an exceptional researcher, Roland is an outstanding teacher and student mentor. In a system that does not necessarily award teaching and mentoring of young students, Roland has maintained an active teaching program in geological, geochemical, oceanographic, and environmental subjects. Roland has supervised the research work of many students, including 28 Ph. D. dissertations. Many of his papers are co-authored with his students. For example, some former students include: (1) Jean-Pierre Vanderborght who did some of the original and classical work in the modeling of nutrient distributions in sediment pore waters, and over the years has been a close associate and friend of Roland's; (2) Gilles Billen who went on to become a world-class scholar in nutrient biogeochemistry; (3) Lei Chou who has been a mainstay of Roland's laboratory over the past two decades; and more recently Phillippe Van Cappellen and Pierre Regnier. Roland encourages all his students to work hard and at their maximum intellectual capacity, if not simply by example alone. With everyone, including his students, Roland suffers fools badly but is too kind and patient to let them know it. He attempts to lead his students gently but persuasively toward self-discovery of the errors of their ways. This was also a quality of Bob Garrels.

Although statistics alone can be a "dull" indication of one's contributions to a field of academic endeavor, I would be remiss not to mention that Roland has published more than 200 articles and has held more than 60 major research grants and contracts during his career-an enviable record of scholarship. As with many "senior professors", he has served on innumerable national and international committees and is a member and active on various committees in the Belgium Royal Academy of Science."

Fred Mackenzie concluded his speech by showing a series of pictures of Roland's progression from student to one of the world's outstanding geochemists. These photos further attested to Roland's image as a truly "holistic" man-a scholar, a teacher, a gentleman, a fine chef, a colleague, and a friend to many scientists and students spanning four generations.

Jean-Pierre Vanderbroght
Universite Libre de Bruxelles

Pensive Roland. On board the R. V. Belgica, Bay of Biscay (La Chapelle Bank), June 1992.



Cheerful Roland. With Fred Mackenzie, Bermuda Biological Station, Summer 1987.

Working Roland. Correcting Sophie Fally's dissertation, Brussels, 1996.

Visit and bookmark the new GS web site
http://gs.wustl.edu

Geochemical Society Archives

For many academic societies, the history of the body is to be found in the various documents and correspondence preserved in the files of one of the officers of the society, such as the Secretary or President, as well as in memories of individuals. If, as has been the case with the Geochemical Society, the officers change from time to time, the society's headquarters usually move to the location of the incoming secretary or the current Executive Editor of GCA. With urgent business to attend to, and professional obligations to be met, the preservation of society files tends to receive little attention and it is possible for documents to become misplaced and lost.

Some years ago the Geochemical Society determined to try and preserve early records, for the benefit of future workers. It was decided to deposit what documents could be located in some library where archival functions were in place, so that the files would be accessible to interested readers. The McMaster University Library, Hamilton, Ontario, became interested in fulfilling this function and appropriate arrangements were made between the Library and the Geochemical Society through actions of its Council and President Samuel Epstein in 1979. Boxes of records have been received at the library intermittently from 1986 onwards. A considerable number arrived in 1998 and 1999. Over the last eighteen months sorting and classification have been in progress into the following categories:

Constitution and By-Laws and History
Membership Lists
Council Minutes and Other Council Material
Finances
Awards
Publications Committee
Geochimica et Cosmochimica Acta
Other G.S. Committees
Newsletters
Special Publications
G.S. Relations with Other Bodies
Miscellaneous Topics
General Correspondence

Much detailed sorting remains to be done, particularly of the files labelled simply Correspondence". Over the next few months the files will be cleaned of duplicate material, then catalogued and prepared for use.

For further information contact Dr. Carl Spadoni, Research Collections Librarian, Mills Memorial Library, McMaster University, Hamilton, Ontario, Canada L8S 4L6; phone 905-525-9140 ext.27369; Web: http: //informer2.cis.mcmaster.ca/library/readydocs/readyweb.htm or the writer at <shawden@mcmaster.ca>.

Denis M. Shaw
McMaster University
Hamilton, Ontario, Canada

Biogeochemistry of Archaea

221st ACS meeting in San Diego, CA, 1-5 April 2001

Archaea are one of the three kingdoms of life on Earth. However, organic geochemical analyses of recent and ancient sediments have primarily focused on bacteria and eukaryotes and their role in the (paleo)environment. With the advent of molecular biology it is now clear that archaea are widespread and important organisms in non-extreme marine, lacustrine and terrestrial environments and thus should have a pronounced impact in (paleo)environments. In this symposium contributions are welcomed which provide insights into the biogeochemistry of archaea in past and present environments.

Deadlines for submission of abstracts are November 1st for hard copies and November 15th for on-line submitted abstracts (see www.acs.org/meeting).

Note that a number of other interesting geochemistry symposia will be organised as well during this ACS-meeting (see : http://membership.acs.org/g/geoc/upcoming.htm).

Stefan Schouten
Netherlands Institute for Sea Research

Call for Proposals

European Facility for High-Pressure Research
Bayerisches Geoinstitut, Bayreuth (Germany), 2000-2003

The aim of the EU Access to Research Infrastructures programme is to fund visiting scientists (users), from institutions in EU countries and Associated States, who wish to use the experimental and analytical facilities of the Bayerisches Geoinstitut. With this funding, visiting scientists are accepted generally for periods of between 2 weeks and 3 months. The funding covers travel expenses, accomodation and living expenses incurred during the stay in Bayreuth, and all experimental costs. The Geoinstitut staff provide full support for the users in terms of training and assisting with experiments.

This opportunity is open to earth scientists, material scientists, physicists and chemists from institutes in EU Member States and Associated States (with the exception of Germany). Proposals from potential users should be submitted for evaluation by one of the following deadlines: 31 March 2000, 31 August 2000, 28 February 2001, 31 August 2001, 28 February 2002, 31 August 2002.

Proposals and requests for further information should be sent to: Prof. D.C. Rubie (Dave.Rubie@uni-bayreuth.de). All necessary information is available on the facility web site:

http://www.bgi.uni-bayreuth.de/job_offers/elsfhp1.php3

5th RIDGE Theoretical Institute on the Subsurface Biosphere of Mid-Ocean Ridges

The RIDGE Program held its 5th Theoretical Institute at the Big Sky Resort in Montana from July 27 to August 1, 2000. More than 100 scientists, representing a great variety of disciplines, attended the Institute. The Institute began with a reception and an informal primer for non-bioscientists on the techniques and tools used to identify and culture microbial organisms. The following day the meeting continued in earnest. Speakers at the Institute, all of whom were invited to 'lecture,' provided overviews of topics related to the possible presence of a biosphere beneath the surface of the oceans' floors. They were also charged with stimulating discussion among the disciplines and trying to explore the best approaches to take to fully study the subsurface biosphere. The talks were grouped into introductory, observational and experimental, theoretical, technological and forward-looking categories. After each group or category of talks was completed, the floor was opened up to everyone for discussion. The ensuing discussions proved to be informative and lively, and many of the participants joined in. The talks served to provide the participants from a range of backgrounds with a basic understanding of our current state of understanding concerning these dynamic systems and the opportunity to explore key unresolved questions

Posters were displayed by most of the meeting attendees, on topics ranging from secondary porosity in basaltic rocks and seismic studies of the ocean crust to the placement of thermophilic organisms into the tree of life. The poster sessions provided opportunities for researchers to discuss their work with an audience with a wide-ranging set of interests, making for excellent interdisciplinary interactions.

The Institute also included a Saturday field trip to Yellowstone National Park, led by Lisa Morgan (USGS), Pat Shanks (USGS) and Anna Louise Reysenbach (Portland State University). During the trip, participants learned of the geological and biological history and diversity of the park, and saw first-hand the kinds of environments discussed at great lengths during the Institute – with no trips on Alvin required!

The focus of the meeting was the increasingly popular, yet so far largely unproven and poorly characterized, notion of a vast biosphere living beneath the Earth's surface at mid-ocean ridges (and perhaps elsewhere). The idea of a subsurface biosphere has been gathering support and a great deal of interest among the scientific community since the discovery of hydrothermal vent systems in the late 1970s (Corliss et al., 1979). Discoveries of primitive forms of archaea and bacteria that inhabit high temperature environments have led to speculation that life on Earth may have begun (Baross and Hoffman, 1985; Stevens and McKinley, 1995; Pace, 1991; 1997) or at least sought refuge from sterilizing impacts (Sleep et al., 1989) in these locations. Many high temperature organisms feed on the geochemical energy provided in hydrothermal systems and do not depend on sunlight for their primary energy source. Observations of large amounts of bacterial material coming out of the sea floor after eruptions indicates that the microorganisms may be inhabiting pore spaces or cracks beneath the surface. Microorganisms found living deep within Columbia River flood basalts in Washington State also support this conjecture (Stevens and McKinley, 1995).

The Earth's subseafloor may harbor a substantial biosphere, sustained by volcanic heat and chemical fluxes from the Earth's interior. Life's existence in what are considered 'extreme' environments on Earth has also led many to speculate about the possibility of life existing elsewhere in the solar system, where similar geochemical systems may provide the energy to sustain life (Nealson, 1997; Shock, 1997; Jakosky and Shock, 1998; McCollom, 1999).

Despite the forest fires raging throughout the northwest United States this summer, the scenery and weather in southwestern Montana couldn't have been better, and the Institute was a rousing success, enjoyed by all who attended. The conveners of the meeting, Craig Cary, Ed DeLong, Deb Kelley and William Wilcock, did the RIDGE program a great service in putting this meeting together. The subsurface biosphere promises to be an area of very interesting and fruitful research in the future, and having researchers from a variety of disciplines cognizant of the problems and challenges that lie ahead will ensure that great progress will be made!

Mitch Schulte
NASA Ames Research Center

References

Baross J. A. and Hoffman S. E. (1985) Submarine hydrothermal vents and associated gradient environments as sites for the origin and evolution of life. *Orig. Life Evol. Biosphere* **15**, 327-345.

Corliss J. B., Dymond J., Gordon L. I., et al. (1979) Submarine thermal springs on the Galapagos Rift. *Science* **203**, 1073-1083.

McCollom T. M. (1999) Methanogenesis as a potential source of chemical energy for primary biomass production by autotrophic organisms in hydrothermal systems on Europa. *J. Geophys. Res.* **104**, 30-729-30742.

Nealson K. H. (1997) The limits of life on Earth and searching for life on Mars. *J. Geophys. Res.* **102**, 23675-23686.

Pace N. R. (1991) Origin of life - Facing up to the physical setting. *Cell* **65**, 531-533.

Pace N. R. (1997) A molecular view of microbial diversity and the biosphere. *Science* **276**, 734-740.

Shock E. L. (1997) High-temperature life without photosynthesis as a model for Mars. *J. Geophys. Res.* **102**, 23687-23694.

Sleep N. H., Zahnle K. J., Kasting J. F. and Morowitz H. J. (1989) Annihilation of ecosystems by large asteroid impacts on the early Earth. *Nature* **342**, 139-142.

Stevens T. O. & McKinley J. P. (1995) Lithoautotrophic microbial ecosystems in deep basalt aquifers. *Science* **270**, 450-454.

More information on the RIDGE program can be found at the RIDGE web site: http://ridge.oce.orst.edu/

UK Marine Science 2000

UK Marine Science 2000, hosted by the Challenger Society for Marine Science, was held on 11 - 15 September at the University of East Anglia in Norwich. This biannual meeting has proved to be a forum for marine scientists of all descriptions to discuss their latest findings and quandaries and this year several hundred scientists with a wide range of experience participated. It was a pleasure to see so many young marine scientists attending and was only a shame that time did not allow for more of them to give oral presentations. As it was, there were around 120 oral presentations and 120 posters. The local organising committee, headed by Professor Tim Jickells of the University of East Anglia did well to pack so much stimulating science into four and a half days.

Keynote speakers were Dr. Bob Dickson (Lowestoft, UK), Prof. Bill Jenkins (Southampton, UK), Prof. Peter Liss (Norwich, UK), Prof. Margaret Leinen (URI/NSF, USA), Dr. D. Symes (Hull Buckland Society Lecturer, UK), Prof. R. Zahn (Cardiff, UK) and Prof. Viktor Smetacek (AWI, Bremerhaven, Germany). Prof. Tim Jickells (East Anglia) gave the welcoming speech. Prof. Harry Elderfield, President of the Challenger Society, presented the awards and prizes at the reception on Thursday. At that occasion, he also handed over the role of president of the Challenger Society to John Shepherd.

The change in name of this meeting from UK Oceanography to UK Marine Science was an effort to move away from the mainly physical oceanography dominated meetings of the past, towards a meeting that was more representative of the marine science community as a whole. As an indication of how well this transition has occurred four out of the twelve sessions run were broadly geochemistry based and fisheries, ocean optics and ocean models also had sessions dedicated to them.

The week's talks started off with Bill Jenkins reminding us that as marine scientists we still have a lot of work ahead of us. Because there is a great deal about our subject that we simply do not understand. He discussed how oceanic tracers that are routinely used in oceanography have provided invaluable insights into ocean processes. His main point, however, was that these tracers have revealed some unexpected results that have yet to be explained or successfully modelled. One example is a nitrate flux out of the thermocline implied from helium-3 results, which cannot be matched with that inferred from physical processes. The implied production from this nitrogen flux is considerably greater than current estimates of production. The first session continued on the theme of open ocean processes and ranged from the purely theoretical to long term measurements. Running alongside this was a session on restricted exchange environments, which concentrated on the geochemical processes affecting the redistribution of materials within fjords, lochs and estuaries.

Monday afternoon saw a session on ocean and climate and the day concluded with Bob Dickson discussing variability in the North Atlantic Oscillation. This session continued into Tuesday morning when several of the presentations concentrated on the Southern Ocean. An ocean-atmosphere carbon cycle model driven over the past four glacial/interglacial cycles by a variable dust flux to the Southern Ocean was presented as a method to investigate the role of atmospheric iron input on CO_2 concentrations. Jenny Pike presented some visually stunning Holocene sediment data from the Antarctica Peninsula, which appear to show seasonal laminae.

Iron is also currently in the spotlights elsewhere. The meeting happened to precede the departure of the RV Polarstern from Bremerhaven, about to collect one thousand litres of seawater on its way to Cape Town. This cruise takes place within the framework of IRONAGES, a major EU Framework 5 programme. It involves twelve European parties, including the University of Plymouth, which will provide core measurements of low-level iron concentrations in seawater. One of the programme's first tasks is a global between-lab comparison for the determination of iron in seawater, co-ordinated by the University of Plymouth in the UK and NIOZ in The Netherlands. The Polarstern can be tracked on its web site (http://www.awi-bremerhaven.de/Polar/polarstern.html).

On Tuesday evening Dr. David Syms gave one of the Buckland Lectures. He described current development in fisheries management and how an ecosystem approach is one which can bridge the gap between fisheries science and fisheries policy. This was followed by a special session chaired by David Pugh in which the subject "What is Marine Science for?" was discussed. Ruth Parker from CEFAS, Ralph Rayner from Fugro-Geos and Roly Rogers from DERA each gave introductory talks on what this question meant to them. Although lively discussion followed, it tended more towards the question of how, as marine scientists, we should present ourselves to the public. Professor John Shepherd's comment that "we should not be afraid to ham it up a bit" sticks in my mind.

Wednesday was split between shelf seas, high latitude oceanography and the special session for ocean modelling. Margaret Leinen started off Wednesday morning with a thoroughly mesmerising display of how technological advances are allowing marine science to develop rapidly. She discussed current and future projects that will enable consistent monitoring of areas of the ocean through networks of submarine cables. She also mentioned that the marine scientists of the future could well be exploring the oceans on Europa as well as those on Earth. The poster session took place on Wednesday evening. The evening was run as a social occasion, which provided a relaxed atmosphere in which to discuss the science being presented. The posters were divided into ten sessions similar to those of the oral sessions and were of an extremely high standard.

Professor Viktor Smetacek started Thursday morning off with his ideas about the "pelagic arms race" and the impact that defence mechanisms in plankton have on biogeochemical cycles in the ocean. Defence mechanisms in phytoplankton was a theme continued later that morning when indirect defence mechanisms through infochemicals in tritrophic systems were discussed. The phrase "talking trees" was not one I thought I would hear at a marine science conference! The morning continued with a biogeochemical feel with more results from the Southern Ocean iron release experiment.

A significant proportion of Thursday was given to the benthic environment session. Several of the talks were related to the BENBO interdisciplinary programme. Carol Turley discussed a series of experiments performed during one of the BENBO cruises to investigate the effects of temperature, pressure, water depth and sediment chemistry on the rate of deep-sea bacterial production. These experiments showed bacterial productivity decreased with increasing water depth, probably as a result of the phytodetritus delivery to the seabed.

Thursday was concluded with the awards ceremony at Norwich City Hall, where Peter Liss was awarded the Challenger Medal for his sustained contribution to marine science. The conference dinner followed and there was much jollity and dancing to a thoroughly entertaining band called the Cleaving Heavages. John Shepherd, the new president of the Challenger Society, proved to be an excellent mover on the dance floor!

Although Thursday was a late night, the turn out for Peter Liss' talk at ten past nine on Friday morning was good. After making some comments about the award he had been given the night before, he went on to discuss the important role that marine biota play in determining the chemistry of the atmosphere and therefore in controlling the Earth's radiation balance. This lead nicely into the final biogeochemistry session where Richard Geider revisited Redfield ratios and discussed how, even in nutrient-replete phytoplankton, there is significant variation in the N:P ratio. Toby Tyrrell continued on the theme of nitrogen fixation as he presented his results of the abundance of *Trichodesmium* along the Atlantic Meridional Transect. The session finished with more talk of micro-nutrient enrichment experiments.

UK Marine Science 2000 was a great success both in the level of science that was presented and also in the range of disciplines covered. I can only encourage more of the geochemistry community to participate in the next meeting in 2002.

Clare Postlethwaite
School of Ocean and Earth Science
Southampton Oceanography Centre
Clare.F.Postlethwaite@soc.soton.ac.uk

Enjoying the conference lifestyle! From left to right: Dr. Doug Connelly (SOC), Dr. David Hydes (SOC), Dr. Peter Statham (SOC), Mervyn Greaves (Cambridge Earth Sciences), Paula McLeod (SOC), Mark Moore (SOC), Maeve Lohan (SOC), Dr. Jonathan Sharples (SOC).

Postdoctoral Fellowship in Mineral/Solution Interactions

We invite applications for a position at the Interface Geochemistry Group, University of Copenhagen in an interdisciplinary project funded by the European Union. Other partners include the Forschungszentrum Rossendorf in Dresden as well as others in Germany, Switzerland, Sweden, England and Spain. The job will require some travelling to meetings and for research. Funding covers one year in Copenhagen with an extension of several months depending on submission of acceptable yearly reports. Further extension is possible by contract with Rossendorf for another 18 months. The job will begin as soon as possible but no later than 1 February 2001. European citizenship is NOT required.

The Interface Geochemistry Group uses wet-chemistry and surface-sensitive analytical techniques to investigate the geochemical processes that take place between solids and fluids. Our task in the project is to stuidy the uptake behaviour of calcite from solutions containing trivalent lanthanides. Data from these safe rare Earth elements will be used for modelling behaviour of actinides, to improve the scientific base for Safety Assessment Protocols for Radioactive Waste Repositories. We will use wet-chemistry methods and high resolution techniques including Atomic Force Microscopy (AFM), XPS (X-ray photoelectron spectroscopy) and TRLFS (Time-resolved laser fluorescence spectroscopy).

Candidates should have a PhD in aqueous geochemistry or physical chemistry or solid-state physics or mineralogy. Expertise with the above mentioned techniques is not required but familiarity with spectroscopic methods is an asset. The successful candidate will take the major role in the project and will contribute to experimental planning.

An expert assessment committee will evaluate the applications. Terms of appointment, salary and increments are set according to national professional agreement. Applications should contain CV, publication list, coordinates for 3 references, a statement of research interests and previous experience. Review of applications will begin 15 November 2000.

Questions may be addressed to stipp@geo.geol.ku.dk, or tel: +45 35 32 24 80. Applications should be sent to: Dr. S.L.S. Stipp, Geological Institute, 0ster Voldgade 10, DK-1350 Copenhagen K, Denmark.

Visit and bookmark the new GS web site
http://gs.wustl.edu

Living with cyanide

1. Introduction

In the previous issue of *The Geochemical News* (#104, July 2000), I summarized what the media and UNEP/OCHA reported about the recent environmental disaster in Eastern Europe and supplemented it with information from various sources. That first article forms part of the backdrop, part of the social context if you will, for the article you are looking at now. Cyanide plays the lead role in both articles, but this one pays more attention to cyanide itself. However, neither article should be regarded as an authoritative and/or complete review, but as an introduction for those of us who are not very familiar with cyanide and its significance. As a geochemist, however, you will instantly recognize that the characteristics that make cyanide so toxic, difficult to handle and difficult to analyze also explain why it is used so widely. What you may not know is that thermodynamics has rather limited control over cyanide behavior in nature and how many questions cyanide raises, for instance about its solubility.

The cyanide issue is indeed very complex. ‘Cyanide decomposes as soon as it gets released and does not do much harm,’ say some. ‘Not true!’ respond others. ‘The chemistry of cyanide is has been studied extensively and is well-known,’ report some. ‘Very little is know about the behavior of cyanide, and researchers have only just started to study it in detail,’ judge others. ‘Cyanide does not accumulate in organisms,’ say some. ‘Is that really the case?’ ask others. ‘Cyanide is bad, bad, bad,’ say some. ‘Cyanide is not only bad,’ counter others. The variety in opinions is also caused by the complexity of cyanide’s chemistry, its biochemistry and its geochemistry. And on your point of view.

2. Use of cyanide - sources of cyanide contamination

2.1 The mining industry

2.1.1 Use of cyanide in the mining industry

Let’s start with an open door: the mining industry uses a lot of cyanide. In 1989, the mining industry in the United States alone used about 70 million kg, but it used about 50 million kg in 1988 (Eisler, 1991 and references therein). The current number is bound to be much higher, but its value does not really matter, except for cyanide manufacturers such as DuPont. Cyanide is used as a flotation reagent in base-metal and gold mining (Bell, 1974), for instance to separate gold-rich pyrite from arsenopyrite, and in cyanidation, to extract gold and silver from ores during dump leaching, heap or column leaching. Cyanidation is still the method of choice for most of the world’s gold mines.

Gold in rocks may occur in fractures and along grain borders, or enclosed in pyrite, arsenopyrite, chalcopyrite and other minerals. Oxidation of sulfide ores (weathering) may release some of the gold at the surface of an ore deposit and this is easily recoverable, as is placer gold. The remainder of the ore is usually crushed and then subjected to cyanidation. The cost goes up with the amount of mechanical processing, but gold is leached much quicker from finer material. Dump leaching involves, of course, uncrushed material but takes considerably much longer than heap leaching, where the material is crushed first and placed on a leach pad next. In both cases, the cyanide solution is then allowed to trickle through the heap. Varieties with vats and columns use the same principle.

Refractory ores do not release their gold during cyanidation without special prior preparation, such as bioleaching, autoclaving (pressure oxidation), roasting (thermal oxidation), and chlorination. Gold that is part of sulfide minerals such as pyrite and arsenopyrite forms a major refractory ore category. Carbonaceous gold ores are another special category, because the carbon competes with the cyanide. Copper/gold ores require uneconomically high quantities of cyanide. Copper forms at least three complexes during cyanidation and hence consumes a lot of cyanide that is unable to complex gold. Examples of other ‘cyanicides’, as they are called, are pyrrhotite, natural organic acids, sulfates, and arsenates, (Fagan, 1998). Interested ‘non-hardrockers’ may want to check out books like Guilbert and Park (1986) and Evans (1995), for further details about ore geology.

The mining industry has used and still uses a wide range of processes. As our insights in environmental issues change, what is considered environmentally justifiable or not continues to change as well. What was perfectly alright ten or twenty years ago, may be considered very unfriendly to the environment today. And vice versa.

The cyanidation process involves dilute solutions of usually sodium or potassium cyanide and has been used commercially for over 100 years, with patents dating back to the end of the 19th century (Fagan, 1998; Hilton and Haddad, 1986; Johnson *et al.*, 1998). Even though the process has been used for so long, its mechanisms still are not fully understood (Fagan, 1998). Its general description is fairly simple. Gold ions are not abundant in aqueous solutions, but gold can be oxidized to Au(I) and Au(III). Oxygen can easily oxidize gold in alkaline cyanide solutions, where gold has a relatively low (-0.4V) oxidation potential (Fagan, 1998). The cyanide keeps gold in solution as $(Au(CN)_2)^{-1}$ (the only gold-cyanide complex involved in cyanidation) and thus prevents the formation of oxide layers (Hilton and Haddad, 1986; Haddad and Rochester, 1988).

Aqueous solutions of cyanide are actually not thermodynamically stable, but in the absence of catalysts and at high pH, oxidation to cyanate is very slow (Fagan, 1998). To prevent outgassing of HCN, the cyanide solution is kept at a pH well above the pKa of HCN (about 9.2), say 10.5. Lime or sodium hydroxide is used to control the pH (Fagan, 1998; Haddad and Rochester, 1988). Cyanide also removes other precious metals and base metals from ore. Zinc and copper are relatively weakly complexed by cyanide while gold, silver, iron and cobalt are strongly complexed. Kinetics plays a role as well, of course. Although cyanide complexes cobalt(II) strongly, as $(Co(CN)_6)^{3-}$, four steps are involved and the full complexation process is relatively slow (Fagan, 1998).

Cyanide can not only be lost through evaporation as HCN gas, but also through hydrolysis (oxidative pathways that break the C-N bond), conversion into thiocyanate, precipitation of cyanometallic compounds (notably with sulfidic ores), and adsorption/coprecipitation (notably with ferric oxides, in the case of oxidized ores). Stable-isotope tracers can be used to study these losses (Johnson et al., 1998).

Gold is recovered from the leachate with activated carbon or zinc (see for instance Hilton and Haddad, 1986), although ion exchange resins were often used in the former Soviet Union (Fagan, 1998). The zinc method dissolves zinc and precipitates gold, which can be summarized as follows.

$$2Zn + 8CN^- + O_2 + 2H_2O \Leftrightarrow 2(Zn(CN)_4)^{2-} + 4OH-$$

$$Zn + 2(Au(CN)_2)^- \Leftrightarrow 2Au^- + (Zn(CN)_4)^{2-}$$

$$Zn + 2(Au(CN)_2)^- + H_2O \Leftrightarrow 2Au + HZnO_2^- + 3H^+ +4CN^-$$

Activated carbon can be mixed with the ore slurry and then mechanically separated. Alternatively, the leachate can be lead over the carbon. In both cases, the gold-cyanide complex adsorbs to the carbon, which is then washed to remove most other metal complexes. Various methods, often also involving cyanide, can be applied to strip the gold off the carbon, after which electrolysis yields the precious metal (Haddad and Rochester, 1988). The carbon must be abrasion-resistant, coarse (size, easier to separate) and porous (large surface area). Common sources for the activated carbon are coconut shells, peat, coal, and fruit kernels.

The leach process can be monitored, for instance by assessing the free cyanide concentration of the leach fluid or by determining the gold concentration of the leachate emerging from the carbon tanks (Haddad and Rochester, 1988; Hilton and Haddad, 1988). The leachate later becomes the so-called tailings, which are allowed to sedimentate in tailings ponds.

Mining companies are becoming increasingly cyanide-conscious. In the United States, they now need to account for their cyanide in the framework of Toxic Chemical Inventory Reporting, but that is not the only reason. Cyanide is also fairly expensive, and controlling cyanide therefore generally lowers the mining costs (Johnson et al, 1998). Most mining companies also try to avoid environmental disasters and the damage they can do to the company's image.

Gold mines are also continuously being developed (Chadwick, 2000; Clifford, 2000) and the use of cyanide in mining therefore remains a hot topic, particularly after a spill such as in Romania. However, reprocessing old tailings with cyanide does not only yield more gold and silver; it also lowers the tailings' metal content and may remove other pollutants, remnants from other processes, such as amalgamation. Moreover, techniques as well as our environmental consciousness and knowledge have improved over the years and this should also be taken into account. In addition, there doesn't seem to be a good alternative for cyanidation yet.

2.1.2 Alternatives for cyanide in the mining industry

In the past, mercury was often used to recover gold (Fagan, 1998). This process is called amalgamation and is based on formation of a gold-mercury amalgam, which occurs when the mercury comes in contact with the ore. Mercury is not only highly toxic, amalgamation is also much less efficient than cyanidation. Amalgamation, however, is relatively simple and is therefore still used in smaller operations.

Currently, alternative leaching agents for refractory ores are hypochlorous acid, thiourea, thiosulfate, hydrochloric acid and an ammonia/cyanide mixture (Fagan, 1998). Bromides (acid and alkaline), chlorides, thiourea and thiosulfate are alternatives for cyanide, but are not widely used, may be less efficient or may also work well for very specific ore types. Gravity separation methods have also been mentioned as potential alternatives for cyanide (Stewart, 1990), but these still appear to be used only in combination with a cyanidation or flotation step. Developing good alternatives for cyanidation should be a very rewarding challenge for geochemists.

Of course, cyanide is not the only problem that mining companies face. Acid mine drainage is also often in the spotlight. The cyanide process does not even have to be a problem in itself. Accidents and leaks create the problems and earthquakes can also. Good planning, responsible design and allocating sufficient funds for cleanup are at least as important as the decision to use cyanide. Having said that, I cannot but refer immediately to the Summitville case to restore a sense of reality.

The Summitville gold mine in Colorado had caused problems before, mainly related to acid drainage. It threatened to become a much bigger problem when the mining company went bankrupt in the middle of closing up the mine, and had 150 to 200 million gallons of spent leachate left to clean. The State of Colorado responded by asking the EPA to take over and it was probably the American taxpayers who ended up footing the bill of over 100,000,000 US dollars (Bigelow and Plumlee, 1995).

Fig. 1. An idyllic site. Contaminated with cyanide and other pollutants.

2.2 Manufactured-gas plants

Not mining activities but manufactured gas plants (MGPs) are the most common source of cyanide contamination (Kjeldsen, 1999). Before natural gas was discovered, gas was produced from coal and this coal gas initially contained large proportions of hydrogen sulfide, tar and cyanide. The tar was removed first, after which the gas was bubbled through oxide boxes containing bog ore and sometimes also wood shavings (Ghosh *et al.*, 1999b). The bog ore took up the hydrogen sulfide and cyanide through formation of iron sulfides and Prussian Blue, an iron cyanide solid. Spent box material was sometimes sold as pesticide, but was also often used as filler and buried on the gas plant's grounds (Kjeldsen, 1999; Meeussen *et al.*, 1995). In The Netherlands, the southern

Continued on page 18

Continued from page 17

areas near the coal mines used mine gas, but eventually, all the countries' stoves and heaters were converted for natural gas, after the Slochteren natural gas resources were discovered in the 60s. Gas plants were also built in the U.S. and other countries, where similar developments took place. The United Kingdom had at least about 3000 and possibly some 5000 MGP sites (Barclay *et al.*, 1998). The Netherlands had 234 (Didde, 1995; Meeussen *et al.*, 1994).

The nature and extent of the contamination often make the impact of mining spills appear much more devastating and much better known with the public. MGPs, however, are almost always located in highly populated residential areas, which means a higher potential risk for human beings and also results in high cleanup costs. Barclay *et al.* (1998) give a typical cyanide concentration range at MGP sites of 1 to 1,000 mg kg^{-1} soil, but add that the concentration may be as high as 8,000 mg kg^{-1} and give concentrations as high as 50,000 mg kg^{-1} for sites in the State of New York.

2.3 Other uses and sources of cyanide

Iron cyanides such as Prussian Blue have also been used in dyes, inks, cosmetics and other products for more than 150 years (Meeussen, 1994; Ghosh *et al.*, 1999a). Some drugs, for instance sodium nitroprusside, contain significant amounts of cyanide. Electroplating factories, zinc and aluminum smelters, and road salt storage facilities (cyanide is added as an anti-caking agent) are also often sources of potential cyanide contamination. In addition, cyanide has a wide range of 'household' applications, such as fumigation, pesticides, rodent control, and predator and pest control. An example of the latter are devices used by U.S. Fish and Wildlife Service Animal Damage Control Programs (Eisler, 1991), to keep populations of certain species in check. Pellets from these devices are known to also kill other species than those they were intended for (Eisler, 1991).

3. Analysis and speciation of cyanide

Nowadays, with the current environmental awareness, pollution laws and decision support systems often need concentrations to determine what action should be taken at a contaminated site. This has of course increased the need for reliable and detailed analyses and for spatial distribution data (Staritsky *et al.*, 1992). However, what is analyzed depends on the regulations and the purpose of the analysis. Cyanide determinations during heap leaching are done to assess whether the solution is still potent enough, and also to check if environmental regulations are complied with. Analysis for environmental purposes may be more detailed, but it still depends on who wants the analyses done and why. And on who does the analyses.

Free cyanide is HCN and CN^- together. Dissolved HCN is a weak acid that dissolves and mixes very well in water. Cyanide ions are sometimes called pseudohaline ions, because their chemical behavior resembles that of halide ions. However, the term 'free cyanide' is not as clear-cut as it sounds and does not necessarily mean 'uncomplexed cyanide'. Weak-acid dissociable cyanide (WAD; Cu, Zn and Ni complexes) easily releases its cyanide, but not always that easily, otherwise copper would not be such a problem during cyanidation. Particularly the presence of copper can distort analyses. While copper-complexed and zinc-complexed cyanide both may show up as 'free cyanide' in analyses of leach solutions, the copper-complexed cyanide is not available for leaching gold. On the other hand, copper-complexed cyanide may not show up in free cyanide analyses for environmental purposes and may mask a rising cyanide concentration. Fagan (1998) reviewed the stability constants of the three Cu(I) complexes that are formed during cyanidation: $(Cu(CN)_2)^-$, $(Cu(CN)_3)^{2-}$ and $(Cu(CN)_4)^{3-}$. Organic compounds, sulfide, and zinc can also interfere with the analysis of 'cyanide' (Fagan, 1998; Haddad and Rochester, 1988; Hilton and Haddad, 1986). Strong-acid dissociable cyanide (SAD) includes the cyanide complexes of gold, silver, cobalt and iron. Fagan (1998) developed a reversed phase ion interaction chromatography method, which uses UV detection to measure individual metal complexes and a post column method (based on the König reaction) to determine free cyanide. There is in fact a large number of methods available for cyanide-related analysis, based on several techniques (titrimetry, spectrophotometry, AAS, spectrofluorometry, potentiometry and amperometry). While developments such as flow injection analysis and membrane diffusion greatly advanced analysis, most of these methods focus on either 'free' cyanide, 'total' cyanide, WAD, 'extractable' or 'amenable' cyanide. Covering them all would go too far here. Thorough analysis methods tend to be expensive and time-consuming and interpreting cyanide analyses is just as complicated as the analyses themselves. The quotation marks are meant to convey that working on practical analysis methods for 'cyanide', and perhaps also the interpretation of results, is another nice task for geochemists.

There are of course many more cyanide compounds than free, WAD and SAD. Examples are cyanate, hypocyanate, the nitriles (synthetic organocyanides), cyanogen and cyanogen chloride. The latter can for instance be formed when cyanide spills are treated with sodium hypochlorite. There are fewer methods to determine cyanate than cyanide: Kjelldahl Nitrogen method, electrochemically and colorimetrically (Fagan, 1998). Cyanate is less toxic than cyanide.

4. Toxicity

There is no question that free cyanide is highly toxic to almost all organisms. Cyanide is a very fast-acting poison, in a way comparable to adding a bit of sugar or sand to a gas tank. Under certain conditions, many but not all people can smell cyanide (the smell of bitter almonds). Of those who can, not everyone starts discerning it at the same concentration.

The symptoms of cyanide poisoning vary. The first stage may lead to headache, vertigo, weak yet rapid pulse, nausea and vomiting. The second stage is more alarming and may for instance include convulsions. The third stage is the final stage, leading to death, but cyanide poisoning does not automatically lead to death. Cyanide has a very steep dose-response curve (Kjeldsen, 1999), meaning that a little bit more can do a lot more damage. The body will detoxify relatively small doses of cyanide with little difficulty and any signs of poisoning will slowly disappear, with no remaining health effects. Cyanide can be exhaled as HCN and CO_2 in breath, and may react with cystine, and with vitamin

B12 (to cyanocobalamin). Probably most of the cyanide will react with thiosulfate, catalyzed by enzymes such as rhodanese, and is then excreted in urine as thiocyanate (Eisler, 1991). However, thiosulfate levels in the human body are usually low, and the amount of thiosulfate in the body and thiocyanate metabolism vary between individuals and species. Fish are very sensitive to cyanide, which is one of the reasons why cyanide is used to catch fish. Birds are less sensitive than fish but more sensitive than most other species. Cattle appear to be more vulnerable than sheep, horses and pigs (Eisler, 1991). The human body's response depends on the nutritional state of the person (vitamin B12 deficiencies) and on the specific cyanide compound it is dealing with. WAD is about as toxic as free cyanide. SAD is less toxic (Kjeldsen, 1999), simply because these complexes don't release cyanide as easily as WAD. Iron cyanide complexes, for instance, are about a factor 1000 less than cyanide and not surprisingly, appear to withstand the gastric acids as well (Kjeldsen, 1999; Meeussen, 1993). The toxicity of organic cyanide compounds varies, but is also basically related to the ease with which they release cyanide. The medical literature reports one case of cyanide poisoning from ingesting an organic solvent, acetonitrile. Thiocyanate is also much less toxic than cyanide but may accumulate in tissues and then create health problems (Eisler, 1991). Chronic cyanide poisoning is probably best known from detective stories, but is actually more common in areas where cyanide-containing plants, such as cassava, are staple food. No teratogenic, mutagenic and carcinogenic effects have been documented. Cyanide may have some therapeutic effects against some forms of cancers (Eisler, 1991).

Poisoning may take place via skin contact, via inhalation or via ingestion, although the latter is less common (Kjeldsen, 1999). Some snake venoms may produce HCN upon tissue destruction following injection. Cyanide poisoning may also result from exposure to smoke from a fire and from tobacco smoke. People who smoke and patients with renal insufficiencies just prior to dialysis have higher blood plasma thiocyanate levels (Eisler, 1991).

There are several antidotes for cyanide poisoning, for instance cobalt salts or a nitrite-thiosulfate combination, the choice of which is often according to local medical custom.

Let's move from organisms to the environment next: how does the environment metabolize cyanide?

5. What happens to cyanide after it has been released?

With spills or leaks from mine sites, the first thing to happen is dilution. This is often the main attenuation mechanism. Complexed cyanide often remains mobile and does not adsorb, partly because it is negatively charged, as are most particle surfaces (Kjeldsen, 1999). The amount of light, the pE and the pH, the presence and amount of other compounds and elements, and the presence or absence and amount of certain microorganisms determine what happens further. Winter conditions are unfavorable, because evaporation and degradation are less in winter, for instance because UV light destroys cyanide (Meeussen *et al.*, 1989) and the UV intensity is less in winter. The pH is unlikely to be above the pKa of HCN and HCN therefore also volatilizes. Some cyanide will be converted to cyanate and other compounds. Iron complexes tend to be relatively harmless as long as they don't break down. Basically, cyanide itself is probably best outgassed/converted and diluted. Outgassing is also a form of dilution, of course. The strongly complexed cyanide is perhaps best kept complexed, while the weaker complexes should be allowed to break down and converted to other forms as rapidly as possible. Gold cyanide complexes released from a gossan tailings pile in Canada were rapidly degraded (reduction of gold by divalent iron) and also converted into colloids (Leybourne *et al.*, 2000). The sediments and the water close to the source and at a distance contained high gold concentrations, but the size of the gold in water increased with distance from the source. The authors hypothesize that cyanide is oxidized and that this would fit in with higher nitrate concentrations found downsteam. This would also indicate that cyanide persisted in the ground water over a considerable distance (Leybourne *et al.*, 2000). Finally, microbes also convert some of the cyanide (*s.l.*).

The situation is somewhat different at MGPs and other sites, where solids initially dominate, and where solubilities play a large role. Iron complexes are the main metal complexes at MGP sites, also because soil usually contains a lot of iron. In the dark, iron complexes are fairly stable. On exposure to daylight and perhaps specifically the UV part of the daylight spectrum, iron complexes decompose rapidly after which HCN gas is released. This should be controlled (not necessarily prevented) as much as possible, because it might increase the risk for residents. At the moment, it is not entirely clear which iron phases are formed at MGP sites. The solubilities of those phasesdetermine the concentration of free cyanide to a large degree as well as the concentration of dissolved iron cyanide complexes.

Cyanide waste at former MGPs usually takes the form of iron cyanide compounds, where iron comes from the bog ore and from soil. The best-known iron cyanide solid is Prussian Blue ($Fe_4(Fe(CN)_6)_3$), which is stable in an oxidizing environment (Ghosh, 1999a), but should dissolve at higher pH. Another well-known iron cyanide compound, Turnbull's Blue ($Fe_3(Fe(CN)_6)_2$) dominates at lower pE (Ghosh, 1999a). These minerals share the same crystal structure (face-centered cubic), but have different proportions of Fe^{2+}/Fe^{3+} (Ghosh *et al.*, 1999a). Prussian Brown, Berlin Green and Berlin White (phases with more extreme Fe^{2+}/Fe^{3+} proportions) are unstable. Meeussen and coworkers (1992c) performed the first extensive solubility study of Prussian Blue, but used outdated stability constants according to Ghosh *et al.* (1999a) (older NBS constants instead of more recent revised ones). Ghosh *et al.* (1999a) also object that the data of Meeussen and his coworkers do not pertain to equilibrium, because the reaction period was fixed and relatively short. They conclude that the solubility product for Prussian Blue reported by Meeussen and his colleagues has to be inaccurate. (Although I have included the Meeussen 1992c reference, I did not have this paper and the related data available when I wrote this article and was unable to assess this issue.)

Ghosh and his colleagues (1999a) used the program MINEQL$^+$ and its more recent stability constants to calculate the speciation of cyanide in equilibrium with $Fe(OH)_3$ (Fig. 3). $Fe(OH)_3$ was chosen because it is so common and because most

Continued on page 20

Continued from page 19

soils contain large amounts of iron. The solubility of $Fe(OH)_3$ is also expected to determine to a large degree what happens to cyanide at former MGP sites. Precipitation and dissolution experiments carried out by Ghosh *et al.*, (1999a) yielded higher concentrations than calculated. Adding other iron cyanide phases to the MINEQL$^+$ model resulted in much lower calculated solubilities. Precipitation of cyanide with ferric oxides can also interfere with cyanidation, apparently lowering the solubility of cyanide under those conditions.

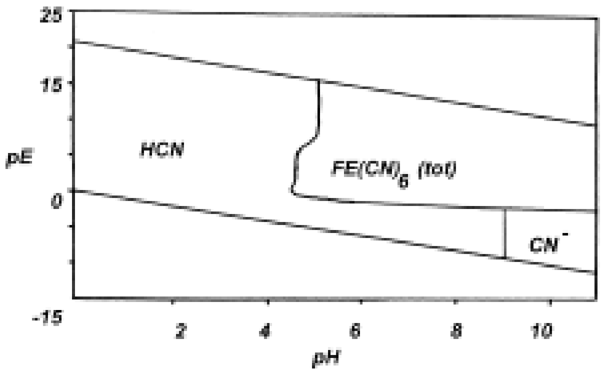


Fig. 2. Dissolved cyanide species in equilibrium with $Fe(OH)_3$, according to Ghosh et al. (1999a). Calculated with MINEQL$^+$.Total cyanide = 0.6mM; total iron = 0.5mM, total potassium = 0.4mM, total sodium = 0.06 mM, total chloride = 0.0612M and I=0.06M NaCl. $Fe(CN)_6$(tot) is complexed cyanide.

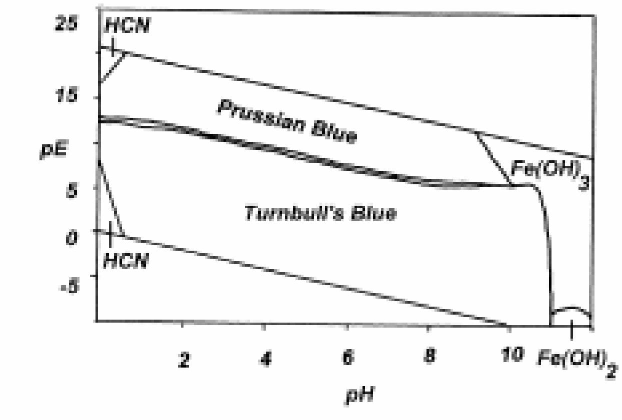


Fig. 3. pE-pH diagram for iron cyanide phases in water, without excess iron, according to Ghosh et al. (1999b). Calculated with MINEQL$^+$ using observed solubility products. Note the field where Turnbull's Blue and Prussian Blue coexist. Conditions in natural soils are usually restricted to the central part of this diagram.

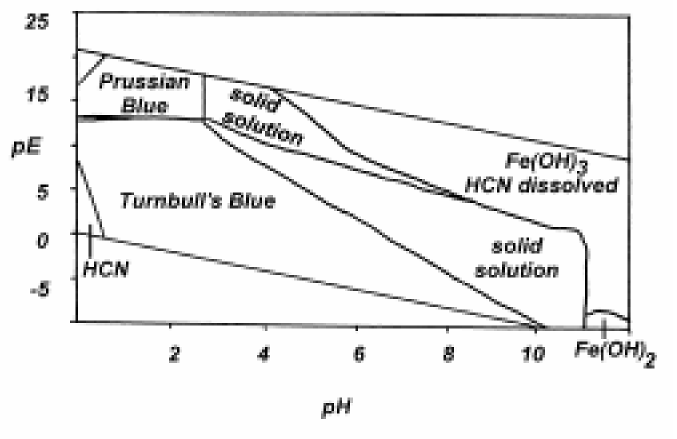


Fig. 4. pE-pH diagram for iron cyanide phases in water, in the presence of excess iron, according to Ghosh et al. (1999b). Calculated with MINEQL$^+$ using observed solubility products. Note again the field where Turnbull's Blue and Prussian Blue coexist. Conditions in natural soils are usually restricted to the central part of this diagram.

The increase in solubility in the presence of excess iron, found by Ghosh and his colleagues (1999a), rose with pH. The authors hypothesize that this may be caused by coprecipitation of iron hydroxide and iron cyanide, and that these precipitates may form a solid solution during the aging process. The conclusions from their work are that cyanide solubility increases with pH in iron-rich soils and is higher than in iron-poor soils (see Figs. 2, 3 and 4). Mixing or equilibrium may also exist with other phases, such as manganese iron cyanide, in that case leading to lower solubilities (Kjeldsen, 1999 and references therein).

Ghosh *et al.* (1999a) add that cyanate (CNO^-) theoretically may dominate in highly oxidizing environments, but that conversion of cyanide into cyanate proceeds very slowly, unless in the presence of ozone or hydrogen peroxide (also stated by Fagan, 1998). Cyanate in turn will rapidly undergo hydrolysis.

Meeussen *et al.* (1994) use the solubility product for Prussian Blue from their earlier work, and also calculate dissolved iron cyanide concentrations in equilibrium with Prussian Blue and iron hydroxide, with the model ECOSAT. Their results indicate that at pH > 7, more than one mole L^{-1} would be in equilibrium with Prussian Blue (the solid). In other words, Prussian Blue would not precipitate.

At low pH and low pE iron generally tends to dissolve more easily (Meeussen *et al.*, 1994) and iron hydroxide is not expected to precipitate under those conditions. This was confirmed by experiments by Ghosh *et al.* (1999a). Precipitation of Prussian Blue is not expected in alkalic soils, but solid Prussian Blue was found at alkalic sites (Meeussen *et al.*, 1994, 1995). This may be due to slow dissolution kinetics, limitations by difffusion, a local acidic microenvironment created by dissolution of Prussian Blue, perhaps in combination with the influence of bicarbonate (Meeussen *et al.*, 1994). The alkalic sites did often have a lower pH (5.5) in the blue-colored top layer. The solubility of

Prussian Blue increases rapidly from almost zero at pH 4 to very high at pH 7. Meeussen and his coworkers (1994) hypothesize that dissolution of Prussian Blue may take place so slowly that Prussian Blue is able to persist for decades.

Ghosh *et al.* (1999b) studied an MGP site over a sand-gravel aquifer in the United States. They found more than 98% of the cyanide present as stable iron complexes (non-reactive). WAD, although only present in small proportions at this particular site, is expected to be more reactive and to undergo some form of degradation. Dilution appeared to be the main attenuation mechanism at this site, according to the authors, and this has also been found at other sites. Ghosh and his coworkers analyzed for total cyanide, WAD, free cyanide and in some cases (high cyanide concentrations) also for metal cyanide complexes (ion chromatography). They also attempted to characterize the spatial distribution of the contamination, as did Staritsky *et al.* (1992), for a former galvanic factory site in The Netherlands. This often helps to limit the cleanup costs.

Kjeldsen (1999) also discusses the discrepancy between calculated and measured free cyanide concentrations. Both Kjeldsen (1999) and Meeussen and coworkers (1994) arrive at the conclusion that iron-complexed cyanide degrades extremely slowly in soils in the dark, with half-lives ranging from decades to 1000 years (excluding microbial activity).

Besides uncertainties regarding the solution chemistry of iron cyanide compounds, there are also questions and discrepancies pertaining to the influence of daylight, UV or perhaps particularly the UV component of daylight, on the decay of iron cyanide complexes. The uncertainties also sometimes raise questions about experimental results (compare with choosing cells for UV-VIS spectrophotometry).

Containing the contamination can be very important if there is not enough natural attenuation and if the polluted site is located in a highly populated/residential area, as is usually the case with MGPs. Correct assessments and accurate predictions of cyanide behavior are needed to be able to deal with these sites as well as possible.

6. Cleaning up tailings solutions and remediating contaminated sites

The international community does not appear to agree on the treatment to be used after a spill. Cyanogen chloride may form after treatment with sodium hypochlorite. Hydrogen peroxide oxidizes cyanide into cyanate, which is much less toxic. In practice, it will probably mainly depend on what is available in what quantities, and on other local conditions. The methods will aim at immobilizing and containing the cyanide, converting it into a less toxic compound or both.

Several plants and organisms produce cyanide or cyanide-containing compounds, for instance as a defense mechanism. Partly as a response to the former, other organisms exist that either are able to neutralize this toxicity or actually use cyanide compounds as a substrate (Barclay *et al.*, 1998; White and Schnabel, 1998). The latter can be enlisted to help us tame cyanide on-site.

Barclay *et al.* (1998) report on metal cyanide degradation by fungi, which is relevant for MGP sites. These authors isolated fungal cultures from MGP sites. A culture of *Fusarium solani* and *Trichoderma polysporum* was maintained on tetracyanonickelate. A mixture of *Fusarium oxysporum*, *Scytalidium thermophilum* and *Penicillium miczynski* was cultured on hexacyanoferrate. Both culture mixes were able to use $K_4Fe(CN)_6$ as sole nitrate source, at acidic pH. The cultures also rapidly degraded $K_2Ni(^{14}CN)_4$ at pH 7.

Cellan (1996) compared lab and commercial neutralization data for the Homestake Santa Fe mine. Barren solutions from the site were used to rinse spent ore from the mine's leach pads. In the lab, this process removed most WAD from the leached ore. The lab results apparently compared well with the actual site data. Cellan recommends lab tests that closely follow the conditions at the site, such as bed thickness, to be included in the planning of mines and mine closures.

Given and Meyer (1999) report on the tailings solution treatment applied at the Homestake Nickel Plate Mine in British Columbia. Cyanide, thiocyanate, ammonia and nitrate were removed by aerobic and anaerobic biological treatment, while a High Density Sludge (HDS) process was applied to remove metals. Breakpoint chlorination, hydrogen peroxide and the Inco SO2/air process are alternative methods, according to these authors. Breakpoint chlorination is the only process that also removes thiocyanate, ammonia and nitrate but it is very expensive and results in problematic high chloride concentrations. It turned out that the existing plant could be converted into a biological treatment facility with very little effort and expense. The treatment plant became operational in October of 1996.

According to Given and Meyer (1999), thiocyanate is converted by several bacteria, notably *Thiobacillus thiocyanoxidans*, *Thiobacillus thioparus*, and *Thiobacillus denitrificans*, through addition of an organic carbon source, according to:

$$SCN^- + 2H_2O + 2O_2 \Leftrightarrow SO_4^{2-} + NH_4^+ + CO_2$$

Nitrosomonas and *Nitrobacter* species use inorganic carbon and proceed with the conversion of ammonia via nitrite into nitrate. In this process, pH needs to be controlled, for instance with soda ash or lime. The nitrification process also requires temperatures of ideally 15°C or higher, oxygen needs to remain high enough and the high metal contents may interfere with the nitrifiers.

Cyanide and cyanate can be taken care of by species of *Pseudomonas*, *Alcaligenes*, and *Achromobacter*, and also with the help of *Chromobacterium violaceum*, which produces rhodanase. The resulting cyanate, also a product of the Inco SO2/air process and from WAD conversion, at neutral to acidic pH, can be hydrolyzed to form ammonia and bicarbonate.

WAD can be adsorbed onto biomass and then converted into cyanate. SAD can only be removed by precipitation (see also the sections on MGP sites).

Pseudomonas, *Micrococcus*, *Achromobacter* and *Bacillus* species were used to denitrify the solution in anaerobic conditions, with addition of an organic carbon source. This results in

Continued on page 22

Continued from page 21

formation of nitrogen, carbon dioxide, water and hydroxide. The pH, however, needs to remain approximately neutral and this is achieved by addition of sulfuric acid. The process is highly sensitive to temperature (the reaction rate doubles with a 4-degree increase). Temperatures below 10°C are not advisable for this process.

The HDS process uses ferric sulfate to precipitate ferric arsenate and gypsum. Other metals precipitate as hydroxides during this process. The article by Given and Meyer does not indicate what happened to the precipitates formed in the HDS process, but presumably they are treated as toxic waste.

Cellan *et al.* (1999) carried out laboratory experiments focused on revegetating former mining sites. The high salt content (sodium, nitrate) of neutralized leach material is often a problem. According to Cellan *et al.*, prior leaching of the salts to sufficient depths, with water from local wells, prior to adding a growth medium, yields better results.

White and Schnabel (1998) report that biological treatment was also applied at another Homestake mine, in South Dakota. The paper describes the development and use of a mobile sequencing batch biofilm reactor system. In this case, the organisms were isolated from a municipal waste treatment plant in Fairbanks, Alaska. The authors state that the microbes in their reactor removed all cyanide and, upon addition of glucose, also converted all excess ammonia. The addition of glucose forced the organisms to acquire their nitrogen from ammonia in order to be able to use the glucose. Nitrification and evaporation of ammonia and evaporation of HCN apparently did not take place.

7. Examples of cyanide pollution cases

7.1 Northparkes, New South Wales, Australia

The following example was found on the Internet. Northparkes is an open-pit gold mine in New South Wales that uses cyanide in flotation. When the mine at some point started processing ore with a higher Cu proportion, it probably had to keep adding cyanide to the leach solution. Only the 'free' cyanide contents was monitored in the tailings, and only for process purposes. There was no requirement to monitor WAD. While the measured free cyanide appeared to remain normal, the proportion of copper cyanide complexes in the tailings actually rose and rose which went unnoticed until birds started dying around the tailings dam in May 1995. According to the Australian Minerals and Energy Environment Foundation Australia (AMEEF Australia), copper complexes are especially toxic to birds and 2700 birds died. Measures taken included traditional bird 'scare' tactics that are also used in orchards (AMEEF Australia web site and other sites, listed in references). North regrets the birds' deaths and no longer uses cyanide at Northparkes, according to North Limited's managing director in a press release from September 1996 (North, 1996).

Regretfully, Northparkes recently experienced a disaster of a different nature, when four workers were killed during a cave-in during a shut-down in November of 1999 (Hagopian, 2000 and other sites, listed in references).

7.2 Dutch manufactured-gas plants and a Belgian site

The geology of The Netherlands, basically a large river delta, has not yet inspired anyone into starting a gold mine, but the country does have 234 sites of former manufactured-gas plants (Didde, 1995; Meeussen *et al.*, 1994). The first Dutch gas plant opened its doors in 1826 and the last one closed in 1969 (Didde, 1995). In 1995, the total cleanup costs for Dutch former gas plant sites were estimated at NLG 4,000,000,000 (Didde, 1995), which translates into roughly USD 1,600,000,000 at the current high exchange rates. That's a lot of money for a small country tinier than many American counties. The high costs can be attributed to the complexity of the pollutant mix and the location usually being in the middle of residential areas (Didde, 1995).

Fig. 5. A polluted MGP site: the 'Westergasfabriek' in Amsterdam, The Netherlands

A case of cyanide pollution only recently made public is located in Amsterdam, at just a half hour's walk from where I live. The object also photographs conveniently well (Fig. 5). It had been known for years that the grounds of this MGP were seriously polluted, for instance with benzene and heavy metals (EPA). The local belief however appears to be that only a few months ago the pollution was discovered to include cyanide as well.

In 1992, the local city district council acquired the Westergasfabriek (western gas plant), which had closed in 1967. Thirteen of the plant's seventeen structures are pretty and characteristic buildings in neo-renaissance style, with red bricks, stepped gables and other ornaments, built between 1885 and 1905 (EPA). Most of them are now considered national monuments and protected. After cleanup, the terrain will be converted into a park. The buildings already house a cinema, a restaurant, exhibitions, the district's city council, a café, and other facilities and are also home to theater companies, opera performances and conferences. Even the enormous gas tank plays its new role well (Fig. 6).

A local neighborhood paper reported that cyanide was discovered on the grounds in May, after members of a work crew started vomiting and experiencing breathing problems (Landsaat, 2000). A 'strange smell' was reported as well (Landsaat, 2000), but no further description was given. Members of theater companies rehearsing on the grounds apparently had been complaining about skin rashes and breathing problems for several months (S.J. Reed, pers. comm., 2000), although the significance of this is not clear. According to the health authorities (Milieudienst, pers. comm., 2000), neither is it clear whether the workers actually became unwell due to cyanide poisoning. My personal impression is that the authorities had known about the cyanide contamination, as the opposite would be surprising, but that something, although what is unclear, happened that warranted further action, which included closing off most of the grounds. I have requested but not yet received further information from the authorities about this case. The soils in the lower parts of The Netherlands tend to consist of calcareous clays and have a relatively high pH, while the higher parts have sandy, acidic soils (Meeussen *et al.*, 1994). In view of the location of this MGP site, a sandy soil is unlikely. The groundwater level will be relatively high.

Fig. 6. The remaining gas tank at the Westergasfabriek in Amsterdam is now home to opera performances and conferences.

Performances were canceled, samples were taken, analyses were carried out, and the terrain was cordoned off, according to the local community paper. On July 18, the daily *Het Parool* reported that the local health authorities had declared the situation safe and not compromising the health of residents and visitors.

The information that is readily available appears to be provided by the public and by newspapers (notably Staatskrant, 2000), not by the authorities. One of the workers on the Westergasfabriek grounds worried about a red pimple on his chest (Landsaat, 2000). Might it be caused by the cyanide on the terrain? He did not know.

The cleanup approach for Dutch former gas plant sites varies. In the province of Zeeland, 800 truckloads of soil were removed from the Oranjebolwerk site: 10,000 cubic meters of soil were cleaned by extraction and 15,000 were cleaned thermally (Pelgrim, 2000). Another former gas plant site is the Griftpark in Utrecht. The pollution in the Griftpark was discovered in the late 70s. Removing the contaminated soil was considered too costly. Instead, the pollution was isolated by an impermeable clay layer, a concrete wall of about 50 meters deep and 1235 meters long, and topped by a 1.5 meter thick cap of gravel, a lining, sand and top soil (Marlet, 1999). At Hoogeveen, the authorities removed some 500 truckloads of soil. In addition, more than 2,000,000 cubic meters of groundwater were rid of 187 kg naphthalene, 382 kg cyanide and 97 kg aromatics (Provincie Drenthe, 1997). The Amsterdam western gas plant is on a canal and special attention will need to be given to water pollution. I did notice ducks and coots on the canal, but only a few. The site itself has a lush vegetation, except of course where the soil was recently excavated. According to the Wester gas plant web site and the local neighborhood site, the pollution will be isolated by a steel dam and covered by a layer of 1.5 m of clean soil.

Fig. 7. Grounds behind fences: MGP site in Amsterdam (Westergasfabriek).

According to the Dutch daily *De Volkskrant*, neighboring country Belgium also discovered an an interesting case of cyanide pollution two years ago (De Graaf, 1998). Nothing would grow on some spots in the little village of Rumst, where part of the soil was blue. Prussian Blue and high enough cyanide concentrations can result in blue/green soil colors, while ferric thyocyanate complexes may lead to reddish colors (Kjeldsen, 1999). A survey had been carried out once, on those soils with the blue spots where nothing would grow, but no contamination was found at the time. Because nobody had thought of cyanide. Later, a physician pointed out that the blue color might have something to do with iron cyanides. New analyses revealed cyanide concentrations twenty times higher than the Dutch legal limits for soils. Dutch regulation had to be used, because Belgian law did not even mention cyanide. The grounds lie behind fences now but nobody knows who is going to pay for the cleanup. ‘The polluter should pay,’ said the village’s mayor. But who’s the polluter? Nobody seems to know. A metallurgical factory once occupied the site, but it is also possible that someone else later dumped wastes on the abandoned terrain. In terms of cleanup, however, nothing much is expected to happen for another ten years. The local community does not appear to be very worried.

Continued on page 24

Continued from page 23

8. Conclusions

Cyanide causes problems for mining companies, but there don't seem to be good alternatives for cyanidation yet. If there were, the mining companies would be using them right now, on a large scale. The mining industry and the chemistry profession are highly aware of the problems associated with mining. For example, IUPAC's Chemistry and the Environment Division recently held a workshop in Potchefstroom, South Africa (http://www.saci.co.za.35th_convention.webcirc1.htm), addressing environmental chemistry aspects of mining. South-African chemists appear to agree that Africa's largest pollution problems come from mining (IUPAC, 1999). The public is also increasingly becoming aware of the problems with cyanide. But as this article will have shown, mining is not the only area for which cyanide research is highly relevant. Particularly families with children living close to former MGPs have questions about cyanide as well. The authorities are faced with the difficult task to assess what is tolerable and what is not. There is no clear-cut solution, no straightforward answer. In both kinds of pollution cases, mining and urban, good communication with the public is also vitally important. Dutchmen with pimples should not have to lie awake worrying about cyanide.

Cyanide is an excellent example of a highly interesting research topic that spans a wide range of geochemistry. It also shows geochemistry's relevance for society and the geochemical community's obligation to share its knowledge with society almost too well.

Angelina W.M.G. Souren
Associate Editor for the Geochemical News
Armadillo Research Services
E-mail: Angie@armadillo-research.com

Main references for present article (GN issue 105)

Adams, M. Meaningful cyanide speciation and deportment. Lakefield Oretest web site. (http://www.oretest.com.au/cnspeciation.htm)

Australian Minerals and Energy Environment FoundationAustralia (AMEEF Australia) (http://www.ameef.com.au/publicat/bpem/cyan_mn.htm) (see also http://www.erin.gov.au/epg/environet/tech/cs/cs_046_te.html and http://www.boardofstudies.nsw.edu.au/elemental/np.html and http://www.north.com.au/news-releases/archives-199609/rel-1996090401.html)

Barclay M., Hart A., Knowles C.J., Meeussen J.C.L., and Tett V.A. (1998) Biodegradation of metal cyanides by mixed and pure cultures of fungi. *Enzyme and Microbial Technology*, **22**, 223-231.

Bell A.V. (1974). Base-metal mine waste management in Canada. In: Jones (ed.) *Minerals and the environment.* The Institution of Mining and Metallurgy, London, UK.

Bigelow R.C. and Plumlee G.S. (1995) The Summitville mine and its downstream effects. An on-line update of Open File Report 95-23. USGS. (http://greenwood.cr.usgs.gov/pub/open-file-reports/ofr-95-0023-summit.htm)

Cellan R.R. (1996) Comparison of laboratory and commercial neutralization - Rinse data from gold heap leach operation. Presented at the Annual Meeting and Exhibit Society for Mining, Metallurgy, and Exploration, Inc., Phoenix, AZ. (http://www.homestake.com/health_safety/health_safety_sublevels/reports/other_reports/envcell.htm)

Cellan R., Cox A., Uhle R., Jenevein D., Miller S., and Mudder T. (1997) Design and Construction of an IN SITU Anaerobic Biochemical System for Passively Treating Cyanide Drainage. Paper presented at the 1997 National Meeting of the American Society for Surface Mining and Reclamation, Austin, Texas. (http://www.homestake.com/health_safety/health_safety_sublevels/reports/other_reports/envinsit.htm)

Cellan R., Cox A., Burnside L., and McClelland G. (1999) Options for Revegetating Neutralized Heap Leach Material. Homestake Mining Company Report. (http://www.homestake.com/health_safety/health_safety_sublevels/reports/other_reports/leach.htm)

Chadwick J. (2000) Latin gold. *Mining Magazine*, **August 2000**, 66-74.

Clifford D. (2000) Rio Narcea's ongoing growth. *Mining Magazine*, **February 2000**, 82-86.

Cyanide speciation and deportment. Technical Note 10. (http://www.oretest.com.au/technote10.htm)

De Graaf (1998) Het blauwe gifterrein was jarenlang vrij toegankelijk. *De Volkskrant*, **February 7 1998**.

Denver Mineral Engineers site (http://www.denvermineral.com/basicp~1.html)

Didde R. (1995) Een zandfilter kan de was doen. Cyanidehoudend grondwater kan gezuiverd via het riool. Delta 6. (http://delta/tudelft/nl/delta/jaargangen/27/6/gas.html)

Eisler R. (1991) Cyanide hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv., *Biol. Rep.*, **85** (1.23), 55pp.

EPA Westergasfabriek - Collaboration of local government and community. An international brownfields case study. (http://www.epa.gov/brownfields/html-doc/westrgas.htm)

Evans A.M. (1995) *Introduction to mineral exploration*. Blackwell Science, Oxford, pp. 396.

Fagan, P.A. (1998) *Development of an ion chromatographic system suitable for monitoring the gold cyanidation process*. Ph.D. Thesis University of Tasmania. (http://www.library.unsw.edu.au/~thesis/adt-root/public/adt-NUN1999.0040/index.html)

Ghosh, R.S., Dzombak D.A., and Luthy R.G. (1999a) Equilibrium precipitation and dissolution of iron cyanide solids in water. *Environmental Engineering Science*, **16** (4), 293-313.

Ghosh, R.S., Dzombak D.A., Luthy R.G., and Nakles D.V. (1999b) Subsurface fate and transport of cyanide species at a manufactured-gas plant site. *Water Environment Research*, **71** (6), 1205-1216.

Given, B. and Meyer, S. (1999) Biological Treatment of Tailings Solution at the Nickel Plate Mine. Homestake Mining Company Report. (http://www.homestake.com/health_safety/health_safety_sublevels/reports/other_reports/npbugpap.htm and http://www.homestake.com/health_safety/health_safety_sublevels/reports/other_reports/biowat.htm)

Guilbert J.M. and Park C.F.Jr. 9(1986) *The geology of ore deposits.* W.H. Freeman and Company, New York, pp. 985.

Haddad P.R. and Rochester N.E. (1988) Ion-interaction reversed-phase chromatographic method for the determination of gold(I)cyanide in mine process liquors using automated sample preconcentration. *J. Chromatogr.*, **439**, 23-36.

Hagopian A. (2000) North nearing decision on opening Northparkes.(caved-in mine), *American Metal Market*, January 10, 2000 (http://www.findarticles.com/m3MKT/5_108/58676335/p1/article.jhtml) (see also http://www.egoli.com.au/newsandviews/archives/5502.html and http://www.north.com.au/news-releases/rel-1999112901.html)

Hilton D.F. and Haddad P.R. (1986) Determination of metal-cyano complexes by reversed-phase ion-interaction high-performance liquid chromatography and its application to the analysis of precious metals in gold processing solutions. *J. Chromatogr.*, **361**, 141-150.

IUPAC (1999) Chemistry and the Environment Division (http://www.iupac.org/projects/1999/6_1_99.html). See also *Chemistry International*, **22** (3), May 2000 (http://www.iupac.org/publications/ci/2000/may/new_africa.html)

Johnson C.A., Grimes D.J., and Rye R.O. (1998) Accounting for cyanide and its degradation products at three Nevada gold mines: Constraints from stable C- and N-isotopes. USGS Open-File Report 98-753. Denver, Colorado.

Kjeldsen P. (1999) Behaviour of cyanides in soil and groundwater: a review. *Water, Air and Soil Pollution*, **115**, 279-307.

Landsaat, M. (2000) Kotsende bouwvakkers in het gifpark. *De Staatskrant*, **September 2000**. (http://www.staatskrant.com/wijkcent/krant/editie/2000/00092907/txt/050101.htm)

Leybourne M.I., Goodfellow W.D., Boyle D.R., and Hall G.E.M.

(2000) Form and distribution of gold mobilized into surface waters and sediments from a gossan tailings pile, Murray Brook massive sulphide deposit, New Brunswick, Canada. *Appl. Geochemistry*, **15**, 629-646.

Marlet G. (1999) Buurtbewoners omarmen hun oude gifpark. *Trouw*, **17 September 1999**. (http://www.trouw.nl/natuur/frame/315025392.html)

Meeussen J.C.L., Temminghof E.J.M., Keizer M.G., and Novozamsky I. (1989) Spectrophotometric determination of total cyanide, iron-cyanide complexes, free cyanide and thiocyanate in water by a continuous-flow system. *Analyst*, **114**, 959-963.

Meeussen J.C.L., Keizer M.G., and De Haan F.A. (1992a) The chemical stability and decomposition rate of iron cyanide complexes in soil solutions. *Environ. Sci. Technol.*, **26**, 511-516.

Meeussen J.C.L., Keizer M.G., and Lukassen W.D. (1992b) Determination of total and free cyanide in water after distillation. *Analyst*, **117**, 1009-1012.

Meeussen J.C.L., Keizer M.G., Van Riemsdijk W.H. and De Haan F.A. (1992c) Dissolution behavior of iron cyanide (Prussian Blue) in contaminated soils. *Environ. Sci. Technol.*, **26**, 1832-1836.

Meeussen J.C.L. and Keizer M.G. (1993) Cyanide in de bodem: relatie chemie en risico-evaluatie. *Bodem*, **1**, 15-17.

Meeussen J.C.L., Keizer, M.G., Van Riemsdijk W.H., and De Haan F.A.M. (1994) Solubility of cyanide in contaminated soils. *J. Environ. Qual.*, **23**, 785-792.

Meeussen J.C.L., Van Riemsdijk W.H., and Van der Zee S.E.A.T.M. (1995) Transport of complexed cyanide in soil. *Geoderma*, **67**, 73-85.

Mining Magazine January 2000.

Moran, R. (1998) Cyanide uncertainties. Observations on the chemistry, toxicity, and analysis of cyanide in mining-related waters. MPC Issue Paper no.1, Mineral Policy Center, Washington, USA. (http://www.zpok.hu/~jfeiler/baiamare/docs/cyanideuncertain.htm)

Moran R.E. (2000) Cyanide in mining: some observations on the chemistry, toxicity and analysis of mining-related waters. (http://www.natural-resources.org/environment/Baia Mare/docs/mining_cyanide.htm)

North Ltd. (1996) Press release. (http://www.north.com.au/news-releases/archives-199609/rel-1996090401.html)

Pelgrim B. (2000) Oranjebolwerk voor zomer klaar. Provinciale Zeeuwse Courant. (http://www.pzc.nl/presentatie/page/0,1416,3_12_1____74325,00.html)

Post, L. Performance cyanide. Wilson McHenry Company site. (http://www.wmc.com.au/sustain/envrep97/page23.htm)

Provincie Drenthe (1997) Provincie rondt sanering gasfabriek Hoogeveen af. Press release. (http://www.nieuwsbank.nl/inp/1997/11/1118U048.htm)

Staatskrant (2000) (http://staatskrant.com/wijkcent/krant/editie/1999/99062805/txt/110101.htm and http://wijkcent. a2000.nl/wijkcent/krant/editie/2000/00072906/txt/030101.htm)

Staritsky I.G., Slot P.H.M., and Stein A. (1992) Spatial variability and sampling of cyanide polluted soil on former galvanic factory premises. *Water, Air and Soil Pollution*, **61**, 1-16.

Stewart A. (1990) Gold processing alternatives. *International mining*, **7**, 29.

Westergasfabriek web site. (http://www.westergasfabriek.nl, Dutch and http://www.westergasfabriek.nl/p_set.htm, English)

White D.M. and Schnabel W. (1998) Treatment of cyanide waste in a sequencing batch biofilm reactor. Wat. Res. 32 (1), 254-257.

Main references for 'Weeping rivers' (cyanide part I) (GN issue 104)

The account of events was mainly taken from the UNEP/OCHA report, while the description of the rivers' and people's responses was mainly a summary from the media.

ATSDR. Cyanide (1997) Agency for Toxic Substances and Disease Registry fact sheet. (http://atsdr1.atsdr.cdc.gov/tfacts8.html). Includes Australian Water Quality Guidelines for Fresh and Marine Waters: (ANZECC, 1992) data.

Balázs, E. (2000) Every cloud has its silver lining, even those responsible for the devastating flooding in eastern Hungary. Budapest Sun, 8 (18).
(http://www.budapestsun.com/full_story.asp?ArticleId={14C7D1A220EF11D4BA78004F49089EA2}&From=News)

Craigmill A.L. (1981) Toxic plants. Cooperative extension University of California Environmental Toxicology Newsletter, 1 (3) (http://ace.orst.edu/info/extoxnet/newsletters/n13_81.htm)

Central European Review (http://www.ce-review.org/). Includes interviews Dr György Csizmazia, "ornithologist, biologist and researcher into the River Tisza at the University of Szeged" and György Imre Török, "Chief Engineer and Deputy Technical Director of the Lower Tisza Provincial Water Authority (ATVIZIG), also based in Szeged" (http://www.ce-review.org/00/7/csardas7.html), statements made by Gábor Kuncze (SZDSZ, Alliance of Free Democrats) during a debate in the Hungarian parliament (http://www.ce-review.org/00/10/csardas10.html).

CDC. Cyanide. (1989) Public Health Statement Agency for Toxic Substances and Disease Registry, December 1989. (http://www.atsdr.cdc.gov/Tox/Profiles/phs8812.html)

Cyanide. (http://www.scorecard.org/chemical-profiles/summary.tcl?edf_substance_id=74-90-8)

Cyanide. National Pollutant Inventory. (http://www.environment.gov.au/epg/npi/contextual_info/context/cyanide.html)

Cyanide Spill Kills Key European Otters (http://ens.lycos.com/ens/feb2000/2000L-02-28-03.html)

Deis, F. The Merck Index: HCN. (http://www.nizkor.org/hweb/people/l/leuchter-fred/hcn/html)

Goldstein R.J. The use of cyanide in marine fish capture. (http://www.marksfish.f9.co.uk/cyanide.htm)

Health Canada. Constituents of tobacco smoke. Health Canada, Ottawa, Ontario K1A OK9. (http://www.hc-sc.gc.ca/hppb/tobaccoreduction/factsheets/inapuff.htm).

International Chemical Safety Cards. (1993) Hydrogen cyanide. (http://www.cdc.gov/niosh/ipcsneng/neng0492.html)

Hydrogen Cyanide. (http://tlchm.bris.ac.uk/~paulmay/misc/motm/hcn/hcn_text.htm)

Kazimuddin, A. (2000) Nightmare in Europe. The Danube river system will take several years to rid itself of the cyanide. (http://www.oneworld.org/cse/html/dte/dte20000331/dte_news.htm)

Koenig R. (2000) Wildlife deaths are a grim wake-up call in Eastern Europe. *Science*, **287**, 1737-1738.

Lakes Environmental Software. Cyanide. Lakes Environmental Software. (http://www.lakes-environmental.com/toxic/CYANIDE.HTML)

Minerals Councils of Australia fact sheets.

Mining Magazine. Jekyll and cyan-Hide. (1999) Mining Magazine. The London Journal about international mining and minerals industry, 180 (1) (http://www.mining-journal.com/mj?MM?mm0199.htmhttp://www.mining-journal.com/mj/MM/mm0199.htm#Jekyll and cyan-Hyde)
Mining and Mineral Sciences Laboratories. (1998) Cyanide effects upon fish. Mining and Mineral Sciences Laboratories Report MMSL 98-039(CR), Canada. (http://www.natural-resources.org/environment/BaiaMare/docs/cyanide_fish.htm)

National Safety Council. Hydrogen cyanide (HCN) Chemical Backgrounder. Environmental Health Center, National Safety Council, Washington, DC (http://www.nsc.org/ehc.ew/chems/hydrcyan.htm)

OCHA. Romania - Waste Spill OCHA Situation Report No. 1, February 29, 2000. OCHA site. (http://wwww.reliefweb.int/w/Rwb.nsf/069fd6a1ac64ae63c125671c002f7289/1e995852d5d91f36c1256894005f71d8?OpenDocument).

OCHA. Romania - Mining Waste Spill OCHA Situation Report No. 1, OCHA/GVA - 2000/0054, March 15, 2000. OCHA site. (http://wwww.reliefweb.int/w/Rwb.nsf/069fd6a1ac64ae63c125671c002f7289/42a0d9b13446bc91c12568a300536f68?OpenDocument).

UN. UN Report: Pollution Remains After Romanian Cyanide Spill (http://ens.lycos.com/ens/apr2000/2000L-04-26-02.html)

UNEP. Tolukuma mine cyanide spill, Papua New Guinea. Web page UNEP Division of Technology, Industry and Economics, Paris, France. (http://www.unep.org/)

UNEP/OCHA Assessment Mission (2000) Cyanide spill at Baia Mare, Romania. Conclusions from the Final Report. (http://natural-resources.org/environment/baiamare/mission.htm).

UNEP/OCHA Assessment Mission, Romania, Hungary, Federal republic of Yugoslavia (2000) Spill of liquid and suspended waste at the Aurul S.A. retreatment plant in Baia Mare. Report United Nations Environment

Continued on page 26

Continued from page 25

Programme, UNEP/Office for the Co-ordination of Humanitarian Affairs, OCHA, Geneva. (http://www.natural-resources.org/environment/BaiaMare/index.htm and http://www.unep.ch/roe/baiamare.htm)

Additional references

Anh, N.B.H. and Sharp, M. (2000) Determination of cyanide by cathodic stripping voltammetry at a rotating silver disk electrode. *Analytica Chimica Acta*, **405**, 145.

Beck M.T. (1987) Critical evaluation of stability constants of metal complexes in solution. Critical survey of cyano complexes. *Pure Appl. Chem.*, **59**, 1703-1720.

Cunningham L. and Williams H.D. (1995) Isolation and characterization of mutants defective in the cyanide- insensitive respiratory pathway of *Pseudomonas aeruginosa*. *J. Bacteriol.*, **177**, 432-438.

Engler H.S., Spencer K.C., and Gilbert L.E. (2000) Preventing cyanide release from leaves. *Nature*, **406** (6792), 144-145.

Fallon R.D. (1992) Evidence of hydrolytic route for anaerobic cyanide degradation. *Appl. Environ. Microbiol.*, **58** (9), 3163-3164.

Hazen USA. Gold ore process development. (http://www.hazenusa.com/golddev1.htm)

Kalnenleks U., Gallnina N. and Poole, R. K. (2000) Cyanide inhibits respiration yet stimulates aerobic growth of *Zymomonas mobillis*. *Microbiology*, **146** (6), 1259.

Korte F., Spiteller M., and Coulston F. (2000) The cyanide leaching gold recovery process is a nonsustainable technology with unacceptable impacts on ecosystems and humans: the disaster in Romania. *Ecotoxicol. Environ. Saf.*, **46**,241-245.

Kunz D.A., Chen J.-L., and Pan G. (1998) Accumulation of -Keto Acids as Essential Components in Cyanide Assimilation by Pseudomonas fluorescens NCIMB 11764. *Appl. Envir. Microbiol.* , **64**, 4452-4459.

Kunz D.A., Nagappan O., Silva-Avalos J., and Delong G.T. (1992) Utilization of cyanide as nitrogenous substrate by *Pseudomonas fluorescens* NCIMB 11764: evidence for multiple pathways of metabolic conversion. *Appl. Envir. Microbiol.*, **58**, 2022-2029.

LaFuente Gonzalez J.M., Martinez Fernandez E., Sanz-Medel, A. (2000) Differential-pulse voltammetric determination of low mu g I^{-1} cyanide levels using EDTA, Cu(II) and a hanging mercury drop electrode. *Analytica Chimica Acta*, **410**, 135.

Logsdon, M.J., Hagelstein, K. and Mudder T.I. (1999) The Management of Cyanide in Gold Extraction. Mining Magazine, London, UK. Pp. 48.

Mansfeldt T. and Biernath, H. (2000) Determination of total cyanide in soils by micro-distillation. *Analytica Chimica Acta*, **406** (2), 283.

Meyers P.R., Rawlings D.E, Woods D.R., and Lindsey G.G. (1993) Isolation and characterization of a cyanide dihydratase from *Bacillus pumilus* C1. *Bacteriol.*, **175**, 6105-6112.

Milosavljevic E.B. and Solujic L. Problems associated with the EPA/ASTM approved method for determination of total cyanide. Infomine. (http://www.infomine.com/technology/labmine/cyanide.html)

Miralles E., Compano R., and Prat M.D. (2000) Determination of metal-cyanide complexes by ion-interaction chromatography with fluorimetric detection. *Analytica Chimica Acta*, **403**, 197.

Mueller M. and Borland C. (1997) Delayed cyanide poisoning following acetonitrile ingestion. *Postgrad. Med. J.*, **73**, 299-300

Nakano N., Yamamoto A., and Nagashima, K. (1999) An automatic measurement of hydrogen cyanide in air by a monitoring tape method. *Analytica Chimica Acta*, **398**, 305.

Ruangkanchanasetr S., Wananukul V., and Suwanjutha S. (1999) Cyanide poisoning, 2 cases report and treatment review. *J. Med. Assoc. Thai.* **82** , S162-167.

Sehmel G.A. (1989) *Cyanide and antimony thermodynamic database for the aqueous species and solids for the EPA-MINTEQ geochemical code.* Report submitted to USEPA, PNL-6835, Pacific Northwest Laboratory, Richland, WA, USA.

Tatsuma T., Komori K., and Oyama N. (2000) Disposable test plates with tyrosines and beta-glucosidases for cyanide and cyanogenic glycosides. *Analytica Chimica Acta*, **408**, 233.

Topp E., Xun L.Y., and Orser C.S. (1992) Biodegradation of the herbicide bromoxynil (3,5-dibromo-4- hydroxybenzonitrile) by purified pentachlorophenol hydroxylase and whole cells of Flavobacterium sp. strain ATCC 39723 is accompanied by cyanogenesis. *Appl. Envir. Microbiol.*, **58**, 502-506.

Williams, R.D. (1995) Environmental Codes of Conduct - Industry Response to a Social Issue. Presented October 1995 at the International Congress on Energy, Environment and Innovative Technology, University of Venezuela and the University of Rome “La Sapienza”, Caracas, Venezuela. (http://www.homestake.com/health_safety/health_safety_sublevels/reports/other_reports/envcode.htm)

Wagman D.D., Evans W.H., Parker V.B., Schumm R.H., Halow I., Bailey S.M., Churney K.L., and Nuttall R.L. (1982) The NBS table of chemical thermodynamic properties - Selected values for inorganic and C1 and C2 organic substances in S 1 units. Supplement No. 2, National Bureau of Standards, U.S. Department of Commerce, Washington, DC, USA.

Yoshikawa K., Adachi K., and Sano H. (2000) Beta-cyanoalanine production by marine bacteria on cyanide-free medium and its specific inhibitory activity toward cyanobacteria. *Analytica Chimica Acta*, **410**, 135.

Call for proposals

EU Geochemical Facility

Applications are invited for access to the EU Geochemical Facility at Bristol University, supported by the European Commission Access to Research Infrastructures action of the IHP Programme. The aim of the Facility is to provide access to modern analytical equipment for research groups who do not otherwise have free use of such equipment in their own country.

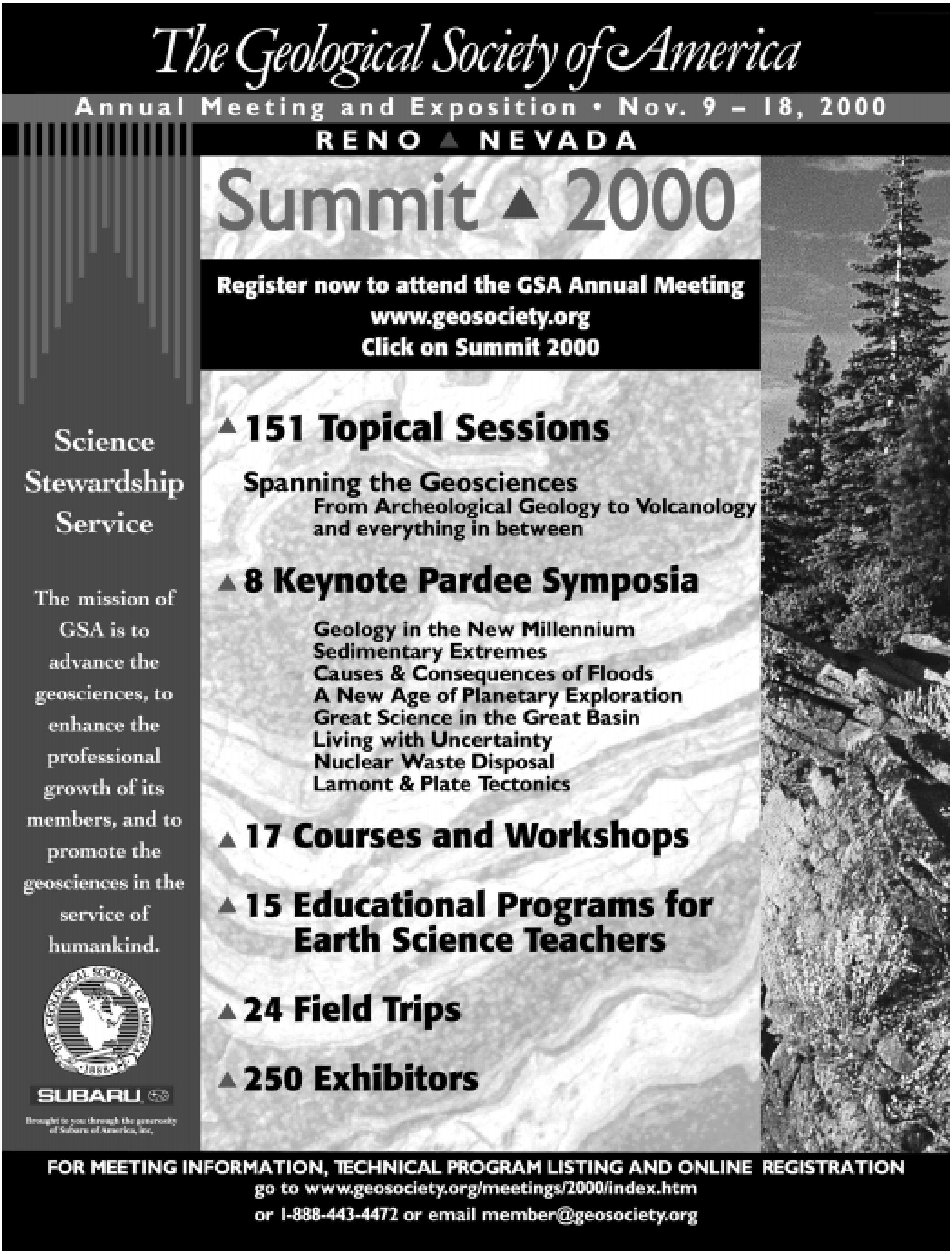
The Geochemical Facility contains a number of modern analytical instruments for geochemical studies. These include electron probe microanalysis, ICP-MS, laser ablation ICP-MS, XRF, ICP-AES,XRD Mössbauer (Fe3+/Fe2+), Fourier Transform Infra-Red spectrometry (CO2 & H2O), LECO (bulk C & S), Nuclear Magnetic Resonance and Scanning Electron Microscopy with qualitative EDS. Analysis of surfaces can be performed using Auger Electron, Secondary Ion Mass and X-Ray Photoelectron Spectrometers. Four well-equipped experimental geochemistry laboratories allow Users to carry out investigations that simulate a wide variety of geological conditions.

Access is restricted to research teams from institutions in EU countries (except UK) plus Bulgaria, the Czech Republic, the Republic of Cyprus, Estonia, Hungary, Iceland, Israel, Latvia, Liechtenstein, Lithuania, Norway, Poland, Romania, Slovakia and Slovenia.

The next deadlines for applications are 15th September and 15th December 2000. Application forms can be downloaded from: http://eugf.gly.bris.ac.uk or are available from the address below.

Prof. Bernard J. Wood
Department of Earth Sciences, University of Bristol
Wills Memorial Building, Queen’s Road
Bristol BS8 1RJ, U.K.

Tel: +44 117 954 5422
Fax: +44 117 925 3385



Meetings Calendar

Nov. 2-4, 2000: Advances on Micas - Problems, Methods, Applications in Geodynamics, Rome, Italy. Accademia Nazionale dei Lincei and Università degli Studi Roma Tre. Abstract deadline: September 1, 2000. Contact: Daniela Volpato, Accademia Nazionale dei Lincei, Via della Lungara 10, I-00165 Roma RM; Tel: +39-06-6868223; Fax: +39-06-6893616; E-mail: segreteria@accademia.lincei.it Web Site: http://www.unimo.it/micas2000/

Nov. 11-12, 2000: MSA Short Course on Sulfate Minerals: Geochemistry,Crystallography, and Environmental Significance. Granlibakken Resort, Tahoe City, California. Co-conveners: Charlie Alpers (cnalpers@usgs.gov), John Jambor (jlj@wimsey.com), and D.Kirk Nordstrom (dkn@usgs.gov). Registration: MSA Business Office, 1015 Eighteenth St NW, Ste 601, Washington, D.C. 20036-5274, USA. Tel: 202-775-4344; Fax: 202-775-0018; E-mail: business@minsocam.org; Web site: http://www.minsocam.org/MSA/SC_SO4.html

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

Dec. 3-7, 2000: Geochemistry of Crustal Fluids, Granada, Spain. Organizers: S. R. Gislason and J. Bruno;
Web site: http://www.esf.org/euresco/00/lc00106a.htm

Dec. 13-15, 2000: 1st French Meeting on Environmental Chemistry/ 1st French Meeting on Stable Isotopes, Nancy, France. Contact: Eric.Lichtfouse@ensaia.inpl-nancy.fr; tel/fax (33) 3 83 59 58 99; http://www.ensaia.inpl-nancy.fr/colloque/

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

March 11-16, 2001: Gordon Conference Polar Marine Science. Field Analyses and Numerical Modeling of Coupled Physical, Chemical and Biological Systems, Four Points Sheraton Ventura, Harbortown,Ventura, California, USA. Web site: http://www.grc.uri.edu/programs/2001/polar.htm

March 20-25, 2001: European Geophysical Society XXVI (EGS 2001) General Assembly, Nice, France. http://www.copernicus.org/EGS/egsga/nice01/nice01.htm

April 8-12, 2001: Biennial Meeting of the European Union of Geosciences (EUG-11) , Strasbourg, France. Web site: http://eost.u-strasbg.fr/EUG/EUG11.html

April 19-23, 2001: Third IAEA Symposium on Isotope Techniques in the Study of Environmental Change, Vienna, Austria. Contact: Pradeep K. Aggarwal, Isotope Hydrology Section, International Atomic Energy Agency, P.O. Box 100, Wagramer Strasse 5, A 1400, Vienna, Austria; Ph. +43-1-2600-21735; Fax +43-1-26007; e-mail: p.aggarwal@iaea.org; www.iaea.org/worldatom/Meetings/Planned/2001/

May 2-4, 2001: ECROFI-16. European Current Research on Fluid Inclusions, Porto, Portugal. Abtsract deadline: January 5, 2001. Contact: XVI ECROFI, Departamento de Geologia, Faculdade de Ciências, Praça Gomes Teixeira, 4099-002 Porto, Portugal; Phone: +351-22-3401471; Fax: + 351-22-2056456E-mail: ecrofi@fc.up.pt. Web site: http://www.fc.up.pt/geo/ecrofi/

May 19-25, 2001: Impact Markers in the Stratigraphic Record: 6th workshop of the ESF-IMPACT Programme. Contact: Francisca C. Martinez-Ruiz, Instituto Andaluz de Ciencias de laTierra (CSIC-UGR), Fac. Ciencias, Fuentenueva s/n., 18002 Granada (Spain); Fax: 34 958 243384; e-mail: fmruiz@ugr.es. http://www.ugr.es/~impact/

May 20-24, 2001: Goldschmidt 2001, Roanoke, VA, USA. Contacts: Mike Hochella (hochella@vt.edu) and Bob Bodnar (bubbles@vt.edu), Department of Geological Sciences, Virginia Tech, Blacksburg, VA 24061-0420.

May 23-June 3, 2001: Strength From Weakness: Structural Consequences of Weak Interactions in Molecules, Supermolecules, and Crystals, Erice, Italy. http://www.geomin.unibo.it/orgv/erice/strength.htm

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

June 10-15, 2001: Gordon Conference on the Interior Of The Earth, Mount Holyoke College, South Hadley, MA, USA

June 25-29, 2001: 4th International Symposium on Applied Isotope Geochemistry (AIG-4), Asilomar Conference Center, Pacific Grove, California, U.S.A. Contact: Tom Bullen, tdbullen@usgs.gov

July 24-27, 2000: International Symposium on Isotopomers (ISI 2001), Yokohama, Japan. Web site: http://nylab.chemenv.titech.ac.jp/ISI2001/isi2001.html

Aug. 19-24, 2001: Gordon Conference on Inorganic Geochemistry, Proctor Academy, New Hampshire. The theme will be the formation, modification and preservation of ore deposits, with a focus on geochemical processes related to tectonic, climatic, and surficial factors. Attendance will be limited; subsidies for students are anticipated. Convened by Jean Cline, Jeff Hedenquist and John Thompson. Contact Jeff Hedenquist, gordongeochem@aol.com

Aug. 25-31, 2001: 20th European Crystallographic Meeting (ECM-20): Crystallography in Natural Sciences and Technology, Kraków, Poland.The Jagiellonian University. In collaboration with Stanislaw Staszic University of Mining and Metallurgy. Contact: ECM20, Conference Secretariat, Faculty of Chemistry, Jagiellonian University, Ul. Ingardena 3, 30-060 Kraków, Poland. E-mail: ECM2001@chemia.uj.edu.pl Web site: http://www.ch.uj.edu.pl/ECM2001.htm

Aug. 26-29, 2001: 6th Biennial SGA Meeting -- Mineral Deposits at the Beginning of the 21st Century, Krakow, Poland. Contact: 6th Biennial SGA Meeting, Dr. Wojciech Mayer, University of Mining and Metallurgy, Faculty of Geology, Geophysics & Environmental Protection, av. Mickiewicza 30, 30-059 Kraków, Poland; Phone: +48-12-6172385; Fax:+48-12-6332936, E-mail: wmayer@geol.agh.edu.pl Web site: http://galaxy.uci.agh.edu.pl/~sga/

September 3-7, 2001: Écorad 2001 -International congress on the radioecology-ecotoxicology of continental and estuarine environments, Palais des congrès, Aix-en-Provence, France. Abstract deadline: October 2000. Contact: ECORAD 2001 - IPSN-DPRE – Bât. 02, Rue Auguste Lemaire B.P. n°6 / 92265, Fontenay-aux-Roses cedex, France; Phone: +33 1 46 54 79 06; Fax: +33 1 46 54 72 90; E-mail:ecorad.2001@ipsn.fr http://www.ipsn.fr/ecorad2001. Web sites: http://www.ipsn-dpre.com/ecorad2001 and http://www.ipsn-dpre.com/ecorad2001/

September 10-14, 2001: 20th International Meeting on Organic Geochemistry (IMOG 2001), Nancy, France. Abstract deadline: December 1, 2000. Contact: E-mail: imog2001@g2r.uhp-nancy.fr. Web site: http://www.imog.uhp-nancy.fr

September 15-20, 2001: The Deep Earth: Theory, Experiment and Observation: Subduction Zones, Ridges and Plumes, Espinho (near Porto), Portugal. Contact: J.A.M. Paulssen, Earth Sciences, University Utrecht, Budapestlaan 4, 3584 CD UTRECHT, The Netherlands; Phone: +31 30 2535089; fax: +31 30 2533486; E-mail: paulssen@geo.uu.nl. Web site: http://www.esf.org/euresco/01/c_cal01.htm

Sept. 17 - 21, 2001: 7th International Conference on Paleoceanography (ICP7), Sapporo, Japan. Abstract Deadline: March 10, 2001 Co-Conveners: Hisatake Okada (Dept. of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University, Sapporo, 060-0810, Japan. Phone: 81-11-706-3537. Fax: 81-11-746-0394. E-mail: oka@cosmos.sci.hokudai.ac.jp), Itaru Koizumi, and Tadamichi Oba

Nov. 5-8, 2001: GSA Annual Meeting, Boston, MA USA. Contact: GSA Meetings, Box 9140, Boulder, Colo. 80301-9140. Tel: +1-303-447-2020, ext. 164; Fax: +1-303-447-1133; WWW: http://www.geosociety.org/meetings/index.htm

Sept. 9-13, 2002: Mineralogy for the new millenium (IMA 2002), 18th General Meeting of the International Mineralogical Association, Edinburgh, United Kingdom. Contact: Mr K. Murphy, Executive Secretary, Mineralogical Society of Great Britain and Ireland, 41 Queen's Gate, London SW7 5HR, United Kingdom: Phone: +44 171 584 7516; E-mail: IMA@minersoc.demon.co.uk.

THE GEOCHEMICAL SOCIETY
SPECIAL PUBLICATION SERIES

Volume	Title	Price, $US
1	Magmatic Processes: Physicochemical Principles, edited by B. O. Mysen (1987)	25.
2	Fluid-Mineral Interactions: A Tribute to H.P. Eugster, edited by R. J. Spencer and I.-M. Chou (1990)	25.
3	Stable Isotope Geochemistry: A Tribute to Samuel Epstein, edited by H. P. Taylor *et al.* (1991)	25.
4	Victor Moritz Goldschmidt: Father of Modern Geochemistry, by Brian Mason (1992)	20.
5	Mineral Spectroscopy: A Tribute to Roger G. Burns, edited by M. D. Dyar *et al.* (1996)	40.
6	Mantle Petrology: Field Observations and High-Pressure Experimentation, A Tribute to Francis R. (Joe) Boyd, edited byY. Fei, C. M. Bertka and B. O. Mysen (1999)	60.
	SPECIAL OFFER!!! Entire 6-volume set ($195. value), expires Dec. 31, 2000	120.

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
Washington University, EPSC 1169
One Brookings Drive
St. Louis, MO 63130-4899

Name ___________________________________

Address ________________________________

____

City ________________State_____ Zip __________

Country_______________________

Check here if GS Member______________

Phone:_____________________________

Fax: ______________________________

E-Mail: ____________________________

ORDER: Special Publications Volume(s): please specify quantity: 1____2____3____4____5____ 6_____

6-volume set ___________

Please enter Grand Total: $ _______________________

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

Number:_____________________________ Exp.______

Signature______________________________________

GEOCHEMICAL SOCIETY MEMBERSHIP APPLICATION AND RENEWAL FORM - 2001

The Geochemical Society, Inc. and
Geochimica et Cosmochimica Acta

In order to process your application or renewal for membership in the Geochemical Society and begin your subscription to *Geochimica et Cosmochimica Acta* for 2001, please fill out this form and mail it with your payment to:

Business Manager, The Geochemical Society
Washington University, EPSC 1169
One Brookings Drive
St. Louis, MO 63130-4899

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: $147.00 ____
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 _____
American Express _______

Credit card # ___________________________________

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 _____

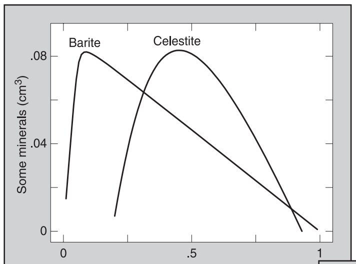
Thank you for your support!

The Geochemist's Workbench®

Graphical solutions to your tough problems — in minutes!

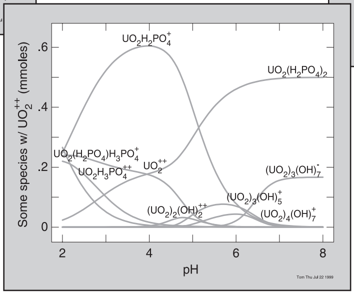
New!!! Version 3.1 for Windows 95/98 and NT

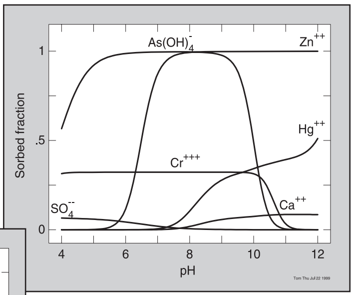
H2O • Ag+++ • Am+++ • As(OH)4- • Au+ • B(OH)3 • Ba++ • Br- • Ca++ • HCO3- • Cs+ • Cl- • Co++ • Cr+++ • Cu+ • Eu+++



Mineral scales formed when formation fluid from a North Sea oil field mixes at reservoir temperature with seawater.

Species distribution of uranyl vs. Ph, in the presence of phosphate.





Predict sorption vs. pH of metals onto HFO.

Applications of GWB include —

- Environmental protection and remediation
- Petroleum and minerals industries
- Nuclear waste repository design
- Acid mine drainage
- Ore leachate design
- General geochemistry
- Classroom education

Your personal toolkit for—

- Reaction paths
- Kinetic rate laws
- Isotope fractionation
- Sorption and surface complexation
- Brine chemistry, "Pitzer equations"
- Temperature-activity diagrams
- Calculating species distribution, speciation diagrams
- Instant reaction balancing, calculation of equilibrium constants and equilibrium equations, temperatures . . .
- Eh-pH, pe-pH, and activity-activity diagrams — in seconds!
- Redox kinetics and catalysis
- Enzymes and biotransformation
- Ion exchange, Langmuir isotherms, K_d sorption and more

Plus —

- Easy-to-use interface designed by geochemists for geochemists!
- Perfect for education
- Call for training!
- Over 200 software solutions at http://www.rockware.com

Price —
$2,900.00 ($1,600.00 academic)

RockWare, Inc. • 2221 East Street, Suite 101 • Golden, Colorado 80401
800.775.6745, 303.278.3534 • fax: 303.278.4099 • e-mail: sales@rockware.com
Over 200 Software Solutions at http://www.rockware.com

The Geochemist's Workbench® is a registered trademark of the University of Illinois.

THE GEOCHEMICAL NEWS
c/o Neil C. Sturchio, Editor
Earth & Environmental Sciences
University of Illinois at Chicago
845 West Taylor St. (MC-186)
Chicago, IL 60607-7059 U.S.A.

NON-PROFIT
U.S. POSTAGE PAID
FOX VALLEY, IL
PERMIT No. 128