The Geochemical News

Newsletter of The Geochemical Society

in cooperation with The European Association of Geochemistry

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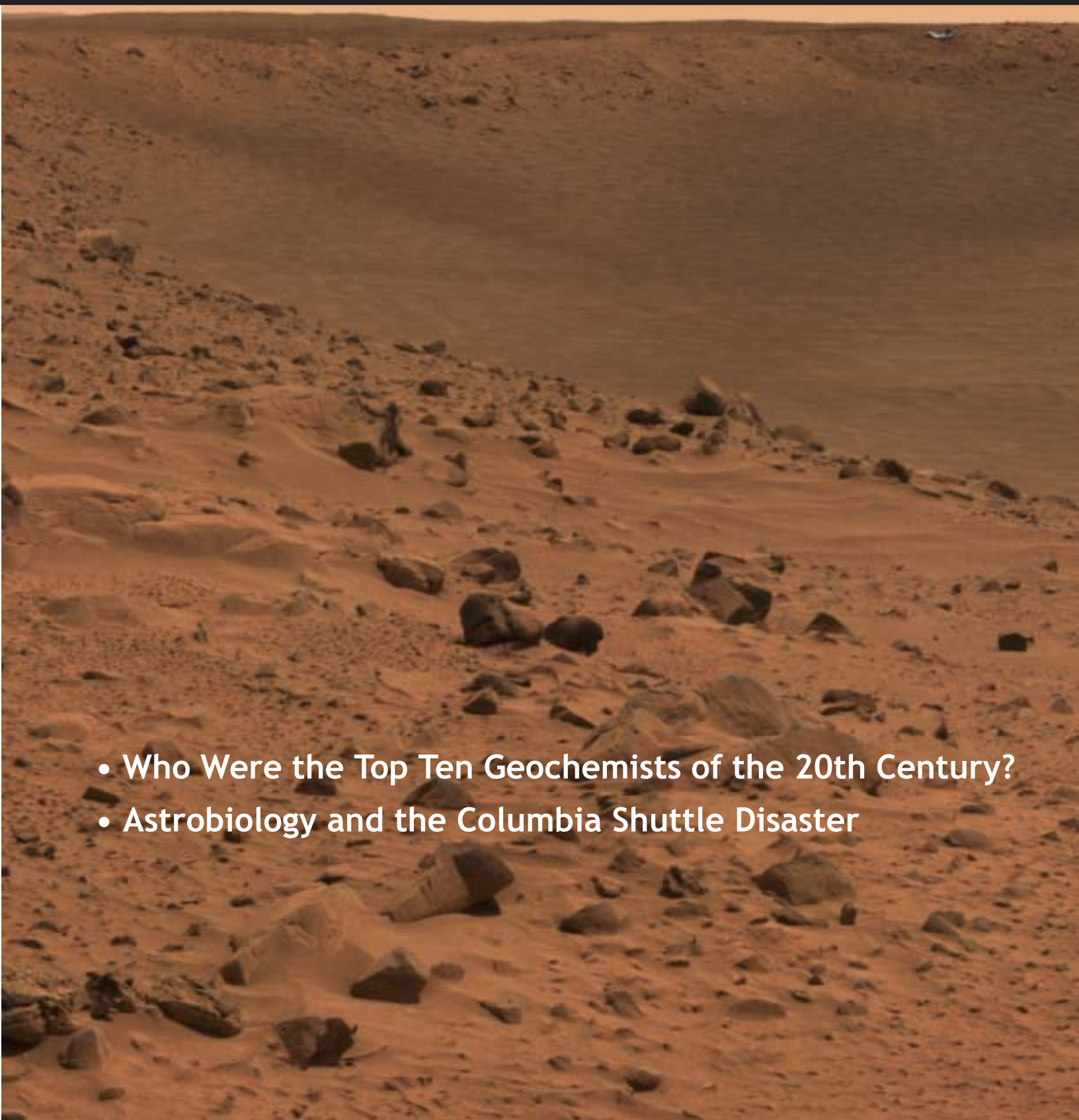

- Who Were the Top Ten Geochemists of the 20th Century?
- Astrobiology and the Columbia Shuttle Disaster

Voyage of Discovery

15th Annual V.M. Goldschmidt 2005

Moscow, Idaho

University of Idaho
Moscow, Idaho USA
May 20-25, 2005

Important Dates:

September 1, 2004
Session proposal deadline

October 1, 2004
Begin acceptance of abstracts

January 15, 2005
Abstract submittal deadline

Hosted by:

University of Idaho
Moscow, Idaho

Washington State University
Pullman, Washington

Complete details: www.uidaho.edu/gold2005

Sponsored by:

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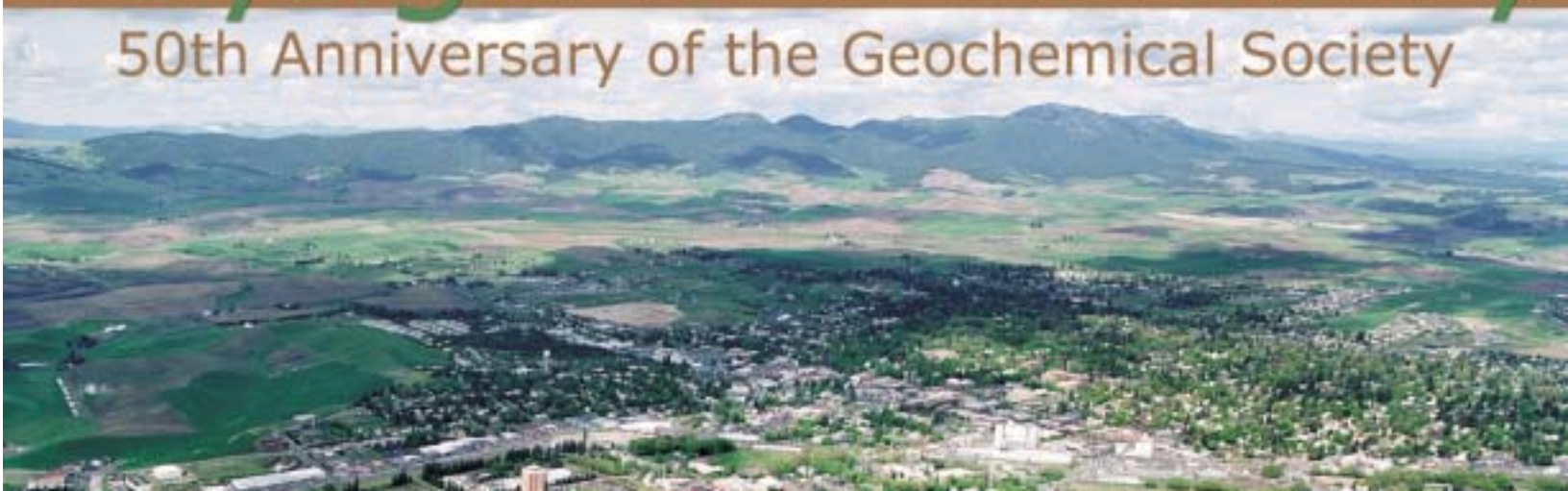
The European Association of Geochemistry
The Mineralogical Society of America

Voyage of Discovery

50th Anniversary of the Geochemical Society



The Geochemical Society

The **Geochemical Society** is a nonprofit scientific society founded to encourage the application of chemistry to the solution of geological and cosmological problems. Membership is international and diverse in background, encompassing such fields as organic geochemistry, high- and low-temperature geochemistry, petrology, meteoritics, fluid-rock interaction, and isotope geochemistry. The Society produces a ***Special Publications Series***, ***The Geochemical News*** (this quarterly newsletter), the ***Reviews in Mineralogy and Geochemistry Series*** (jointly with the Mineralogical Society of America), the journal ***Geochimica et Cosmochimica Acta*** (jointly with the Meteoritical Society), and co-publishes the electronic journal ***G³*** (jointly with the American Geophysical Union: AGU); grants the ***V.M. Goldschmidt***, ***F.W. Clarke*** and ***Clair C. Patterson Awards***, and, jointly with the European Association of Geochemistry (EAG), the Geochemistry Fellows title; sponsors the V.M. Goldschmidt Conference, held in North America in odd years and elsewhere in even years, jointly with the EAG; and co-sponsors the Geological Society of America annual meeting and the AGU spring meeting. The Society honors our first President, F. Earl Ingerson, and our first Goldschmidt Medalist, Paul W. Gast, with the ***Ingerson*** and ***Gast Lectures***, held annually at the GSA Meeting and the V.M. Goldschmidt Conference, respectively. The Geochemical Society is affiliated with the American Association for the Advancement of Science and the International Union of Geological Sciences.

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

The Geochemical News
July 2004

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Cover: Bonneville crater, as photographed by NASA's Mars Exploration Rover Spirit, on March 12th, 2004. Photo courtesy of NASA.

From President Tim Drever

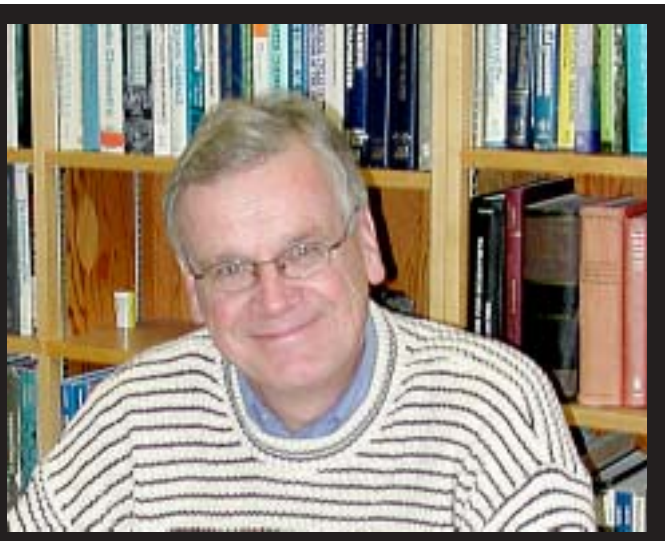
The Goldschmidt Conference in Copenhagen has just ended. It was an excellent meeting. Susan Stipp and her students and colleagues did a tremendous job in putting together a great scientific and social program. Attendance was over 1,500: the Goldschmidt has clearly established itself as the most important conference of the year for geochemists. The scope of the conference was impressive, from formation of planets to microbiology, from atomic-scale processes to environmental pollution.. It is striking how the importance of microbes in many geochemical processes is being recognized.

The EAG held its Council meeting and the Geochemical Society its Board of Directors meeting The two societies agreed to cooperate closely on issues of membership and the Newsletter—further details of our decisions will come in the next *Newsletter*. Speaking of newsletters, the new magazine "Elements: An International Magazine of Mineralogy, Geochemistry, and Petrology" is moving forward, spearheaded by Rod Ewing. Five issues on different thematic topics are planned for 2005 and it will eventually become a monthly. We're all looking forward to seeing the first one. *Elements* will be taking over some of the functions of the *Geochemical News*—the exact details are still to be worked out. The present plan for 2005 and beyond is to continue to publish the Geochemical News online, with one paper issue each year to coincide with the Goldcshmidt. I must say I have mixed feelings about giving up the regular paper *Geochemical News* issues. Carla and Johnson have done such a great job in improving the quality and interest of GN.

The schedule of Goldschmidts has been set (provisionally, at least) for the next few years—2005 in Idaho, 2006 in Melbourne, 2007 in Cologne, and 2008 in Vancouver. That's a great set of locations. The Goldschmidts have grown steadily over the years and I expect the growth will continue.

The end of this month is when the membership of most of our committees rotates. I would like to thank all of those rotating off for their valuable contributions to the Society. I would particularly like to thank Marty Goldhaber, chair of the Program Committee, for a great job in organizing sessions for the GSA and other meetings. The society could simply not function without the work of the enthusiastic volunteers who serve on our committees and I would urge more of you to get involved.

Tim Drever, GS President



Tim Drever

Editors' Corner

The Geochemical Society continues to grow and evolve. On page 4 the GS announces the inception of a new magazine of geochemistry and mineralogy. This new magazine, based on the idea of collaboration and joint effort with several other international earth chemistry societies, and intended to showcase a range of topics from our widely interdisciplinary field, will begin to publish issues sometime next year. But already the plans are underway, and your input is needed to condense and crystallize the details of what this new magazine will cover, how it will be organized, and even what it will be called! Please contribute your ideas; let the editorial board know if you want to participate. This promises to be an exciting new venture, and will no doubt help to publicize and promote the geochemical sciences not only amongst ourselves, but to the public at large.

Johnson R. Haas
Carla Koretsky

Editors

V. M. Goldschmidt Conference
20-25 May, 2005
Moscow, Idaho

www.uidaho.edu/gold2005

Call for Nominations:

2005 A.G. HUNTSMAN AWARDS for Excellence in Marine Sciences

The Huntsman Award was established in 1980 to honour individuals of any nationality who have had and continue to have a major influence on the development of marine science. To mark the Award's 25th anniversary, a 2-day jubilee is planned for September 2005. An award will be presented in each of the categories of:

Marine Geosciences
Physical/Chemical Oceanography
Biological/Fisheries Oceanography
Interdisciplinary Marine Science

The special Award in the Interdisciplinary Marine Science category is intended to recognize exceptional contributions across two or more marine science disciplines, at the interface between the oceans and other natural systems, or in the expansion of marine sciences into new fields.

Please consider preparing a nomination for a colleague in one or more of the above categories. Nominations can be prepared and submitted through the Huntsman websites: http://www.bio.gc.ca/huntsman/huntsman-e.html (English) http://www.bio.gc.ca/huntsman/huntsman-f.html (French). It is preferred that nominations be submitted in English.

Thanking you in advance for your support in ensuring that all qualified candidates will be considered for this prestigious international oceanographic award.

Alain Vezina, Chair, Huntsman Board of Directors
John Loder, Chair, Huntsman Selection Committee (loderj@mar.dfo-mpo.gc.ca)

Cover: A Netherlands windmill. Photo credit Carla Koretsky.

From the Business Office

Welcome Copenhagen Goldschmidt Members!

Included with your full registration to the Goldschmidt conference was a 2004 calendar year membership to the Geochemical Society and to the European Association of Geochemistry.

What does this mean to you?

Well first off, it means you now subscribe to this newsletter, Geochemical News.
Back issues may be viewed on-line at: http://gs.wustl.edu/archives/#NewsLett

Also, you may now take advantage of a conference registration discount at the upcoming GSA Meeting (visit http://www.geosociety.org/meetings/2004/ for more information)

As well as these publication discounts:
25% off Geochemical Society Special Publications
25% off most MSA publications, including *Reviews in Mineralogy and Geochemistry*
25% off Elsevier books
20% off Wiley / Jossey-Bass titles

But more than that, I hope that you will find that you are now a part of a dynamic international geochemical community.

To find out more information about our societies and programs, please visit the Geochemical Society website at: http://gs.wustl.edu or the European Association of Geochemistry website at: http://www.rdg.ac.uk/soil/EAG/. And thank you for becoming a member.

Special Publication Volume 9 is now available. Look for the ad and the order form for this title and the others in the series elsewhere in this issue.

25% off Elsevier Titles and Free Shipping! Through an impressively swift agreement between Elsevier and the Geochemical Society, GS members can now take advantage of a 25% discount on Elsevier titles when ordered through the Geochemical Society using a credit card (please note that this does not include journals or electronic materials). Visit www.elsevier.com for a catalogue listing and use the order form located elsewhere in this issue.

Donations

Special thanks to the following members for additional financial support to the Geochemical Society in 2004.

General Fund
Dr. John A.C. Fortescue
Dr. William F. McDonough
Dr. Brian J. Skinner
Dr. Robert L. Smith

Special Publications Fund
Mr. Vincent Dubost


Seth Davis

If you would like to make a donation to the Geochemical Society, please send me an e-mail and will send you the proper form.

Elements Magazine
The Geochemical Society, with several other associated societies, is moving forward on establishing a new magazine entitled Elements: An International Magazine of Mineralogy, Geochemistry and Petrology. The January 2005 issue will be the first of five issues for the year. All 2005 calendar year members of the Geochemical Society will receive Elements as part of their membership.

If you are interested or know someone who is interested in advertising in Elements, please contact the Elements Managing Editor, Pierrette Trembly at Pierrette_Tremblay@inrs-ete.uquebec.ca for more information.

Have a great summer,

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History of Science

Who were the ten most notable geochemists of the 20th century?

by Nathan Yee and Carla Koretsky

The ten biographies below are reprinted from the recently published book "A to Z of Earth Scientists (Notable Scientists)" by Alexander E. Gates (ISBN 0816045801). We recognize that attempts to create "top ten" lists, whether of pop songs, movies, or scientists, are invariably biased and controversial. The list below was compiled solely from the text of Alexander Gates. We have excluded from consideration scientists who are currently alive. We hope that this series will generate debate and discussion. If you believe we have omitted a significant scientist, please let us know. If there is sufficient response, one or more follow-up articles will be published in future issues of the *Geochemical News*.

Bowen, Norman L.
(1887-1956)
Canadian – American
Petrology - Geochemistry


Norman L. Bowen

Norman L. Bowen was the greatest Petrologist of the 20th century and one of the most influential geologists of all time. His name is known by anyone who has attended a college course in Physical Geology by virtue of the famous Bowen's Reaction Series which appears in every Physical Geology and Petrology textbook in the world. This diagram and concept shows the crystallization sequence of common minerals in igneous rocks of "average" compositions. Plagioclase forms the continuous reaction series because it continuously changes composition with temperature from calcium-rich at high temperature to sodium-rich at low temperature. The discontinuous reaction series shows the crystallization of a sequence of iron-magnesium-rich minerals during cooling of magma or lava from about 1,400 to 750 degrees centigrade. The continuous reaction series crystallizes at the same time as the discontinuous series to form all of the common igneous rocks. Conversely, the diagram and concept shows how minerals melt if rocks are heated to their melting point. It neatly explains assemblages of minerals in igneous rocks, their temperatures of formation and many igneous textures. Although a simplification of a very complex series of processes, the Bowens Reaction Series concept is surprisingly applicable in most rocks.

This widely applicable concept was derived through years of research. Norman Bowen solved many of the basic petrologic (study of rocks) field problems by defining laws and principles derived from experimentally determined chemical relationships (phase diagrams) of common minerals. As a result of this groundbreaking research, petrologists were able to approach igneous rocks quantitatively, whereas previously the main focus was only with description and classification. His experimental work involved the melting and quenching of

rocks at a series of temperatures to determine their relations of crystallization. From these data he would construct a "phase diagram" from which melt percentages, melt compositions, types and percentages of minerals crystallized could be determined at any given temperature. The nepheline-anorthite diagram was the first completed very efficiently using 17 different mixtures and 55 quenching experiments. This system was the first example found in silicates of solid solution. Bowen then studied the two component system of plagioclase, albite-anorthite. These results helped determine the basis for Bowen's views on magma differentiation and crystal fractionation. Both of these theories had not been demonstrated experimentally prior to the research Bowen and his colleagues had accomplished. Bowen subsequently experimented with many other systems.

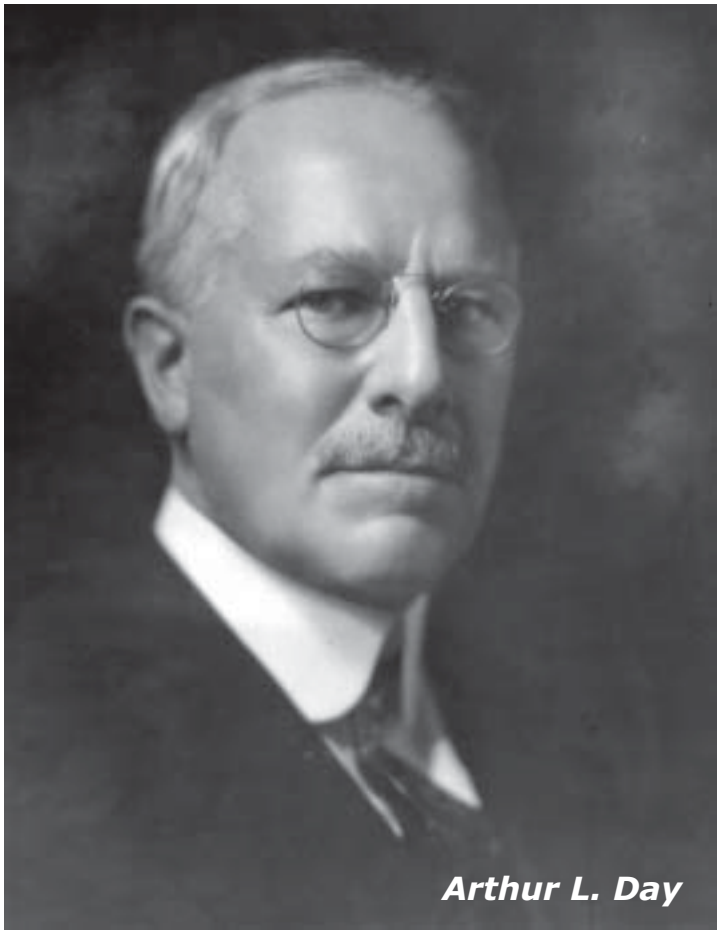
Bowen published numerous classic papers but probably his most famous work was his 1928 book *The Evolution of Igneous Rocks*. In this classic book, he explains phase diagrams for common rock systems. Although still a simplification, the results apply so well to field and petrographic observations of igneous rocks that it became an instant handbook for igneous petrologists. It still remains one of the top few most important books in Geology.

Bowen was born in Kingston, Ontario on June 21, 1887. He completed his elementary and high school education in Kingston public schools, and entered Queens University, Canada. Bowen had his sights on becoming a teacher but after one year decided to join an Ontario Bureau of Mines geological mapping party to Larder Lake with the allure of money and travel. It was a revelation for him and he enrolled in the School of Mining upon his return, registering in mineralogy and petrology. He graduated with a Bachelor of Science degree in Chemistry and Geology in 1909. He received Medals in Chemistry and Mineralogy and was named the 1851 Exhibition Scholar. Bowen continued with his graduate studies at Massachusetts Institute of Technology in Cambridge.

In 1910, Bowen applied to the Geophysical Laboratory at the Carnegie Institution of Washington D.C. to complete an experimental study related to a geological field problem as part of the requirement for his Ph.D. During this time, Bowen married his college sweetheart, Mary Lamont, on October 3, 1911. The following spring (1912) Bowen graduated with a Ph.D. in Geology and was busy fielding job offers. Bowen accepted the position as Assistant Petrologist at the Geophysical Laboratory. Besides a ten-year period of teaching at the University of Chicago, Illinois (1937 to 1946) including two years as department chair, Bowen remained at the Geophysical Lab for his entire career and directed it for most of the time. He embodied the Geophysical Laboratory. Bowen officially retired in 1952 and the next year he moved to Clearwater, Florida to enjoy his golden years. However, he grew restless after only a few months and returned to Washington, D.C. and was appointed Research Associate at the Geophysical Laboratory. Norman L. Bowen died on September 11, 1956.

Norman Bowen led a phenomenally productive career not only in terms of total publications but especially in terms of impact on the field. For example, between 1945 and 1954, five of the twenty most often cited articles in all of Geology were written by Bowen and his associates. There are no truer classics in Petrology than those written by him. As recognition for these outstanding contributions, Bowen received numerous honors and awards. He was a member of the U.S. National Academy of Sciences, the American Academy of Arts and Sciences, the Indian Academy of Sciences, and the Finland Academy of Sciences. He received honorary degrees from Harvard University, Yale University and his alma mater, Queens University. He also received the Bigsby Medal and the Wollaston Medal from the Geological Society of London, the Penrose Medal from the Geological Society of America, the Roebling Medal from the Mineralogical Society of America, the Miller Medal from the Royal Society of Canada, the Hayden Medal from the Academy of Natural Sciences of Philadelphia and the Bakhuis Roozeboom Medal from the Royal Netherlands Academy. The American Geophysical Union named a medal in his honor.

Bowen was also very active in service to the profession. In addition to serving as President of both the Geological Society of America (1946) and the Mineralogical Society of America (1937) he was a member and chair of numerous committees and panels for both societies and the government.



Arthur L. Day

Day, Arthur L.

(1869-1960)
American
Geochemistry – Geophysics

The name of Arthur L. Day is still well-known for the awards in his honor as well as his extensive shaping of the profession. Although he referred to himself as a physicist, his major contributions were in the Earth Sciences. He applied physics and chemistry to the solution of geological problems long before it was fashionable. He was also distinctly interested in practical applications of his high temperature experimental research while director of the Geophysical Laboratory at the Carnegie Institution of Washington D.C. The lab was considered of little use until Day used it to save-the-day in the World War I effort. Quality optical glass for things like gun sights, periscopes, rangefinders, binoculars and the like had come exclusively from Germany prior to 1917. When America entered the war, they found themselves in a critical shortage with military needs of 2,000 pounds of optical quality glass per day while the capacity of the country was 2,000 pounds per month. Arthur Day was appointed to the General Munitions Board (War Industries Board) in charge of optical glass production. He designed a plan to upgrade several commercial facilities and streamline production in existing facilities. Day supervised the production of over 90% of the optical glass produced in the United States and the crisis was averted.

Arthur Day was also the main force in establishing the Carnegie Institution Seismological Observatory in Pasadena, California. He organized numerous agencies and institutions to design it. This facility was the most advanced of its kind at the time and the first of its kind in the United States. It would set the pace for earthquake studies including prediction and prevention. The facility would later become part of the California Institute of Technology when Day retired and boast the likes of Beno Gutenberg and Charles Richter.

Arthur Day also made significant contributions with his research as well. He first extended the capabilities of standard gas thermometers to very high temperatures. He used this as a practical temperature scale for melting points. This research involved the determination of the physical properties and phase relations of solids and liquids. The first system he investigated was plagioclase feldspar but he also looked at sulfur, platinum, graphite and quartz glass. He turned his attention to the geophysics and geochemistry of volcanoes. He devised new gas sampling equipment and sampled exhalations of the Hawaiian volcanoes, Yellowstone National Park, Lassen Peak and Geyserville, California. This research would help determine the composition and phase relations of these gases. He would later work on the volcanic areas of New Zealand. He was also interested in radioactivity and devised new deep sea coring tools to investigate the radioactive contents of marine sediments.

Arthur L. Day was born on October 30, 1869 in Brookfield, Massachusetts where he grew up. He attended the Sheffield Scientific School of Yale University, Connecticut where he earned a Bachelor of Science degree and a Ph.D. in Physics in 1894. He taught Physics at Yale University upon graduation but decided that he needed post-doctoral experience. In 1897, he went to the Physicalisch-Technische Reichsanstalt in Charlottenburg-Berlin, Germany as a volunteer assistant but he was soon offered a paid position. He was offered a one-year position as a Physical Geologist at the newly established high temperature laboratory of the U.S. Geological Survey in 1900 and a permanent position in 1901. Arthur Day married Helene Kohlrausch in 1900; they would have four children. He worked on the high temperature relations of plagioclase but also the extension of the gas thermometer scale to high temperatures at the U.S. Geological Survey. This research caught the interest of the newly established Carnegie Institution of Washington, D.C. and they funded his research for several years. In 1906, they hired him as the director of the newly created Geophysical Laboratory. He remained in the position of Director until his retirement in 1936. This streak was interrupted only with a two-year leave-of-absence in 1918-1920 to become Vice-President in charge of Manufacturing at the Corning Glass Works in New York. His retirement did not curtail his research activities until 1946 when he had a physical breakdown. Arthur L. Day died suddenly of a coronary thrombosis on March 2, 1960.

Arthur L. Day led a very productive career with authorship on numerous scientific articles in international journals, professional volumes and governmental and industrial reports. Most of his geological papers were on high temperature processes and especially on volcanoes. His papers on volatile components in igneous processes and seismology are benchmark studies. In recognition of these many contributions, he received numerous prestigious honors and awards. He was not just a member of the National Academy of Sciences but also Home Secretary and Vice President. He was also a member of the American Academy of Arts and Sciences as well as member of the scientific academies in Sweden, Norway and the U.S.S.R. He received honorary degrees from Columbia University, Princeton University, the University of Pennsylvania and the University of Groningen. He also received the Penrose Medal from the Geological Society of America, the Wollaston Medal from the Geological Society of London, the William Bowie Medal from the American Geophysical Union, the John Scott Award from the City of Philadelphia and the Bakhius Roozeboom Medal from the Royal Academy of Amsterdam among others. Arthur Day also has awards in his honor from both the National Academy of Sciences and the Geological Society of America.

Day served the profession as well. He was President (1938) and Vice President (1934) of the Geological Society of America. He also served as President of the Philosophical Society of Washington and the Washington Academy of Sciences.

Eugster, Hans P.
(1925-1987)
Swiss – American
Geochemistry

Hans Eugster was one of those rare people that can be given the title of "Renaissance Man" because he excelled at so many pursuits. He could have had a successful career as an artist or a musician or a chemist or a mathematician amongst others. Fortunately, for the Earth Sciences, he chose to be a geochemist and an outstanding teacher. Unfortunately, he died far too young. His geochemical research was much like his life; he chose several directions and he excelled in all of them. Probably his greatest contribution to geochemistry was to demonstrate the control of gases, both in terms of presence and participation (called fugacity), on high temperature chemical reactions among minerals in igneous and metamor-

phic rocks. These very minor components can actually control the minerals that will form with the major components. The first components considered were oxygen and hydrogen. With his colleague, David Wones, Eugster investigated their participation in the formation of micas. Later, this work was extended to other minerals as well as other fluid components like carbon, fluorine, nitrogen, and sulfur species. He even looked at acids, bases and metal chlorides in fluids ultimately establishing a whole new field concerned with measuring the properties of fluids. It all led to a quantitative understanding of the role of fluids in the processes of mineral formation within the Earth's crust and mantle.

Although this research may seem purely theoretical, it has practical applications as well. Eugster once began a project with a student through General Electric Corporation to devise a substance that was a perfect insulator in one direction and a perfect conductor in another. Eugster thought that synthesizing micas with gold lining the interstices would solve the problem. The student left and the project fell through. But if it had continued, they would have produced the first "silicon chip" well ahead of its time.

Eugster's second main research direction was in geochemistry as it applies hydrogeology and sedimentology. Considering that his first interest was in high temperature applications, this second direction in surface reactions is surprising. In this research, he evaluated the hydrogeologic, chemical and sedimentologic processes that lead to the formation of continental and marine evaporites. He discovered several new minerals, proposed a new origin for bedded chert including Precambrian banded iron formations. This research included experimental work, thermodynamic modeling, and geologically reasonable computer solutions to the evaporation of sea water, a feat that was attempted several times previously by other researchers without success. Two of the more important papers from this work include *The Evolution of Closed Basin Brines* and *Minerals in Hot Water*.

Finally, Eugster was also interested in the origin of ore deposits. He conducted experiments on the solubility of ore minerals to explain their deposition in hydrothermal systems. He explained several types of deposits with this work and he even investigated the source of these fluids in dewatering granites.

Hans Eugster was born in Landquart, Switzerland on November 19, 1925 where he spent his youth. He gained an interest in Geology climbing to the high Alps in the Grisons where he would lag behind the rest of his family because he was too busy collecting rocks. He attended the Swiss Federal Institute of Technology (ETH) in Zurich where he earned a diploma in Engineering Geology in 1948. He continued at ETH for his graduate studies and earned a Ph.D. in 1951 in Geochemistry. His advisor was Paul Niggli. Eugster had accepted an 8-month post-doctoral research post at Massachusetts Institute of Technology to return to ETH at its conclusion. However, the untimely death of Niggli led Eugster to accept a position at the Geophysical Laboratory of the Carnegie Institution of Washington, D.C. in 1952 with Hatten Yoder. In 1957, he taught a course at The Johns Hopkins University as an adjunct and accepted a permanent position there the following year. He remained at Johns Hopkins for the rest of his life, serving as Chair of the department in 1983 to 1987. He died suddenly of a ruptured aorta on December 17, 1987. He was survived by his second wife, Elaine Koppelman, the James Beall Professor of Mathematics and Computer Science at Goucher College and three daughters from his first marriage. In addition to his talent as a Geochemist, Eugster was also an accomplished violinist, painter, and potter.

Hans Eugster had a very productive career, publishing numerous articles in international journals and professional volumes. Many of them are considered benchmarks of geochemistry. His research contributions have been acknowledged by the geologic profession in terms of honors and awards. He was a member of both the National Academy of Sciences and the American Academy of Arts and Sciences. He received the Arthur Day Medal from the Geological Society of America in 1971, the Goldschmidt Medal from the Geochemical Society in 1976, and the Roebling Medal of the Mineralogical Society of America in 1983. He even had the new mineral eugsterite named after him in 1983. He served as the President of the Mineralogical Society of America in 1985.

Garrels, Robert M.
(1916-1988)
American
Geochemistry

Igneous and metamorphic rocks were treated as chemical systems early in the history of geology because these are diverse minerals involved and they are large enough to analyze. On the other hand, sedimentary rocks hold most of the economic reserves whether petroleum related or ore related. Robert Garrels did for the chemistry of sedimentary rocks what the likes of N.L. Bowen did for igneous rocks, he established the chemical systems. His 1952 paper *Origin and classification in terms of pH and oxidation-reduction* sums up much of his early research which was specifically on rocks which formed as precipitants from water. One of his main areas of study at this time was the origin of iron deposits which he would return to several times. However, he also worked on uranium and vanadium geochemistry. His later work looked at the rock-water interface geochemistry. This work involved both experimental research and advanced thermodynamics. The latter of these set him apart from many of the other researchers of the time and several of his students still maintain that position.

Garrels investigated the interaction of oceans and the sediments produced in them in chemical terms. He studied chemical mass balances between rivers which carry in the chemical species and oceans which receive them. He set the standard for research on geochemical cycles with research on carbon, sulfur, and phosphorous. He modeled the interaction between oceans and the atmosphere with Robert Berner to explain carbon dioxide abundances in the atmosphere in his famous "BLAG" model.

Much of this work was translated into books which became the handbooks for all geologists who ventured into this field. His book *Mineral Equilibria at Low Temperatures and Pressures* in 1960 showed how minerals form at surface and near surface conditions. His famous textbook *Evolution of the Sedimentary Rocks* published in 1971 set the standard for understanding the sedimentary cycle. It uniquely emphasized his research on the ocean-sediment interactions and clearly advanced the level at which students were introduced to the chemistry of sedimentary rocks.

Robert Garrels was born in Detroit, Michigan on August 24, 1916, the second of three children. He spent some of his early years in Saltville, Virginia before moving to Grosse Ile, Michigan in 1928 where he attended high school. Garrels was a true athlete as well as a scholar, specializing in track and field. In fact, later in life he would hold the World high jump record for men over 57 years of age. Garrels entered the University of Michigan, Ann Arbor at 17 years of age vacillating between Chemistry and Literature. Instead, he turned to Geology and graduated with a Bachelor of Science degree with honors in 1937. He entered graduate school at Northwestern University in Illinois the same year. He earned a Master of Science degree in 1939 and a Ph.D. in 1941. He then joined the faculty at Northwestern University but quickly joined the Military Geology Unit of the U.S. Geological Survey for the duration of World War II. He returned to Northwestern University in 1945 but returned to the U.S. Geological Survey in 1952. In 1955, he accepted a position at Harvard University, Massachusetts where he remained for ten years including serving as Chair. He moved back to Northwestern University in 1965 but only remained until 1969 when he accepted a position at Scripps Institution of Oceanography at the University of California at San Diego. There he was married to Cynthia Hunt in 1970. However, Garrels moved to the University of Hawaii in 1971 where he was named the James Cook Professor of Oceanography. In 1974, he returned to Northwestern University only to leave once again in 1980. He accepted the St. Petersburg Progress Chair in Marine Science at the University of South Florida where he remained until his death. He contracted cancer of the spine in 1987 and succumbed to it on March 8, 1988. He was survived by his wife Cynthia, two daughters and a son by a previous marriage and thirteen grandchildren.

Robert Garrels had a very productive career producing numerous articles in international journals and volumes as well as several books. Many of

these books and papers are the classical defining works for the field of sedimentary geochemistry. His work was well recognized and rewarded with honors and awards. He was a member of the National Academy of Sciences. He received honorary doctorates from the Free University of Brussels, Belgium in 1969, the Louis-Pasteur University of Strasbourg, Austria in 1976, and the University of Michigan, Ann Arbor in 1980. He received both the Arthur Day Medal (1966) and the Penrose Medal (1978) from the Geological Society of America. He received the Goldschmidt Medal from the Geochemical Society (1973), the Roebling Medal from the Mineralogical Society of America (1981), and Wollaston Medal from the Geological Society of London, England. He served as the President of the Geochemical Society in 1962.

Goldsmith, Julian R.

(1918-1999)
American
Mineralogy-Geochemistry

Many experimental mineralogists-geochemists specialize in a single mineral, performing research solely on that mineral throughout their career. Julian Goldsmith chose the most abundant and most important rock forming mineral group in the Earth's crust, the feldspars. Following in the footsteps of his mentor, N. L. Bowen, he performed several groundbreaking experiments on alkali feldspars that concentrated on the ordering of silicon and aluminum. With colleagues, he developed a new X-ray diffraction technique to determine the ordering in his samples that is still in use today. He also made a groundbreaking discovery on the formation of sodium feldspar at low temperatures. He was the first to synthesize ordered samples in this range although they are known in nature. Goldsmith never really figured out how he managed this synthesis, but he postulated that he had an unknown flux that drove the process. The flux was surmised to be hydrogen that penetrated his research vessels from dissociated water. Such an explanation would be consistent with observations of high water pressure in natural situations.

Goldsmith was not satisfied with becoming the foremost expert on the feldspars, he also performed extensive research on another important and abundant mineral group, the carbonates. He was interested in the mechanics of the substitution relations of calcium and magnesium with each other in the minerals calcite and dolomite. These experiments have implications for how certain marine animals make their shells. He also investigated the high temperature relations of these minerals and elements and in so doing, he established a method for determining the temperature of formation for metamorphic carbonate minerals. This "geothermometer" is still used today. Yet even conquering carbonates (as much as they can be conquered) was not enough for Goldsmith. He also investigated scapolite, admittedly a less important mineral to rock forming processes. Nonetheless, this further branching into yet another mineral system attests to his versatility.

Even though Julian Goldsmith was certainly one of the pioneers in experimental mineralogy and geochemistry, the trait that he is most remembered for is his humor and friendliness. He literally rebuilt the department (and building) at the University of Chicago and is likely the greatest influence on this great program. The easy-going personality of this great researcher is a rare combination that added greatly to all of his successes.

Julian Goldsmith was born on February 26, 1918 in Chicago, Illinois. He grew up in Chicago during the Great Depression but he was well provided for. He attended the University of Chicago, Illinois and earned all of his college degrees there including a Ph.D. which he earned in Geochemistry in 1947. His dissertation advisor was N. L. Bowen. His graduate career was interrupted by World War II when he left the University of Chicago from 1942 to 1946 to do defense research at the Corning Glass Works in Corning, New York. He accepted a position of Research Associate at University of Chicago upon graduation and remained there for his entire career. Goldsmith inherited N. L. Bowen's lab when he departed for the Carnegie Institution in Washington, D.C. soon after he joined the faculty. He was named Distinguished Service Professor in 1969 and he retired to Professor Emeritus in 1990. Goldsmith served as Chair of the department from 1963 to 1971 and even served as Associate Dean for a short time. He married Ethel Frank and together they had three children. Julian Goldsmith died of leukemia in 1999.

Julian Goldsmith had a very productive career. He produced papers on the thermodynamics of feldspars in the late 1940s and 1950s that he was still being asked for copies of in the 1980s. Most articles are considered ancient and of marginal use if they are over ten years old much less forty years old. His contributions to the science were widely recognized and he received numerous awards and honors. He received the Mineral Society Award and the Roebling Medal from the Mineralogical Society of America in 1955 and 1988 respectively. He also received the Harry H. Hess Medal from the American Geophysical Union in 1987.

Goldsmith performed outstanding service to the profession. He served on the board of the National Science Foundation from 1964 to 1970. He served as both Vice President (1973) and President (1974) of the Geological Society of America. He served as both Vice President (1968) and President (1970) of the Mineralogical Society of America and both Vice President (1955) and President (1965) of the Geochemical Society. Needless to say, he also served on and chaired numerous committees for all three of these organizations. He was also Editor of *Journal of Geology* as well as several other editorial positions.

Holmes, Arthur

(1890-1965)
English
Isotope Geochemistry – Geophysics – Geomorphology - Petrology

Arthur Holmes has been called the greatest Geologist of the 20th century. He made some of the greatest contributions Geology on the whole as well as to numerous individual disciplines. He even made the first steps towards the Plate Tectonic paradigm. His most famous contribution was his reevaluation of *The Age of the Earth* published in the book of the same name. During the 19th century, many scientists attempted to derive an

absolute time scale for our planet. The age of the Earth was a question that had been plaguing geologists for a long time. Lord Kelvin published a scientific paper that proposed geologic time to span 20 to 40 million years. His calculations were based on the assumption of a uniformly cooling earth and gravitational and chemical sources for terrestrial and solar energies. Holmes decided to initiate his own research into the subject and after collecting enough data, he showed that Kelvin's conclusions were not valid by the availability of radioactive heat. He compared the amounts of uranium and thorium in rocks with their decaying products (daughter products) of lead and helium, respectively, and was able to make an assumption of a constant half life for each element. Based on this information, Holmes felt the age of the earth was at least 1.6 billion years old which he later revised to 4 billion years. He also placed the beginning of the Cambrian at 600 million years. These ages were refined later but considering the primitive technology of the time, they are remarkably accurate.

The research Arthur Holmes conducted on the age of the Earth added insight into other questions that were plaguing geologists at the time. By recognizing that radioactive heat was available from the breakdown of uranium, thorium, and potassium, it could no longer be believed that the earth was cooling and contracting. Holmes believed that the tectonic movements of the crust were caused by cyclical expansion alternating with contraction of the crust. He also agreed with Alfred Wegener that continents are drifting in stark contrast to the popular opinion of the profession. Holmes was also the first geologist to deduce that convection currents were present in the mantle of the earth and likely drove the continents. Harry Hess would later expand on this idea to form the basis of the plate tectonic paradigm.

The work of Arthur Holmes in the field of petrology was also groundbreaking. He was a strong believer in the idea that both extrusive and intrusive igneous rocks originated from liquid magma. However, due to the limited amount of physiochemical and thermodynamic data at the time, he began to question the idea. Holmes began to work with the Geological Society of Uganda due to the excellent specimens of alkalic volcanic rocks that were found in the West African Rift Valley and began to think about solid state metasomatism and transformation of preexisting rocks by differential introduction of fluxes of hydrothermal fluid. He also made important links between geophysics and petrology with regard to the origin of kimberlite rocks (diamond pipes). and his belief in eclogite as a high pressure equivelant of basalt. Holmes' wide range of scientific research can be found in detail in his highly regarded book entitled *Principles of Physical Geology*.

Arthur Holmes was born on January 14, 1890 in Hebburn in Tyne, England. His first insight into geology was discovered while he attended Gateshead High School. After graduating from high school, Holmes enrolled at Imperial College in London, England in 1907. He earned a Bachelor of Science degree in Physics under R. J. Strutt (later Lord Rayleigh), but changed to Geology as an advisee of W.W. Watts. Holmes graduated with a second degree in Geology as an Associate of the Royal College of Science in 1910. Holmes did his graduate studies with Strutt in investigating the area of radioactivity with geology. He also took a position as a prospector to Mozambique, Africa to earn money where he learned the art of field work and the began studying Precambrian metamorphic rocks and Tertiary lavas. He contracted malaria there. After graduating with a Ph.D. in 1912, he accepted the position of Demonstrator at Imperial College where he taught petrology. In 1920 he decided to work in industry and accepted the position of Chief Geologist of an oil exploration company in Burma. He lost his young son to dysentery at that time. He returned to England in 1925 to become Professor of Geology and Chair at the University of Durham. Holmes reorganized the entire department and conducted some his most extensive research there. He transferred to the University of Edinburgh, Scotland where he was appointed Regius Chair of Geology in 1943. He remained until his retirement to Professor Emeritus in 1956. Arthur Holmes was married twice, first to Margaret Howe in 1914 and after her death to petrologist, Doris Reynolds in 1939. Arthur Holmes died in London on September 20, 1965.

Arthur Holmes was extremely productive in terms of numbers of scientific articles in international journals and professional volumes. These papers include numerous benchmark studies in a variety of topics ranging from geochronology and the age of the Earth to Geomorphology, Petrology and Earth History. In recognition of his outstanding contributions to the many fields of Geology, Arthur Holmes received numerous honors and awards. He was a Fellow of the Royal Society of London. Among the many other additional awards, Holmes received the Penrose Medal from the Geological Society of America and the Vetlesen Prize from Columbia University. He also has a medal named in his honor at the European Union of Geosciences and a society named after him in England.

Clair C. Patterson

Patterson, Clair (Pat) C.

(1922-1995)
American
Isotope Geochemistry

Even though he was forever an Iowa farm boy, Clair Patterson made three of the greatest contributions to Geology of all time. His first and foremost contribution was to accurately determine the age of the Earth and stony meteorites using isotopic analysis. This research was started during his graduate career under his mentor Harrison Brown and with his friend and colleague, George Tilton where they were studying meteorites. These radio chemists were investigating the uranium-lead decay series and developed radical new methods for measuring microchemical and precise isotopic ratios using mass spectrometry. Patterson's area of specialization was radiogenic lead. Using these techniques, in 1963 after years of careful and exhaustive research on a variety of terrestrial and extraterrestrial materials, he determined that the age of the Earth is 4.55 billion years. Considering our technological advancement since that time, it is surprising that age has undergone only minor readjustment since then. This benchmark work ranks among the greatest achievements in geochemistry of all time.

Patterson's second great contribution was to establish a fundamental basis and methodology to model the patterns of isotope evolution of terrestrial lead. He collected groups of sediments, rocks, and water samples

from the oceans and determined that there were different reservoirs of common lead that were distinctive in each. By analyzing isotopic lead ratios, distinct and common patterns emerged that determined if an area or water body was separate from outside influences or it had mixed sources. This technique has multiple applications for determining origins. It was used to help define ancient plates which had been amalgamated during plate collisions. In many cases, each plate has a separate and distinct common lead reservoir. This means that even if the rocks look the same and there is no other way to delineate the ancient plates, a geologist can still tell them apart using concentrations of common lead isotopes.

His third great contribution is perhaps the most important to humankind. He provided the first and still the most rigorous analysis of the human induced buildup of lead in our environment. He did this by contrasting current lead concentrations with the natural background. He accomplished this comparison by developing new methods to cleanly extract and analyze minute, nanogram quantities of lead. He exhaustively sampled in remote regions of the Earth, in numerous ocean water environments, and in ancient archeological sites. He showed that lead concentrations in contemporary humans is elevated 1000-times greater than that in prehistoric people and just 3 to 6 fold short of outright poisoning. He even showed how this biologic magnification worked its way up the food chain. He did not just publish these results, he became a spokesperson for the elimination of environmental lead and encountered a great deal of criticism as a result. Industry was especially opposed to his findings and even tried to discredit him. However, Patterson persevered and the elimination of lead from gasoline, pipes, and solder can be directly attributed to his careful research and refusal to back down in the face of overwhelming odds. As a result, we owe some of our good health to Clair Patterson.

Alfred E. Ringwood

Clair Patterson was born on June 2, 1922 in Des Moines, Iowa. He attended Grinell College, Iowa and earned a Bachelor of Arts degree in Chemistry in 1943. He earned a Master of Science degree in Chemistry from the University of Iowa in 1944. He served in the armed forces during World War II before returning to graduate school at the University of Chicago, Illinois where he earned his Ph.D. in 1951 in Chemistry. Between 1952 and 1992, Patterson held positions of Research Fellow, Senior Research Fellow, Research Associate, Senior Research Associate and finally Professor of Geochemistry at California Institute of Technology. He retired to a position of Professor Emeritus in 1993. Clair Patterson died suddenly at his home at The Sea Ranch, California on December 5, 1995.

Clair Patterson had a highly productive career authoring numerous articles in international journals and professional volumes. Many of these publications are benchmarks in the field of Geology much less their subdiscipline. His research accomplishments have been well recognized by the geologic profession in terms of honors and awards. He was a member of the National Academy of Sciences. He received honorary doctoral degrees from both Grinell College, Iowa in 1973 and the University of Paris, France in 1975. Even more impressive, was the 1967 dedication of "Patterson Peak" in his honor in the Queen Maude Mountains of Antarctica and the naming asteroid 2511 after him. In addition, he received the J. Lawrence Smith Medal from the National Academy of Sciences, the Goldschmidt Medal from the Geochemical Society, the Professional Achievement Award from the University of Chicago, and the Tyler World Prize for Environmental Achievement. Clair Patterson was one of the great scientists of our time.

Ringwood, Alfred E. (Ted)

(1930-1993)
Australian
Geochemistry

Alfred (Ted) Ringwood is one of the true giants of Geology for many reasons. He is best known for his solution of a fundamental problem in Geology, the transition between the upper and lower mantle. Seismologists had known for many years that seismic velocities in the mantle increase rapidly between 400 and 900 km depth. This transition zone was speculated to be the result of the crushing down of mineral structures (phase transformations) as the result of the extreme pressure. Such reconfiguring of atoms would be similar to the transformation of graphite to diamond with pressure. The problem was that no laboratory in the world could replicate those conditions. Ringwood overcame that problem by synthesizing an olivine structured mineral (olivine is the common mineral in that part of the mantle) except he used the element germanium instead of silicon (the element in natural olivine) in the structure. Because germanium has a smaller atomic radius than silicon but otherwise fits all of the other requirements, it would transform to the new structure at low enough pressures to be within the experimental range at the time. His experiments showed that the olivine structure would convert to a spinel structure and predicted by extrapolation that it should occur in natural olivine at 400 km depth. Later seismic studies found that indeed there is a seismic discontinuity at 400 km and later experimental work with more sophisticated equipment showed that Ringwood was correct. Continued research by Ringwood showed that pyroxene, the other major mantle mineral, converted to garnet structure between 400 and 650 km and that the spinel structure converted to a "perovskite" structure at still greater depths using his experimental models. Papers on this work include *Phase Transformations in the Mantle* and several other similar titles.

Ringwood then attacked the problem of how basaltic magma was generated in the mantle at the mid-ocean ridge. He bucked traditional wisdom and proposed that there was a strange composition substance in the mantle called "pyrolite" from which basalt was derived. He wrote a classic paper on the topic entitled *The Genesis of Basaltic Magmas* in 1967. The pyrolite model was subsequently disproven but the idea that different compositions of basalt are generated at different depths which was also incorporated in the model is still unquestioned and considered a major contribution to the science.

In addition to these gargantuan issues, Ringwood also had several other areas of interest. He gave new insights to the composition of the core of the Earth which are still accepted. He proposed models for the chemical evolution of the Earth, other planets and meteorites. He proposed models for the composition and origin of the moon while working on the Apollo lunar missions with NASA. He championed the idea that the Moon may have been spalled off of the early Earth as the result of a giant impact. Finally, he applied his geochemical expertise to nuclear waste disposal. To each of these highly varied topics he made contributions to the science which still set the standards today.

In recognition of his accomplishments, Ringwood received the Antonio Feltinelli Prize in 1991 from the Academia Lincei in Rome, the oldest scientific society in the world. It was led by Galileo in the early years. It is similar to the Nobel Prize but with only one prize per year in all fields. It has been awarded to the likes of Thomas Mann, Igor Stravinsky, Albert Sabin, and Georges Bracque. The previous Geologist to receive the prize was Harry Hess in 1966, another giant of geology.

Ted Ringwood was born in Kew near Melbourne, Australia on April 19, 1930. He attended Hawthorn West State School, Geelong Grammar School and Melbourne High School as a youth in Melbourne. He enrolled in the University of Melbourne with a Trinity College Resident Scholarship and a Commonwealth Government Scholarship. He graduated with a Bachelor of Science degree in Geology with honors in 1951 and a Master of Science degree with honors in 1953. He continued at the University of Melbourne to earn a Ph.D. in 1956 at 26 years of age. He became a

research fellow at Harvard University in 1957. During this time he made several visits to Sweden to study meteorites and met Gun Carlson who he married in 1960. They would have two children. He returned to join the faculty at the Australian National University in 1959 where he remained for the rest of his life. He served as Director of the Research School of Earth Sciences from 1978 to 1983. Ringwood died of lymphoma on November 12, 1993 at the age of 63.

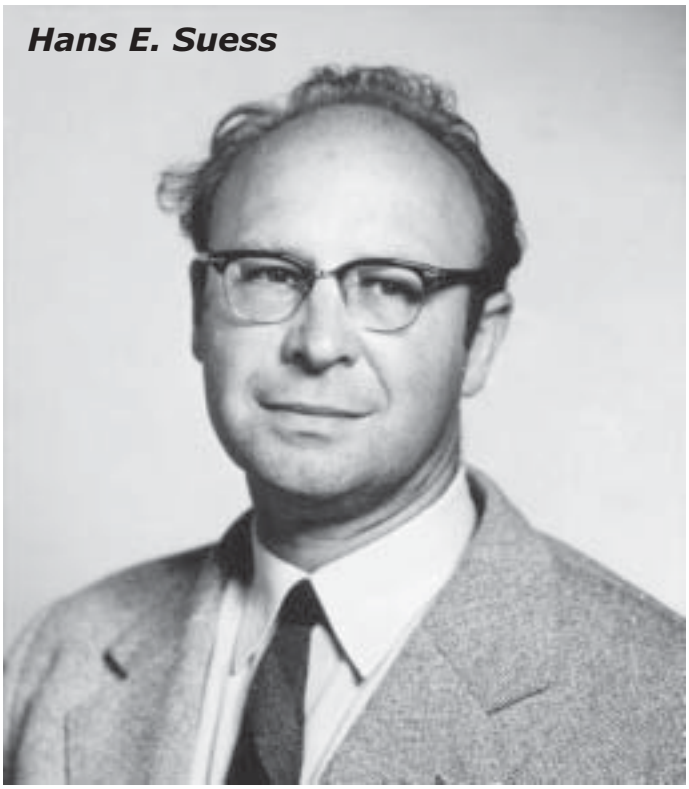
Ted Ringwood led an extremely productive career. He was an author of over 300 publications including articles in international journals and professional volumes as well as books. Many of these papers are benchmark studies on processes, properties and compositions of rocks in the interior of the Earth. Many appear in prestigious journals like *Science* and *Nature*. He also wrote two widely acclaimed books *Composition and Petrology of the Earth's Interior* and *Origin of the Earth and Moon* and even had several patents for high level nuclear waste disposal. Ringwood received honors and awards to numerous to list completely. He was a Fellow of the U.S. National Academy of Sciences and the Australian Academy of Sciences. He received an honorary doctorate from the University of Gottingen, Germany. He received the Mineralogical Society of America Award, the Werner Medaille from the German Mineralogical Society, the Arthur L. Day Medal from the Geological Society of America, the Bowie Medal and the Harry H. Hess Medal from the American Geophysical Union, the Arthur Holmes Medal from the European Union of Geosciences, the Wollaston Medal from the Geological Society of London, the Goldschmidt Award from the Geochemical Society, the Inaugural Rosentiel Award from the American Association for the Advancement of Science, and the Matthew Flinders Lecture and Medal and the J.C. Jaeger Medal from the Australian Academy of Science among many others. He served numerous endowed lectureships from the most prestigious of organizations. He also performed service to the profession like serving as the Vice President for the Australian Academy of Science for example, but it is also too extensive to list here.

Suess, Hans E.
(1909-1993)
Austrian-American
Chemistry-Geochemistry

The truly profound research contributions that Hans Suess made to science spanned the range between chemistry and geochemistry. Although his research covered numerous topics, there are four true benchmark contributions. The first was made while Suess was still in Germany. In 1948 and 1949, Suess worked on the nuclear shell model for the architecture of atoms with Hans Jensen and co-authored a study which would later earn Jensen a Nobel Prize. While at the University of Chicago, Illinois in 1950 and 1951, Suess collaborated with Nobel Prize Laureate Harold Urey. Suess had proposed that the relative abundance of each chemical element in the solar system depends in a fairly regular way on the elemental mass. The pattern of abundance is caused by a combination of nuclear properties and the process by which the heavy elements are created in stars. Harold Urey is the founder of modern planetary science and an expert on meteorites. Together they produced a benchmark study on abundances of elements in the solar system based upon meteorite geochemical data. The documentation of this theory was the basis for NASA's Genesis Mission. A book by Suess on this topic is entitled *Chemistry of the Solar System* and an example of a paper is *The Cosmic Abundances of the Elements*.

These two breakthroughs, however, are not even related to the true reasons for which Suess is famous in the Earth Sciences. The first of these reasons is Suess' development and later refinement of the carbon-14 (radiocarbon) method of isotopic dating. He determined experimentally that the relative concentrations of carbon-14 and nitrogen-14 could determine the absolute age of organic matter within the past 5,000 years or so. This method is now used extensively in archeology as well as recent geologic features and processes. Papers on this research include *Radiocarbon in Tree Rings* amongst others. Suess also collaborated with Roger Revelle to document the increase of carbon dioxide in the atmosphere and the greenhouse effect. The way that Suess determined the amount of added industrial carbon was by using isotopes. Because industry relies so heavily on fossil fuels, the carbon introduced into the atmosphere comes from old sources (oil, gas, and coal) rather than wood. Old carbon has no radioactive isotopes because it has all decayed away. Therefore the component of radioactive carbon in the atmosphere is continually diluted by the addition of non-radioactive carbon. Wood from 1890 is used as the standard against which the atmospheric carbon is compared. This dilution is referred to as the "industrial effect" or the "Suess effect." This and other work on radioactive elements are included in the paper *Radioactivity of the Atmosphere and Hydrosphere*.

Hans Suess was born on December 16, 1909 in Vienna, Austria. He was the son of Franz Suess, a former professor of Geology at the University of Vienna, Austria and the grandson of Eduard Suess who wrote the book *The Face of the Earth* an early work on geochemistry. Even though he had Geology in his blood, Hans Suess studied Chemistry and Physics at the University of Vienna through graduate school. He graduated with a



Ph.D. in Chemistry in 1935. He was a Post-Doctoral Fellow at the Institute of Chemical Technology in Zurich and the First Chemical University Laboratory in Vienna. In 1938, Suess joined the faculty at the University of Hamburg, Germany in Physical Chemistry. He married Ruth Viola Teutenberg in 1940; they would have two children. During World War II, Suess was enlisted into a group of German scientists who were charged with developing atomic weapons. He was also a scientific advisor to the heavy water plant in Vermok, Norway. In 1950, Suess was coaxed to immigrate to the United States where he spent time at the University of Chicago, Illinois as a Research Associate working with Nobel Laureate Harold Urey. He obtained a position as a physical chemist with the U.S. Geological Survey in 1951 but accepted an offer from Roger Revelle to join the Scripps Institute of Oceanography in La Jolla, California in 1955. He became one of the first four professors appointed to the faculty at the University of California at San Diego when it was established in 1958 by Roger Revelle. He retired to Professor Emeritus in 1977 but remained active through the rest of his life including as a Visiting Scientist at the Geophysical Laboratory at the Carnegie Institution of Washington, D.C. Hans Suess died on September 20, 1993.

Hans Suess was very productive during his career, having been an author on over 150 scientific articles. Until 1950, nearly all articles were in German and even after that some are. Several of these papers are benchmarks in science on radiocarbon dating, the greenhouse effect, the nuclear shell model, and the origin and synthesis of the elements. Suess was recognized for his contributions to science with several prestigious honors and awards. He was a member of the National Academy of Sciences, the American Academy of Arts and Science, the Heidelberg Academy of Science, and the Austrian Academy of Science. He was awarded an honorary doctoral degree from Queens University in Belfast, Ireland in 1980. He received the V.M. Goldschmidt Medal from the Geochemical Society, the Leonard Medal from the International Meteoritical Society, the Alexander von Humboldt Prize from the Humboldt Society and a Guggenheim Fellowship.

Tuttle, O. Frank

(1916-1983)
American
Geochemistry-Petrology


Frank O. Tuttle

Frank Tuttle was one of the greatest experimental petrologists to grace the field. He invented the "Tuttle press" and the "Tuttle bomb" which allowed him for the first time to adjust the temperature and pressure of his experiments at will to simulate virtually any conditions in the Earth's crust. These inventions revolutionized the entire field of experimental petrology. The current equipment for experimental studies is really just a modified version of that which he invented in the late 1940s. Not only did he perform his own experiments, the data from which has withstood the test of time but he also set the foundations for all work to follow. His experiments centered around multivariate chemical systems in the felsic range of compositions. Most of this work was done with his close colleague N. L. BOWEN. They did experimental studies on quartz, defining the stability fields for its many polymorphs, feldspars, and feldspathoids. They conducted experiments on synthetic systems of MgO-SiO2-H2O and K2O-Al2O3-SiO2-H2O and would provide the basis for standard petrogenetic grids. They conducted melting relations in natural and synthetic granite and defined the entire granite system. Tuttle visited many locations worldwide to collect samples of classic and odd granites for this work. He sampled the Harker Collection at Cambridge University in England and visited the French Pyrenees, the Isle of Skye, Scotland, Finland and Norway among others. His publication *Origin of Granite in the Light of Experimental Studies in the System NaAlSi3O8-KAlSi3O8-SiO2-H2O* with N. L. Bowen in 1958 is still considered the ultimate classic work on granites. Other publications include *Chemistry of the Igneous Rocks: I. Differentiation Index* and *The Granite Problem: Evidence from the Quartz and Feldspar of a Tertiary Granite*.

Tuttle investigated other systems as well. Notably, he and P. J. WYLLIE investigated the system CaO-CO2-H2O and defined the origin and processes in the genesis of the odd carbonitite magmas. This work resulted in a book entitled *Carbonatites*. They also investigated the *The Hydrothermal Melting of Shales* in a publication of the same name and the effect of volatile components with sulfur, phosphorous, lithium, and chlorine on granite magma. He worked with RICHARD JAHNS on pegmatites among others. Each of these projects established a new benchmark in petrology.

Frank Tuttle was born on June 25, 1916 in Olean, New York. He grew up in Smethport, Pennsylvania and graduated from Smethport High School in 1933. He worked in the Bradford, Pennsylvania oil fields for several years and enrolled in the Bradford Campus of the Pennsylvania State University on a part-time basis. He enrolled at the main campus in State College in 1936 and earned a Bachelor of Science degree in Geology in 1939 and a Master of Science degree in 1940. He enrolled at Massachusetts Institute of Technology and completed his coursework by 1942 before his graduate work was put on hold because of World War II. He and his lifelong partner, Dawn Hardes, were married in 1941. They would have two daughters. Tuttle's war effort was in research and it took him from Massachusetts Institute of Technology to the Geophysical Laboratory of the Carnegie Institution in Washington, D.C. to the U. S. Naval Research Laboratory in Maryland. He was involved in the synthesis and characterization of crystals for defense applications. It was during this time that he met N. L. Bowen. Before even completing his Ph.D. in 1948, Tuttle joined Bowen at the Geophysical Laboratory in 1947. He joined the faculty at Pennsylvania State University at State College in 1953 and served as Dean of the College of Mineral Industries in 1959 and 1960. In 1960, he was diagnosed with Parkinson's Disease and resigned his position as Dean. The symptoms would recur throughout the remainder of his life. In 1965, Tuttle moved to Stanford University in California where he spent the remainder of his career. In 1967, he requested a medical leave from Stanford University as a result of his declining health and tendered a formal resignation in 1971. In 1977, he was diagnosed with Alzheimer's Disease and moved to a nursing home. He died on December 13, 1983 from complications induced by the Parkinson's Disease, one year after his wife. Tuttle was an avid golfer.

Frank Tuttle had a very productive career despite his health problems. He was an author on numerous articles in international journals and professional volumes in collaboration with several of the top geologists ever. These papers are true classic works on experimental geochemistry and petrology especially with regard to granite that have been cited in other articles countless times. His contributions to geology were well received by the profession as evidenced in his numerous honors and awards. Tuttle was a member of the National Academy of Sciences. He received the first ever Mineralogical Society of America Award (1952). He also received the Roebling Medal from the Mineralogical Society of America (1975) as well as the Arthur L. Day Medal from the Geological Society of America (1967). He received other honors too numerous to fully list here.

An Investigation, Interrupted:

Panspermia and Martian Meteorite ALH84001

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Although the unthinkable loss of the Columbia shuttle STS-107 space flight mission occurred more than a year ago, we cannot forget this tragic event. This article, regarding one of the many experiments on this ill-fated space flight mission, is dedicated to the memory of the seven astronauts who sacrificed their lives for the lofty goal of space research, and to their families.

ALH84001

The story of our scientific project begins about 4.5 billion years ago (the Igneous Age), when the well-known Martian meteorite Allan Hills 84001 (ALH84001), an orthopyroxene cumulate, formed originally from molten lava, possibly from an ancient Martian volcano (Jagoutz, 1994; Nyquist et al., 1995). It is nearly certain that ALH84001 is from Mars, as are 11 other meteorites, called the SNCs, that are also almost certainly from Mars (Mittlefehldt, 1994a). The strongest evidence for their Martian origin is that they, like ALH84001, contain traces of gas that are just like the unique Martian atmosphere (Bogard and Johnson, 1983; Gilmour et al., 1996, 1995; Grady et al., 1996; Leshin et al., 1996; Miura and Sugiura, 1995; Miura et al., 1995; Swindle et al., 1995).

To a geologist, ALH84001 is an igneous rock, similar to many that crystallized from lava inside the earth. It is also similar to an important group of igneous meteorites (the diogenites), and was classified as one of them until 1994 when its Martian origin was recognized (Mittlefehldt, 1994b). It consists of 97-98% orthopyroxene with minor plagioclase glass, chromite and carbonate. The presence of oxidized iron in the chromite (Fe, Cr, Mg spinel) led to its reclassification as a Martian meteorite. This was confirmed by oxygen isotope analyses (Clayton, 1993). There is little other connection between ALH84001 and the other Martian meteorites.

As a part of the abundant geological history of ALH84001 (Treiman, 1995), about one billion years after its crystallization some kind of liquid flowed through ALH84001 and deposited rounded globules of carbonate minerals (Knott et al., 1995). The "famous" possible Martian fossils are in these carbonate globules. This small amount of carbonate is the center of attention concerning the possibility of life on Mars. These small grains, which are barely visible to the naked eye, range up to 200 microns in size. There is considerable debate about the origin of these carbonates. These grains are the sites of the three types of evidence that have been suggested to represent fossil life on Mars: polycyclic aromatic hydrocarbon (PAH) organic molecules; oxide and sulfide biominerals; and nanofossil-like structures (McKay et al., 1996). To summarize the geological aspect of this meteorite, 99% of it provides evidence for the earliest geological history of Mars, while no more than 1% of it bears witness to the interaction of the rock with the Martian hydrosphere and atmosphere and possible evidence of life.

According to the best estimates (Eugster, 1994; Miura et al., 1995; Nishiizumi et al., 1994; Swindle et al., 1995), ALH84001 was probably blasted off Mars as a result of an asteroid impact on the Martian surface about 16 million years ago (or was shielded in a larger boulder for a long time before the boulder was broken about 16 million years ago). This period of 16 million years is the time ALH84001 was in space, carrying possible ancient life forms from Mars, and exposed to microgravity ("weightless" conditions), cosmic rays and other radical conditions, which – as will be discussed later – have further implications: generally, for the concept of panspermia (wherein life might spread between planets), and specifically, to our current experiment.

However, after leaving Mars, ALH84001 orbited the sun on its own, like a small asteroid. As a result of many collisions and the gravity of other planets (especially that of Jupiter) ALH84001 was slowly nudged farther and farther from Mars. Coincidentally, its orbit changed enough so that it came near the Earth's orbit. Finally the Earth and ALH84001 collided, when ALH84001 landed on earth, in Antarctica, about 13,000 years ago (Jull et al., 1995).

ALH84001 was found in Antarctica in December 1984 by a team of meteorite hunters from the ANSMET (ANtarctic Search for METeorites) program, who have found more than 7,000 meteorites. When it was found, ALH84001 weighed about 2 kilograms. It was shaped like a rounded brick (6x4x3 inches), and was partly covered with black glass (as though it had been dipped in tar). The glass, called fusion crust, forms on all meteorites when they burn through the earth's atmosphere. ALH84001 looked green inside, but back in civilization it looks much grayer inside than green.

Panspermia

Panspermia — literally, "seeds everywhere" - is the theory that microbes in space bring life to planets like Earth, or the process whereby this happens. In different versions of the theory, the microbes are transported by light pressure, unmanned spaceships, meteorites, or comets. Many objections to the non-directed versions of the theory were overcome in the last decades of the 20th century, when extremely hardy bacteria and apparently immortal bacterial spores were found on Earth, and water was discovered beyond Earth. Evidence of organic compounds in meteorites and interstellar dust has led to general acceptance of the theory that prebiotic compounds can come from space (pseudo-panspermia).

The aforementioned discovery of relics of possible ancient life in the Martian meteorite ALH84001 has given new life to the idea of panspermia, wherein life might spread between planets - particularly from Mars to Earth - by way of microorganisms living in meteors traveling through space.

The Experiment

The experiment, called GOBBSS (Growth of Bacterial Biofilms on Surfaces during Spaceflight), was performed by the following investigators (in alphabetical order): Craig Schwandt, David McKay, David Warmflash, Eran Schenker, Neva Ciftcioglu, Tariq Adwan, Yuval Landau. The experiment was conducted on the *Columbia* space shuttle STS-107 Space Flight Mission as part of ITA's (Instrumentation Technology Associates, Exton. PA) Commercial Payload, the CIBX-2. This is an ITA corporate biomedical payload that performs both cancer research and student experiments through a commercial Space Act Agreement between ITA and NASA. The experiment was conducted under the auspices and funding of the Planetary Society, Pasadena, CA, USA, and in collaboration with:
the National Astrobiology Institute Associate NASA Johnson Space Center, Houston, TX, USA; the Israel Aerospace Medicine Institute, Jerusa-

lem, Israel; the Department of Biology, Misericordia College, Dallas, Pennsylvania, USA; the M.D.-Ph.D. Excellence Program, Sackler School of Medicine, Tel Aviv University, Israel.

Objectives:

Gaining a better understanding of life's ability - particularly, bacterial biofilms - to survive under conditions of microgravity ("weightless" conditions) and radiation would contribute to our understanding of what role, if any, panspermia plays in the evolution and distribution of life in cosmos.

ALH84001

Biofilms are thin layers (usually a micron or less) of microbial cells that can form on nearly any moist surface in environments in which microorganisms can live. Cells in a biofilm can consist of several microbial species living side by side and sharing metabolites, and these cells can also become encased in a mineralized matrix which forms an extracellular component part of the film.

Biofilms have formed on surfaces of "weightless" environments, such as the Mir space station and space shuttles. If microbial life forms had emerged on Mars, it is possible that the Martian biosphere would have been dominated by microbial mats and biofilms early in the planet's history. The survival of microorganisms living inside material catapulted into space from Mars may thus be enhanced by the ability of the organisms to live as part of a biofilm in a rock traveling as a meteor in the space environment. On Mars, biofilms may serve to help protect microbial colonies and maintain a more hospitable local environment. During space transport of a meteorite, microbial colonies in cracks and cavities, if protected by biofilms, may have a greater probability of surviving the journey through space. The colonies might be protected by biofilm material from extreme drying out, from sterilizing UV light, and from some kinds of radiation.

In recent decades, microbial survival in conditions of microgravity and in high levels of radiation has been demonstrated. Biofilms have been observed on surfaces inside spacecraft. However, to date, no studies have been performed on the ability of biofilms to form in the weightless space flight environment on the surfaces of rock material (their most common location in nature), specifically the rock material similar to that of ALH84001 and other Martian meteorites.

Space Study:

On the STS-107 mission, the plan was to test the ability of microorganisms to form biofilms on inorganic crystal surfaces (similar in structure to meteorites that have been identified as having come from Mars) in microgravity conditions. During space flight, sterilized, plasma-cleaned, small chips of inorganic crystals were exposed to a mixed population of microbial species inside a DMDA (Dual Materials Dispersion Apparatus) device, in ITA's CIBX-2 module. After 12 days of continued space flight microgravity conditions, microbial growth was then deactivated when the sample was fixed with gluteraldehyde.

The chips of inorganic crystals were supposed to be examined with scanning electron microscopy (SEM) and the quantity and characteristics of biofilm formed on them were supposed to be compared between the flight samples and ground control samples.

Expected Results:

The expected results were that microorganisms would form biofilms on inorganic crystals under conditions of microgravity as well as in the ground control samples and that these biofilms will be visible on SEM. Furthermore, it was expected that the number of chips in the flight sample containing biofilms and the thickness of these biofilms would be similar to what would be found in the ground control sample. Any significant difference in biofilm development between the space colonies and ground control colonies might be significant, and might stimulate additional experiments.

A finding that biofilms can form as easily on inorganic crystal surfaces under microgravity conditions as under 1G conditions would support the possibility that microbial colonies enclosed in protective biofilms can form on any large or small planetary body where there is water and rock, and that well-developed biofilms may enhance microbial survival during space transport.

The DMDA experiment module

Results:

Tragically, the Columbia shuttle mission was never completed. However, the DMDA device containing the experiment samples was found among the thousands of pieces of debris, and the team worked about 4 months later to recover the flight samples and to try to extract as much information as possible from these samples.

Analyzing the samples has revealed that apparently, upon impact, the samples were mixed into each other in such a way that there was no scientific meaning to the resulting mutually-contaminated samples (the control and the experimental ones). Moreover, during the months that the DMDA was on the ground (until recovery of the samples), some of the recoverable chips dried out due to leakage of the fixing agent.

Nevertheless, examination of the recovered chips using scanning electron microscopy revealed a cratering in the absence of a biofilm on some of the flight samples. This may be the

result of the impact and the high temperature experienced by the samples during the crash in combination with the four month exposure to the fixing agent.

Unfortunately, due to the above-described inherent technical problems, it was impossible, scientifically, to demonstrate a significant difference between the growth of biofilms on the chips in microgravity conditions versus 1G. Overall, the confounding factors simply place too many limits on the results to be able to draw any conclusions at all.

However, it is essential to continue investigating different aspects of this subject at the next opportunities - not only because of the importance of this issue to our understanding of the development of life in the universe, but also to be able to declare that this scientific mission of the Columbia team was not in vain.

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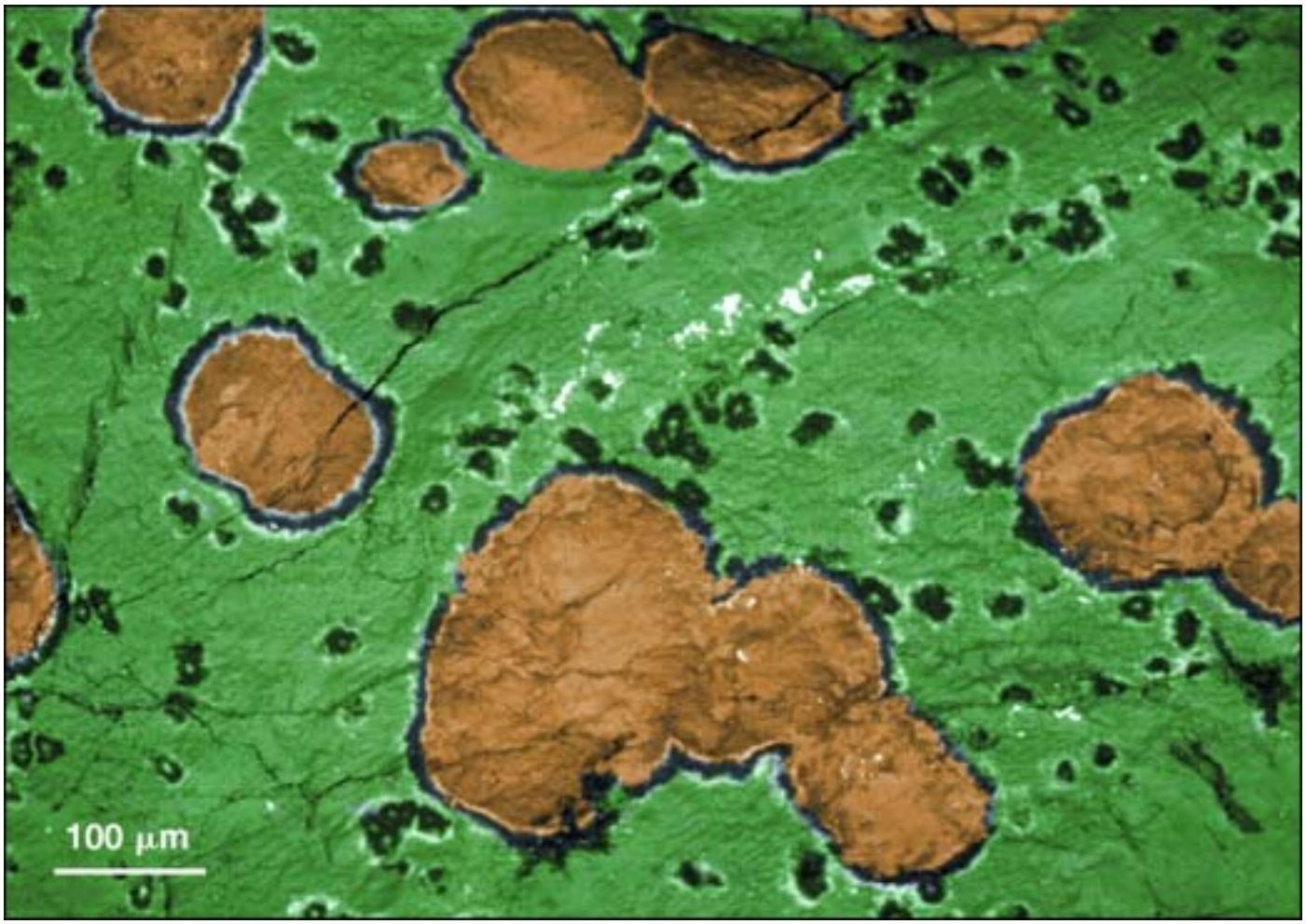

Backscatter electron (BSE) image of ALH84001, showing the distribution of carbonate globules (rounded grains) in a matrix of (mostly) orthopyroxene. (McKay et al., 1996).

EMPLOYMENT OPPORTUNITIES

The Alfred-Wegener-Institute for polar- and marine research (AWI) in Bremerhaven, is seeking applications for two PhD positions (BAT IIa/2; 3 years)

The interdisciplinary Carbongroup at the AWI consists of biologists, geologists and physicists. Their common goal is to determine and understand the impact of a changing environment on biological processes and biogeochemical cycling of e.g. carbon and silica in marine systems and to develop proxies for Paleoceanographic and -climate reconstructions (http://www.awi-bremerhaven.de/Carbon). The successful candidates will join a Dutch/German cooperative project āDivalent Cations: Development and Validation of Proxy Relationships (from empiricism towards a process understanding) and an EU-project on "Carbonate Chemistry, Carbon Cycle and Climate Change (a multidisciplinary view)"

Tasks: The projects aim is to further our mechanistic understanding of trace element proxies in foraminifers and corals. During the course of the project the applicant will have the opportunity to be involved in other cooperative projects on biomineralization. The main tasks will be to carry out culture experiments with benthonic and planktic foraminifera (and possibly corals), to carry out inorganic precipitation experiments as well as numerical process modeling.

Requirements: A master degree in geology biology, physics or chemistry. A good understanding of inorganic chemistry and a basic knowledge of the oceanic carbonate chemistry are elemental. A background in geochemistry/ paleoclimatology and experience in interdisciplinary working environments are beneficial. Skills or qualifications in numerical modeling is advantageous.

The application should include a CV, a statement describing the required expertise and contact information for three referees. We will begin reviewing applications three weeks after the publication of this announcement. Applications and inquiries should be directed electronically to Dr. Jelle Bijma (jbijma@awi-bremerhaven.de)

Two PhD stipends are available to work within the Danish Center of Earth Systems Science (DCESS) at the University of Southern Denmark in Odense, Denmark

The charter of DCESS is to unravel the progress of the biological and the geochemical evolution of the Earth over time. Within the group we employ geochemical techniques to explore the history of Earth surface oxidation. We also conduct active microbiological research exploring how the products of microbial metabolisms might leave clues in the geologic record as to the presence of specific metabolic types (sulfate reducers for example) and the environmental conditions where the organisms lived (oxygen and sulfate concentrations for example).

The PhD project must fit into the charter of DCESS, and some possible ideas include: 1) unraveling the biochemistry of isotope fractionation by organisms in the S cycle, 2) exploring isotope fractionations associated with novel nitrogen metabolisms, 3) exploring experimentally and mathematically the function of a carbon cycle dominated by prokaryotic organisms. Other topics are also possible.

Danish PhDs take 3 years with an extremely attractive salary of about 50,000 USD/yr (40,000 Euros/yr). Interested persons please contact Don Canfield at:, Institute of Biology, University of Southern Denmark, Campusvej 55, 5230 Odense M, Denmark, email: dec@biology.sdu.dk

Vacant Marie Curie fellowship in EUROBASIN

A Marie Curie Fellow position for 2005 is available within the EUROBASIN Marie Curie Training Site at the Organic Geochemistry Section of GeoForschungsZentrum Potsdam (<http://www.gfz-potsdam.de/pb4/pg3/index_en.html>), the German national research centre for geosciences. Technical facilities are extensive and state-of-the-art. The Fellow will be member of a multidisciplinary and international team of PhD students, post-docs and staff.

The application deadline is 1 September 2004. The proposed length of stay is 9 months. Proposals in the fields of Fluid Evolution and Basin Dynamics and Biosphere-Geosphere Interactions are welcome. The first field is firmly fixed in the abiotic realm, and is concerned with the generation, sequestration and transport of subsurface fluids within the context of sedimentary basin evolution. The second theme addresses how selected organic and inorganic moieties, formed, transformed and redistributed in the geosphere under the influences of changing pressure and temperature, may be utilised by microbial communities as an energy source. The work to be carried out shall be based on 2D and 3D basin modelling, laboratory experiments, regional studies or in the ideal case a combination of all three. Topics of particular interest are: Gas generation in sedimentary basins from thermal and biological processes, Petroleum biodegradation within the context of basin development, and Thermal histories of inverted basins.

For a summary of fellow requirements, allowance, travel, etc. please check: <http://www.geo.vu.nl/users/nsg/eurobasinweb/index.htm>
Research proposals should be directed to: Prof. Brian Horsfield, Section 4.3, GeoForschungsZentrum Potsdam, Telegrafenberg, D-14473 Potsdam, Germany

MEETINGS ANNOUNCEMENTS

SHORT COURSE ANNOUNCEMENT

CHARACTERIZATION AND TOXICITY ASSESSMENT OF MINE-WASTE SITES

Saturday, November 6th, 2004
Geological Society of America Annual Meeting, Denver, Colorado
Cosponsored by the *Geochemical Society of America*

Abandoned mine-waste sites cover thousands of acres in the western United States. This course will provide simple and practical methods for characterizing and assessing the toxicity potential of mine-waste piles. These methods include quick inexpensive field leaching tests that offer an evaluation of acid and trace-metal release from mine-waste material, field techniques to determine bioaccessibility and bioavailability of metals to aquatic organisms, and a simple decision tree to assess adverse effects from mine wastes. This 1-day course will include an afternoon field trip, and is intended for professionals and students involved in the environmental sciences, federal and state personnel concerned with mining wastes, waste-site managers and personnel, and (or) researchers in hydrological contamination studies.

Faculty: LaDonna M. Choate, Sharon F. Diehl, David L. Fey, Philip L. Hageman, Bruce D. Smith, Kathleen S. Smith, U.S. Geological Survey; James F. Ranville, Thomas R. Wildeman, Colorado School of Mines; James P. Herron, Colorado Division of Minerals and Geology.

Summary of Short Course Topics

LaDonna Choate and Jim Ranville	Methods to Determine Bioaccessibility of Metals from Waste
Kathy Smith Tom Wildeman	Fundamentals of Mine-Drainage Formation and Chemistry
Sharon Diehl	The Importance of Geology
Bruce Smith	Geophysical Applications to Mine-Waste Piles
Kathy Smith	Sampling and Chemical Analyses of Solids, Waters, and Leachates
Phil Hageman	Leaching Studies
David Fey	Acid-Base Accounting
Tom Wildeman	Chemical and Physical Criteria to Assess the Toxicity Potential of Mine-Waste Piles, and Use of the Decision Tree

Take a box lunch on a field trip to the Argo Water Treatment Plant, Idaho Springs, CO and the Rattler Mine Dump, Russell Gulch and environs lead by Jim Herron and Tom Wildeman. Field trip will include demonstration of leaching tests and field analytical techniques.

Meetings Announcements

MOSCOW, IDAHO, USA
MAY 20-25, 2005

Web-site: www.uidaho.edu/gold2005

University of Idaho and Washington State University

The Goldschmidt Conference is the premier annual meeting in geochemistry and mineralogy. As did past conferences, the meeting in Idaho will cover the full range of geochemistry from cosmochemistry to the origin of life. However, this conference will be special because 2005 is the 50th Anniversary of the Geochemical Society – come celebrate this anniversary in the foothills of the Rocky Mountains! The conference also takes place during the bicentennial of the Lewis and Clark expedition - the Corps of Discovery. The Local Organizing Committee invites you to come on a voyage to discover the latest in the fields of geochemistry and mineralogy, and the superb geology and unparalleled opportunities for outdoor recreation in the Inland Northwest. To register interest, log on to the web site above or e-mail: gold2005@uidaho.edu. Details on the program, travel, accommodation, field trips, etc. are available on the web site.

Important Dates:

January 15, 2005: Deadline for abstract submission.
March 20, 2005: Early registration ends, late registration begins.

Sponsors: The Geochemical Society, the European Association of Geochemistry, the Mineralogical Society of America, the Mineralogical Association of Canada, the Geochemical Society of Japan, the International Mineralogical Society, the Division of Geochemistry of the American Chemical Society, the International Humic Substances Society, the Society for Geology Applied to Mineral Deposits, and the Microbeam Analysis Society.

Meetings Calendar

July 4-9, 2004: 16th International Conference on Phosphorus Chemistry (ICPC 16), Birmingham, England. Contact: Prof. Pascal Metivier, Rhodia, R&D for Phosphorous and Performance Derivatives Oak House, reeds Crescent Watford, WD24 4QP, U.K.; Phone: +44 1923 485609; E-mail: pascal.metivier_AT_eu.rhodia.com; Web site: http://www.icpc2004.com

July 5-7, 2004: Geo-Environment 2004, International Conference on Monitoring, Simulation and Remediation of the Geological Environment, Segovia, Spain. Contact: Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton,SO40 7AA, UK; E-mail: gmckeogh_AT_wessex.ac.uk; Web site: http://www.wessex.ac.uk/conferences/2004/geoenvironment04

July 5 - 9, 2004: Joint AOGS 1st Annual Meeting & APHW 2nd Conference, Suntec Singapore, Singapore. Web sites: http://www.asiaoceania.org and http://www.secondaphw.org

July 6, 2004: MORE-SGEG: Tectonics to Mineral Discovery, Orange, Australia.
Web site: http://www.earth.monash.edu.au/seminars/MORE-Conference-2004.html

July 12, 2004: BHS International Conference on Hydrology: Science and Practice for the 21st Century, London, United Kingdom. Website: http://www.hydrology.org.uk/bhs2004/welcome.htm

July 12-16, 2004: Geoscience Africa, International Conference, University of the Witwatersrand, Johannesburg, South Africa. Web site: http://www.wits.ac.za/geoscienceafrica

July 19-22, 2004: Groundwater Quality 2004, University of Waterloo, Ontario, Canada.
Web site: http://gq2004.uwaterloo.ca/.

July 25-29, 2004: 11th International Symposium on Solubility Phenomena, Including Related Equilibrium Processes (11th ISSP), Aveiro, Portugal. Contact: Prof. Clara Magalhaes, Department of Chemistry, University of Aveiro, P-3810-193 Aveiro, Portugal; Phone: +351 234 401518; Fax: +351 234 370084; E-mail: mclara_AT_dq.ua.pt; Web site: http://www.dq.ua.pt/11th_issp

July 25-30, 2004: 7th INTECOL International Wetlands Conference, Utrecht University, Utrecht, The Netherlands. Web site: http://www.bio.uu.nl/INTECOL

July 26-30, 2004: International Symposium on Ice-Water-Ice: Processes Across the Phase Boundary, Portland, Oregon, USA. Contact: S. Ommanney, International Glaciological Society, Scott Polar Research Institute, Lensfield, Road, Cambridge CB2 1ER, UK; Phone: +44 1223 355974; Fax: +44 1223 336543; E-mail: Int_Glaciol_Soc_AT_compuserve.com; Web site: http://www.igsoc.org/

Aug 1-6, 2004: Gordon Research Conference "Water & Aqueous Solutions", Holderness School. Web site: http://www.grc.uri.edu/04sched.htm

Aug 2-6, 2004: 67th annual meeting of the Meteoritical Society, Rio de Janeiro, Brazil. Contact: E-mail: congrex_AT_congrex.com.br. Web site:
http://www.meteoriticalsociety.org/simple_template.cfm?code=news_meetings

Aug 2-7, 2004: 9th International Chemistry Conference in Africa (ICCA), Arusha, Tanzania. Web site: http://www.udsm.ac.tz/News_events/9icca.html

Aug 8-13, 2004: Gordon Research Conference "The Role of Water in Rock Deformation", Mount Holyoke College, South Hadley, MA, U.S.A. Contact: Andreas Kronenberg, Chair, or Mark Jessell, Vice-chair; E-mail: a-kronenberg_AT_tamu.edu or mjessell_AT_lmtg.ups-tlse.fr; Web site: http://www.tectonique.net/grc/

Aug 8-13, 2004: Gordon Research Conference Organic Geochemistry, Holderness School. Web site: http://www.grc.uri.edu/04sched.htm

Aug 12-15, 2004: MYRES-I: Heat, Helium, Hotspots, and Whole Mantle Convection, UCSD campus, La Jolla, CA, USA. Contact: Thorsten Becker, IGPP-0225, UCSD, 9500 Gilman Drive; Phone: +1 858 534 4643; Fax: +1 858 534 5332; E-mail: tbecker_AT_igpp.ucsd.deu; Web site: http://www.myres.org/myres1/

Aug 16-18, 2004: The 2004 Petroleum Hydrocarbons Conference, Wyndham Baltimore — Inner Harbor, Baltimore, Maryland, USA. Contact: National Ground Water Association, 601 Dempsey Road, Westerville, Ohio 43081, USA; Phone: +1 614 898-7791; Fax: +1 614 898-7786; E-mail: customerservice_AT_ngwa.org; Web site: http://www.ngwa.org/e/conf/0408165040.shtml

Aug 16-20, 2004: Western Pacific Geophysics Meeting, Honolulu, Hawaii, U.S.A. Sponsor: AGU. Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 U.S.A.; Phone: +1-202-777-7333; Fax: +1-202-328-0566; E-mail: meetingsinfo_AT_agu.org; Web site: www.agu.org/meetings

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

Aug 22-26, 2004: 228th ACS National Meeting, Philadelphia, PA, U.S.A. Web site: http://membership.acs.org/g/geoc/upcoming.html and http://oasys.acs.org/acs/228nm/geoc/papers/index.cgi

Aug 25-31, 2004: 22nd European Crystallographic Meeting, Budapest, Hungary. E-mail: ecm22.mke_AT_mtesz.hu; Web site: http://www.ecm22.mtesz.hu

Aug 29-31, 2004: Frontiers and opportunities in Antarctic geosciences, Certosa di Pontignano (Siena), Italy. Conveners: C.A.Ricci (Italy), C. Siddoway and T. Wilson (USA). Registration deadline: June 15, 2004. Web site: www.mna.it/english/News/novita_set.htm

Aug 30-Sept 3, 2004: 2nd International Conference on Recrystallization and Grain Growth, Annecy, France. Primarily for and by metallurgists. Web site: http://www.rex-gg-2004.org/

Aug 30-Sept 8, 2004: Spectroscopic Methods in Mineralogy (school) including 5th European Conference on Mineralogy and Spectroscopy (ECMS 2004), Vienna, Austria. School organizers: Anton Beran and Eugen Libowitzky; Web site: http://www.minsocam.org/MSA/SC/

Sept 3-5, 2004: 4th International Symposium on Chemistry and Biological Chemistry of Vanadium, Szeged, Hungary. Contact: Prof. Tamas Kiss, University of Szeged, Department of Inorganic and Analytical Chemistry, PO Box 440, H-6701 Szeged, Hungary; Phone: +36 62 544337; Fax: +36 62 420505; E-mail: tkiss_AT_chem.u-szeged.hu; Web site: http://www.staff.u-szeged.hu/~vanadium/

Sep 4-9, 2004: 8th International Global Atmospheric Chemistry Conference, Christchurch, New Zealand. Contact: Kim Gerard, PO Box 13 494, Christchurch, New Zealand; E-mail: kim_AT_conference.co.nz; Web site: http://www.IGAConference2004.co.nz

Sept 5-8, 2004: UK Luminescence and ESR 2004, University of St Andrews, UK. Contact: Richard Batchelor; E-mail: rab_AT_st-andrews.ac.uk; web site: http://www.st-andrews.ac.uk/gg/Conference/uklum2004.shtml

Sept 5-9, 2004: MEEMSV IV International Workshop, La Londe les Maures, France.
Contact: Seismology, volcanology. J. Zlotnicki; Phone: +33 (0) 5 63 72 31 00; Fax: +33 (0) 5 63 72 30 32; e-mail: meemsv-2004_AT_caret-blanche.fr; Web site: http://www.carte-blanche.fr/~meemsv-2004/

Sept 6-8, 2004: International Workshop on the Application of Isotope Techniques in Hydrological and Environmental Studies, Paris, France. Contact: Jean-Luc Michelot, FRE CNRS-UPS "OrsayTerre", Universite de Paris-Sud, Bat. 504 91405 Orsay, France; Phone: +33 (0)1 69 15 67 91; Fax: +33 (0)1 69 15 49 17, E-mail: michelot_AT_geol.u-psud.fr

Sept 6-10, 2004: ECORAD 2004, Aix en Provence, France. Web site: http://www.irsn-dpre.com/ecorad/

Sept 6-12, 2004: EUROSOIL 2004, Freiburg, Germany. Web site: http://www.forst.uni-freiburg.de/eurosoil/

Sept 8-10, 2004: International Symposium of Earth System Science (ISES 2004), Istanbul, Turkey. Contact: Symposium Secretariat, ODS Congress Management, Yildiz Cicegi 12/1, 34337 Etiler, Istanbul, Turkey; Phone: +90 212 287 5800; Fax: +90 212 3522660; E-mail: secretariat_AT_earthsystem2004.org; Web site: http://www.earthsystem2004.org/

Sept 11, 2004: Tectonics, Magmatism and Metallogeny of Active Continental Margins, Vladivostock, Russia. Contact: E-mail: iagodconf_AT_fegi.ru; Web site: http://www.fegi.ru/IAGOD/

Sept 14-17, 2004: 21st edition of the French Meeting for Mass Spectrometry,
Strasbourg, France, Web site: http://21jfsm.u-strasbg.fr/

Sept 19-22, 2004: 8th International Congress on Applied Mineralogy (ICAM 2004), Aguas de Lindoia, Aguas de Lindoia, Sao Paolo, Brazil. Contact: Dogan Paktunc, Phone: +1 613 947 7061; Fax: +1 613 996 9673; E-mail: dpaktunc_AT_nrcan.gc.ca; Web site: http://www.icam2004.org

Sept 19-23, 2004: Extremophiles 2004: 5th International Conference on Extremophiles - An ASM Conference, Cambridge, Maryland, USA. Web site: http://www.asm.org/Meetings/index.asp?bid=19177

Sep 20-22, 2004: Environmental and Subsurface Science Symposium 2004, The Davenport Hotel, Spokane, WA, USA , by the Inland Northwest Research Alliance (INRA) and Idaho National Engineering and Environmental Laboratory (INEEL). Contact: BethAnn Melad, PO Box 587, Meridian ID, 83680; Phone: +1 208-288-0290; Fax: +1 208-288-0291; EMail: rsvp_AT_meetingsystems.com; Web site: https://www.b-there.com/breg/esss04

Sept 20-24, 2004: 2nd Mid-European Clay Conference, Miskolc, Hungary. Contact: Dr I. Viczian; E-mail: viczian_AT_ludens.elte.hu or Dr T.G. Weisburg; E-mail: weiszburg_AT_ludens.elte.hu

Sep 26-Oct 1, 2004: The Society for Organic Petrology (TSOP), 21st Annual Meeting, Crowne Plaza Hotel, Coogee Beach, Sydney, Australia. Contact: Neil Sherwood, CSIRO Petroleum Resources, PO Box 136, North Ryde NSW 1670 Australia; Phone: +61 2 9490 8666; Fax: +61 2 9490 8197; E-mail: Neil.Sherwood_AT_csiro.au; Web site: http://www.tsop.org/mtgsyd.htm

Sep 27-Oct 1, 2004: SEG 2004: Predictive Mineral Discovery Under Cover, University of Western Australia, Perth, WA, Australia. Organization: Society of Economic Geologists (SEG), Geoconferences WA, and Society for Geology Applied to Mineral Deposits (SGA). Contact: Susan Ho, P.O. Box 80, Bullcreek WA 6149, Australia; Phone: +61 8 9332 7350; Fax: +61 8 9310 6694; E-mail: susanho_AT_geol.uwa.edu.au; Web site: http://www.cgm.uwa.edu.au/geoconferences/index.asp

Oct 12-15, 2004: Lithoprobe celebratory conference, Ontario Science Centre, Toronto, Ontario, Canada. Contact: Ron Clowes; Phone: +1 604 822 4138; E-mail: li_AT_lithoprobe.ubc.ca; Web site: http://www.lithoprobe.ca/about/events/celebratoryConference.asp

Oct 13-16, 2004: SOLAS Science 2004, Halifax, Nova Scotia, Canada. Web site: http://www.uea.ac.uk/env/solas/ss04/

Oct 18-20, 2004: Deep-Water Sedimentary Systems of Arctic and North Atlantic Margins, Statoil Conference Center, Stavanger, Norway. Organization: Norwegian Geological Society. Contact: Ole J. Martinsen, Norsk Hydro Research Center, N-5020 Bergen, Norway; Phone: +47 5599 6937; Fax: +47 5599 5704; E-mail: ole.martinsen_AT_hydro.com; Web site: http://www.geologi.no/cgi-bin/geologi/imaker?id=1657

Oct 18-22, 2004: VIIIth International Earth Sciences Congress, Santiago de Chile, Web stie: http://www.igm.cl/Cct2004/Cct2004_es/index.htm

Nov 7-10, 2004: GSA 2004 Annual Meeting & Exposition, Denver, Colorado. Web site: http://www.geosociety.org/

Nov 8-11, 2004: LPI Workshop on Chondrites and the Protoplanetary Disk, Kaua'i, Hawai'i, US. Web site: http://www.lpi.usra.edu/meetings/chondrites2004/

Nov 14-19, 2004: IAVCEI 2004 General Assembly Volcanism and its Impact on Society, Puc—n, Chile. Contact: Jos A. Naranjo or Jorge Clavero, General Secretariat IAVCEI 2004 GA, Av. Santa Maria 0104, Providencia, Santiago, Chile; Phone: +56-2-737 50 50; Fax: +56-2-777 19 06; E-mail: iavcei_AT_sernageomin.cl; Web site: www.sernageomin.cl/iavcei and http://www.agu.org/meetings/STG/iavcei_stg.html (for travel grants, deadline July 15)

Nov 22-23, 2004: GeoSur 2004 - International Symposium on the Geology and the Geophysics of the Southernmost Andes, the Scotia Arc and the Antarctic Peninsula, Hilton Buenos Aires Hotel, Buenos Aires, Argentina. Contact: Angela Marchetto, OGS, Borgo Grotta Gigante 42c - 34010 SGONICO TS Italy; Phone: +39 040 2140339; Fax: +39 040 327040; E-mail: amarchetto_AT_ogs.trieste.it; Web site: http://www.ogs.trieste.it/GeoSur2004/index.html

Dec 15-18, 2004: ACE 2004 - 5th European meeting on environmental chemistry (ACE), Bari, Italy. Contact: Dr. Michele Aresta, METEA Research Center, University of Bari, via Celso Ulpiani 27, 70126 Bari, Italy; E-mail: resta_AT_metea.uniba.it; Web site: http://www.emec5.uniba.it/

Dec 5-8, 2004: Salt-Sediment Interactions and Hydrocarbon Prospectivity: Concepts, Applications, and Case Studies for the 21st Century, Adam's Mark Hotel, Houston, TX U.S.A. GCSSEPM Foundation. Contact: Paul J. Post; Phone: +1 504-736-2954; Fax: +1 504-736-2905; E-mail: paul.post_AT_mms.gov: Web site: http://www.geolsoc.org.uk/template.cfm?name=GCSSEPM1

Dec 6-7, 2004: Channel Flow, Ductile Extrusion and Exhumation of lower-mid crust in Continental Collision Zones, The Geological Society of London, Burlington House, London, U.K. Contact: Helen Wilson, Geological Society of London, Burlington House, Piccadilly, London W1J 0BG; Phone: +44 (0)20 7434

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9944: Fax: +44 (0)20 7494 0579; E-mail: helen.wilson_AT_geolsoc.org.uk; Web site: http://www.geolsoc.org.uk/template.cfm?name=channel_flow

Dec 11-20, 2004: Short Course and Workshop on Recent Advances in Magmatic Ore Systems in Mafic-Ultramafic Rocks (IGCP Project 479), Hong Kong. Contact: Ms. Christina Yan Wang, Department of Earth Sciences, University of Hong Kong, Hong Kong; E-mail: wangyan2002_AT_hkusua.hku.hk; Web site: http://www.hku.hk/earthsci/IGCP479/

Dec 13-17, 2004: AGU Fall Meeting, San Francisco, California, U.S.A. Contact: E. Terry, AGU Meetings Department, 2000 Florida Avenue NW, Washington, DC 20009 U.S.A.; Phone: +1-202-777-7335; Fax: +1-202-328-0566; E-mail: eterry_AT_agu.org; meetinginfo_AT_agu.org; Web site: www.agu.org/meetings

Jan 9-12, 2005: Winter Conference: Norsk Geologisk Forening 100 years, Røros, Norway. Web site: www.geologi.no

Jan 16-20, 2005: Chapman Conference on The Science and Technology of Carbon Sequestration, Bahia Resort Hotel, San Diego, CA, USA. Web site: http://www.agu.org/meetings/cc05acall.html

Jan 18-20, 2005: 4th Asia Pacific Symposium on Environmental Geochemistry, Perth, Western Australia. Organization: APSEG4, EIGG, Brodie Hall Building, 1 Turner Park, Bentley, WA 6102, Australia; Phone: +61 8 9266 3577/7824; Fax: +61 8 9266 7824; E-mail: apseg4_AT_curtin.edu.au; Web site: http://www.apseg4.curtin.edu.au/

Feb 10-11, 2005: seismic geomorphology, Westchase Hilton Hotel, Houston, Texas, US. Contact: Jessica Canfor, Geological Society of London, Burlington House, Piccadilly, London W1J 0BG, UK; Phone: +44 (0)20 7434 9944; Fax: +44 (0)20 7494 0579; E-mail: jessica.canfor_AT_geolsoc.org.uk; Web site: http://www.geolsoc.org.uk/seismicgeomorphology

Feb 25- March 2, 2005: Aluminium: Lithosphere to Biosphere (and Back), Sixth Keele Meeting on Aluminium, Bu aco, Portugal. Contact: Dr. Christopher Exley; E-mail: c.exley_AT_keele.ac.uk; Website: http://www.keele.ac.uk/depts/ch/groups/aluminium/meeting2005/meeting2005.htm

Apr 3-7, 2005: International Conference on the Biogeochemistry of Trace Elements (ICOBTE), Adelaide, Australia. E-mail: 8thICOBTE_AT_csiro.au,; Web site: http://www.clw.csiro.au/conferences/8thicobte/

Apr 14-20, 2005: 5th International Symposium on Eastern Mediterranean Geology, Thessaloniki, Greece. Web site: http://geonet.geo.auth.gr/5thISEMG/

Apr 24-29, 2005: World Geothermal Congress - 2005, Antalya, Turkey. Web site: http://www.wgc2005.org/

Apr 25-29, 2005: European Geosciences Union (EGU) XXX General Assembly, Nice, France. Sponsors: EGU, AGU. Contact: EGU Office, Max-Planck-Str. 13, 37191 Katlenburg-Lindau, Germany; Phone: +49-5556-1440; Fax: +49-5556-4709; E-mail: egu_AT_copernicus.org; Web site: www.copernicus.org/EGU/EGU.html

May 2005, Li ge, Belgium 37th International Li ge Colloquium on Ocean Dynamics: Gas Transfer at Water Surfaces, Li ge, Belgium. Web site: http://www.uea.ac.uk/env/solas/Colloque%202005.pdf

May 15-18, 2005: Window to the World, John Ascuaga's Nugget, Sparks, Nevada, USA. Contact: Geological Society of Nevada, P.O. Box 13375 Reno, NV 89507, USA; Phone: +1 775 3234569; Fax: +1 775 323 3599; E-mail: gsnsymp_AT_unr.edu; Web site: http://www.gsn2005.org/

May 15-18, 2004: Halifax 2005, Dalhousie University, Halifax, Canada. 2005 joint meeting of the Geological Association of Canada, the Mineralogical Association of Canada, the Canadian Society of Petroleum Geologists and the Canadian Society of Soil Sciences. Web site: http://www.halifax2005.ca/

May 18-20, 2005: Eurock 2005, International Symposium, Brno, Czech Republic.
Contact: Dr Pavel Konecn˘, Inst. of Geonics AS CR, Studentsk‡ 1768, CZ-70800 Ostrava-Poruba, Czech Republic; Phone: +420 69 6979111; Fax: +420 69 6919452: E-mail: konecpa_AT_ugn.cas.cz

May 20-24, 2005: Fifteenth Annual V.M. Goldschmidt Conference, Moscow, Idaho, USA; Web site: http://www.uidaho.edu/gold2005

May 23-27, 2005: AGU Joint Assembly, New Orleans, Louisiana, U.S.A. Contact: AGU Meetings Department, 2000 Florida Avenue, NW, Washington, DC 20009 U.S.A.; Phone: +1-202-777-7333; Fax: +1-202-328-0566; E-mail: meetinginfo_AT_agu.org; Web site: www.agu.org

June 2005: Acid Rain 2005 7th International Conference on Acid Deposition, Prague, Czech Republic. Contact: E-mail acid2005_AT_chmi.cz

June 5-9, 2005: 105th General Meeting American Society for Microbiology, Atlanta, GA, U.S.A. Web site: http://www.asm.org/Meetings/index.asp?bid=470

June 27-July 1, 2005: International Conference on Mining and the Environment and Metals and Energy Recovery: Securing the Future, SkellefteŒ, Sweden.
Contact: Expolaris Kongresscenter, SkellefteŒ, SE-931 78 SkellefteŒ, Sweden; Phone: +46-919-736000; Fax: +46-910-736010; E-mail: kongresscenter_AT_skelleftea.se or tomas.from_AT_metallgruppen.se or manfred.lindvall_AT_boliden.se or helena.ornberg_AT_kongresscenter.skelleftea.se

July 17-21, 2005: 17th Caribbean Geological Conference, San Juan, Puerto Rico. Contact: J.H. Schellekens, Dept. of Geology, University of Puerto Rico, P.O. Box 9017, MayagŸez, Puerto Rico, 9017; Phone: +1 787 265 3845; E-mail: Geoconf _AT_uprm.edu

July 17-22, 2005: 14th International Symposium on Carotenoids. Edinburgh, U.K. Contact: Prof. Andrew J. Young, School of Biological and Earth Sciences, John Moores University, Byrom St. Liverpool L3 3AF, U.K. Phone: +44 151 231 2173; Fax: +44 151 207 3224; E-mail: a.j.young_AT_livjm.ac.uk

July 31-Aug 8, 2005: Fifth International Dyke Conference IDC5, Pohtimolampi Wilderness Hotel, Polar Circle, Rovaniemi, Finland. Contact: Rovaniemi-Lapland Congresses, University of Lapland, PO BOX 122, FIN-96101 Rovaniemi, Finland; Phone: +358 (0)16 341 2799; Fax: +358 (0)16 317 843; E-mail: congres_AT_ulapland.fi; Web site: http://idc5.gsf.fi/

Aug, 2005: IUCr-20 - XX Meeting and General Assembly of the International Union of Crystallography, Florence, Italy.

Aug 7-11, 2005 10th International Platinum Symposium: "Platinum-Group Element - from Genesis to Beneficiation and Environmental Impact", Oulu, Finland. Contact: Congress Oulu, P.O. Box 56, Fin-90015 Oulun kaupunki, Finland; E-mail: congressoulu_AT_ouka.fi; Web sites: http://www.congressoulu.fi/ and http://platinumsymposium.oulu.fi/

Aug 8-11, 2005: Earth System Processes II, Calgary, Alberta, Canada. Ancient earth systems, modern earth system processes, and earth system futures. An interdisciplinary, integrative scientific meeting exploring the interactions among Earth's lithosphere, atmosphere, hydrosphere, cryosphere, and biota. Organization: Geological Society of America and Geological Association of Canada. Web site; http://www.geosociety.org/meetings/esp2/

Aug 20-23, 2005: The 8th Biennial SGA (the Society for Geology Applied to Mineral Deposits) Meeting "Mineral Deposit Research: Meeting the Global Challenge", Beijing, China. Contact: 8th SGA Biennial Meeting, Secretary: Dr. Jingwen Mao, Institute of Mineral Resources Chinese Academy of Geological Sciences, 26 Baiwanzhuang Road, Beijing, 100037 China; Fax: +86-10 68 33 63 58; E-mail: mail_AT_sga2005.com; Web site: http://www.sga2005.com

Sep 5-09, 2005: 7th symposium on the Cretaceous, University of Neuch‰tel, Neuch‰tel, Neuch‰tel (Karl F llmi and Thierry Adatte, Geological Institute, University of Neuch‰tel, Phone: 41-32-7182655 FAX: 42-32-7182601 EMail: karl.foellmi_AT_unine.ch, thierry.adatte_AT_unine.ch Web: http://www.unine.ch/geologie/isc7/)

Sep 7-11, 2005: 6th International Conference on Geomorphology, Congress Hall-Auditorium of Zaragoza, Zaragoza, Spain. (Organizing Secretariat Geomorfologia, Facultad de Ciencias, Universidad de Zaragoza, C/Pedro Cerbuna 12, Zaragoza 50009, Spain; Fax: +34 976 761106; E-mail: iag2005_AT_posta.unizar.es; Web site: http://wzar.unizar.es/actos/SEG/index.html

Sept 11, 2004: Tectonics, Magmatism and Metallogeny of Active Continental Margins (IAGOD conference), Vladivostock, Russia. Web site: http://www.fegi.ru/IAGOD/

Sept 11-15, 2005: 12th International Meeting on Boron Chemistry, Sendai, Japan. Contact: Prof. Xibai Qiu, IUPAC-2005 Secretariat c/o Chinese Chemical Society, P.O. Box 2709, Bejing 10080, China; Phone: +86 (10) 6256 8157; Fax: +86 (10) 6256 8157; E-mail: qiuxb_AT_iccas.ac.cn.

Sept 12-16, 2005: 68th Annual Meteoritical Society Meeting, Gatlinburg, Tennessee, USA; web site: http://geoweb.gg.utk.edu/2005/metsoc2005.html

Sept 19-23, 2005: 22nd International Geochemical Exploration Symposium (IGES): "From Tropics to Tundra", Perth, Western Australia. Web site: http://www.promaco.com.au/conference/2005/iges/

Sept 20-24, 2005: 2nd International Congress of Seas and Oceans, Szczecin - Swinoujscie, Poland. E-mail: icso_AT_wsm.szczecin.pl; Web site: http://www.wsm.szczecin.pl/iirm/kongres/

Sept 26-29, 2005: MRS 2005 Scientific Basis for Radioactive Waste Management XXIX, Gent, Belgium.

Oct 16-19, 2005: GSA 2005 Annual Meeting & Exposition, Salt Lake City, Utah. Web site: http://www.geosociety.org/

Nov 6-11, 2005: International Gondwana 12 Conference, Mendoza, Argentina; Web site: http://cig.museo.unlp.edu.ar/gondwana
Nov 13-15, 2005: Geology Forum 05, Cape Town, South Africa. Topic: metalliferous ore deposits. Contact: Jon Wills; E-mail: jon_AT_min-eng.com; Website: http://www.min-eng.com/geologyforum05/index.html

Dec, 2005: 6th European Meeting on Environmental Chemistry, Belgrade, Yugoslavia. Contact: Dr. Branimir Jovancicevic, Department of Chemistry, University of Belgrade, Akademski trg 12-16, POB 158, 11001 Beograd, Yugoslavia; E-mail: bjovanci_AT_chem.bg.ac.yu; Web site: http://www.science.plym.ac.uk/ace/Meetings.html

Dec 5-9, 2005: AGU Fall Meeting, San Francisco, California, U.S.A. Contact: E. Terry, AGU Meetings Department, 2000 Florida Avenue NW, Washington, DC 20009 U.S.A.; Phone: +1-202-777-7335; Fax: +1-202-328-0566; E-mail: eterry_AT_agu.org; meetinginfo_AT_agu.org; Web site: www.agu.org/meetings

Dec 16-22, 2005: 13th International Conference of the Geological Society of Africa, Cairo, Egypt, 16-22. Contact: Dr Mahmoud Abdeen, GSAf Vice-President (North Africa); E-mail: m_m_abdeen_AT_hotmail.com; Web site: http://gsaf.narss.org/

Feb 20-24, 2006: AGU Ocean Sciences Meeting, Honolulu, Hawaii.

July, 2006: IMA-2006 - XIX General Meeting of the International Mineralogical Association, Kobe, Japan.

July 16-23, 2006: 7th International Conference on the Occurrence, Properties, and Utilization of Natural Zeolites (Zeolite '06), Socorro, New Mexico, USA. Contact: Dr. Bowman: E-mail bowman_AT_nmt.edu.

Aug 27-Sept 1, 2006: 17th International Mass Spectrometry Conference (IMSC), Prague, Czech Republic. Web site: http://www.imsc2006.org/

Oct 22-25, 2006: GSA 2006 Annual Meeting & Exposition, Philadelphia, Pennsylvania. Web site: http://www.geosociety.org/

Dec, 2006 - 7th European Meeting on Environmental Chemistry, Brno, Czech Republic. Contact: Dr. Josef Caslavsky, Institute of Analytical Chemistry, Czech Academy of Science, Veveri 97, 61142 Brno, Czech Republic; E-mail: caslav_AT_iach.cz: Web site: http://www.science.plym.ac.uk/ace/Meetings.html

Dec 11-15, 2006: AGU Fall Meeting, San Francisco, California, U.S.A. Contact: E. Terry, AGU Meetings Department, 2000 Florida Avenue NW, Washington, DC 20009 U.S.A.; Phone: +1-202-777-7335; Fax: +1-202-328-0566; E-mail: eterry_AT_agu.org; meetinginfo_AT_agu.org; Web site: www.agu.org/meetings

Oct 28-31, 2007: GSA 2007 Annual Meeting & Exposition, Denver, Colorado. Web site: http://www.geosociety.org/

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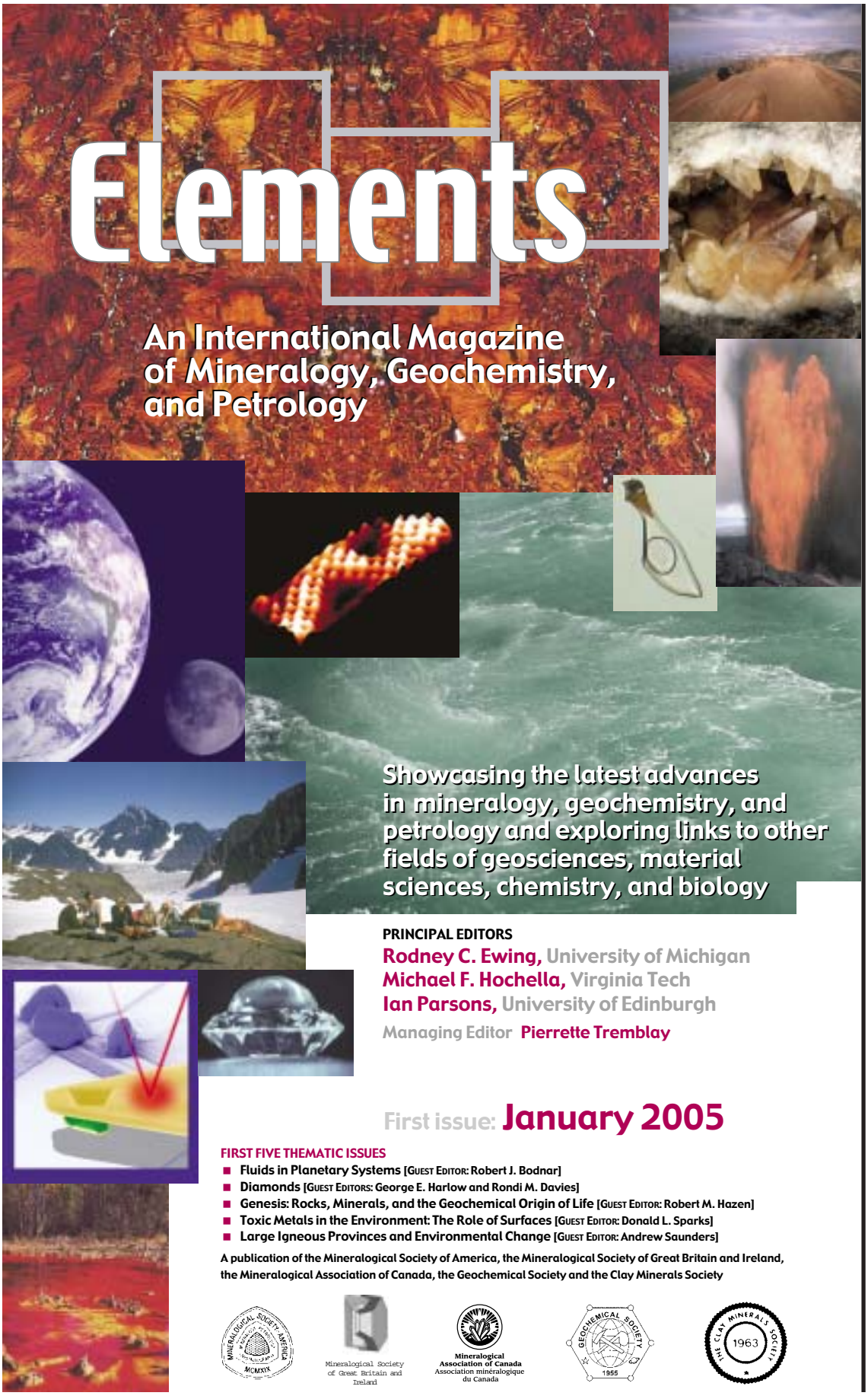

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