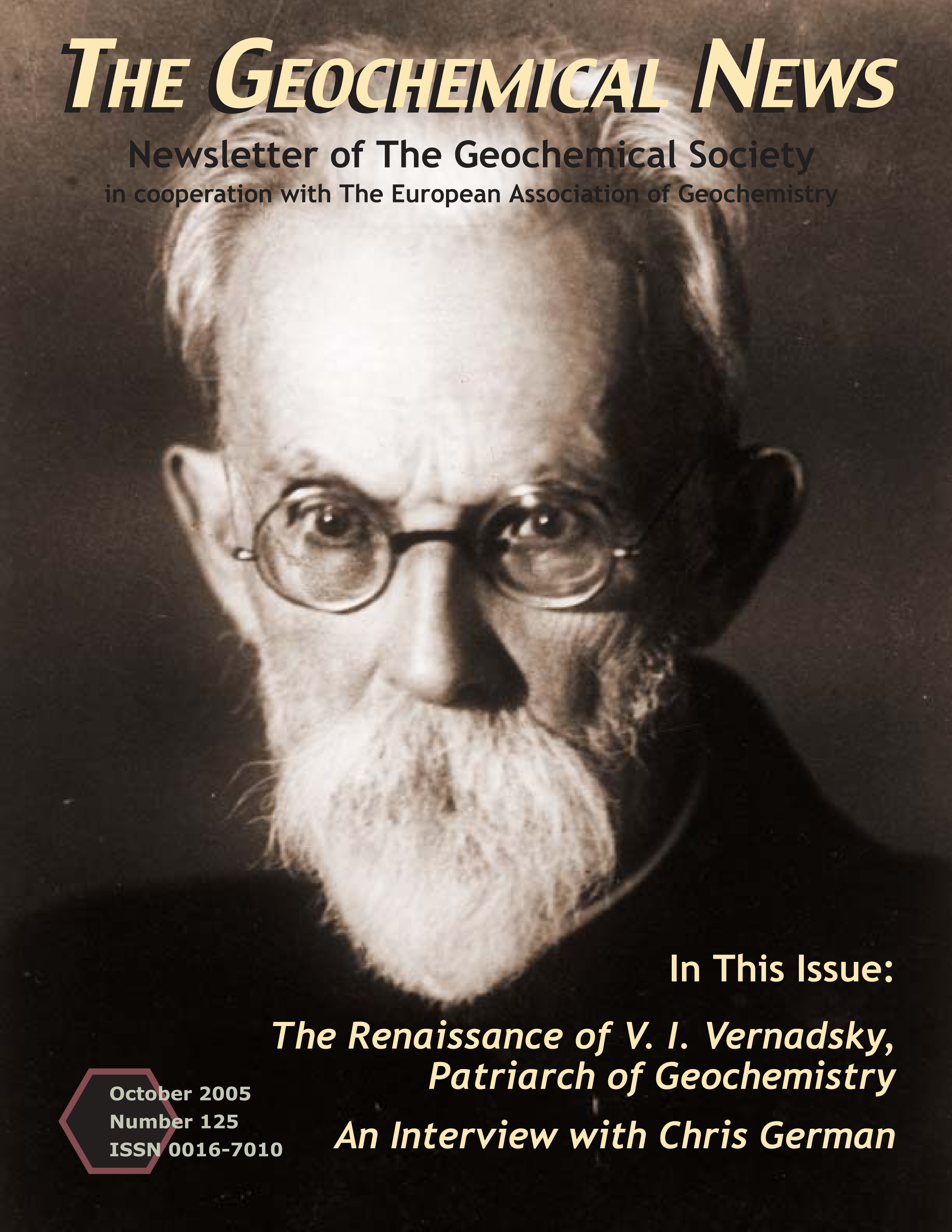
THE GEOCHEMICAL NEWS

Newsletter of The Geochemical Society
in cooperation with The European Association of Geochemistry



In This Issue:

The Renaissance of V. I. Vernadsky, Patriarch of Geochemistry

An Interview with Chris German

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The Geochemical Society

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

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

The Geochemical News
October 2005

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From the GS President,

This will be my last letter as President of the GS and I would like to take the opportunity to look back over the last couple of years. Personally, it's been a great experience, meeting and working with geochemists from all over the globe. I have been particularly impressed by the way the Society works—relying on a corps of dedicated volunteers who contribute their time and effort to making everything happen. I would like to thank particularly Judy McKenzie, who will be rotating off the Board of Directors after six years of service, as Vice-President, President, and Past President. We appreciate enormously all she has done for us. I would also like to thank Harry Elderfield, Gilbert Hanson, and Michael Whiticar, whose terms on the Board of Directors are coming to an end, and our ever-reliable Secretary, Jeremy Fein, and Business Manager, Seth Davis.

January 2005 saw the launch of *Elements* magazine, a combined venture of various mineralogical and geochemical societies. The result is impressive: it's a great magazine to read and I am confident it will achieve its goal of increasing communication and collaboration among members of the sponsoring societies. A particular thanks to Rod Ewing, whose efforts really got the magazine going. With the advent of *Elements*, we decided to change the *Geochemical News* to an online format, with the exception of one paper issue to coincide with the Goldschmidt conference. The feedback I have received so far has been all positive. The online format is more flexible, without any arbitrary page limit, and the production time is shorter, providing more up to date information. Carla Koretsky and Johnson Haas are doing a great job.

Several initiatives are underway to follow up on decisions taken at the Board of Directors' meeting in Idaho. Discussions with the EAG over possible integration of the two societies are continuing. We are looking into an initiative to give the Society more of a voice on public policy and funding issues. Trish Dove is taking the lead on redesigning our website and on organizing a competition for a new logo for the GS. With all respect to the creator of the present version, it does look old and dated: I think it's high time we came up with a new one. I hope you will encourage your students, and friends and colleagues in the graphic arts world, to give it a try.

Tim Drever

Next year's Goldschmidt conference will be in Melbourne, followed by Cologne in 2007 and Vancouver in 2008. It's really impressive how the Goldschmidts have expanded every year and become more global in perspective. The GS is truly a global organization.

Sue Brantley will be taking over as President in January. The Society will be in good hands and I wish her well.

I hope to see you all in Australia!

Tim Drever, GS President

From the EAG President,

Geochemistry is a thriving science in Europe, but is there enough provision for the practitioners to develop their science? The EAG would like to help develop meetings, workshops and short courses, as well as ensuring that there are geochemistry sessions at large meetings in Europe. We have (regrettably rather limited) funds, a recognised position as a European organisation, and a number of councillors who are keen to facilitate the development of our subject at all levels. If you are interested in organising any kind of activity for geochemists and think that it would be helpful to do it through the EAG, then please get in touch with any of the officers to discuss your ideas. While the Goldschmidt conferences are our main activity, there is plenty of scope for other developments, and the umbrella of our organisation exists to help any member who wants to progress with an initiative. We look forward to hearing from you!

And if you don't want to organise a whole meeting, please consider sending your nominations for the (junior) Houtermans or (senior) Urey medals to the committee chairs.

For the Houtermans medal (under 35), contact Terry Seward (ETH Zurich) at: **tseward@erdw.ethz.ch**

For the Urey medal, contact Alex Halliday (Oxford) at: **Alex.Halliday@earth.ox.ac.uk**

Bruce Yardley, EAG President

COVER: V. I. Vernadsky in 1944 shortly before his death. (Used with permission from Bailes, 1990)

Editors' Corner

In this Issue...

We venture into the history of science with a fascinating article on Vladimir Vernadsky, a titan of Russian science from the early 20th century, who not only popularized the concept of the earth system as a *biosphere*, but also expanded the notion of human influences on the terrestrial environment by promoting the concept of the *noosphere*... the sum of human knowledge and its manifestations in the physical world. Vernadsky paved the way for many of the global systems paradigms we take for granted today, and which become ever more prominent in our research, and in our concerns for the future. Chris German's research exemplifies this perspective, and we're thrilled to bring you an in-depth interview with this renowned geochemist, prepared by associate editor Angelina Souren.

Meetings Calender

With this issue of GN, we've moved the meetings calender off the printed page and onto the GS website. This change in content will be permanent, and reflects our feeling that an online resource for meetings information is more fluid, more easily amended, and probably more legible than the format we've used over the last few years in GN. Also, a meetings calender is printed in every issue of Elements magazine, so everyone should still have plenty of conference information at their disposal. We'll continue to print expanded advertisements of upcoming meetings in GN, and we invite everyone to send us their conference, workshop, and session announcements.

Science Podcasts: Opinions Wanted!

In the last year the popularity of podcasting has grown exponentially, from an obscure cult following to a major online medium. One of the beneficiaries of this phenomenon has been science reporting, with dozens of popular podcasts now available that showcase science news, scientist interviews, and other science-related content. In the next issue of GN I (JRH) plan to talk about podcasting and science, and I'd like to hear from our readers. What science podcasts are your favorites? Do you use podcasting in your courses, or assign 'readings' from popular science podcasts? Have any of our members been interviewed on podcast programs? If so, drop me an email and let me know!

Until next issue,

Johnson R. Haas (johnson.haas@wmich.edu),
Carla Koretsky (carla.koretsky@wmich.edu),

Editors

Employment Opportunities

Postdoctoral Position in Aqueous Geochemistry

The Department of Geological Sciences at Indiana University has an opening of a postdoc position in aqueous geochemistry. We have a wide range of research activities that provide opportunities for individuals who are interested in reactive transport modeling, high-resolution transmission electron microscopy, kinetics, thermodynamics, and surface adsorption and coprecipitation experiments. Experience is less important than motivation and education of the individual. It could be an excellent opportunity for candidates who have received a solid education in traditional geochemistry, but wish to broaden or branch into environmental and groundwater geochemistry.

The successful applicant will be working with Chen Zhu at Indiana University. Appointment is initially for one year, with renewals possible pending on availability of funds and performance. Salary is competitive and includes fringe benefits. Bloomington is a beautiful and affordable college town, with incredible world-class music and art activities.

Applicants should send a letter, along with cv and names of 3 references to **chenzhu@indiana.edu**.

Indiana University is an Equal Opportunity/Affirmative Action employer. Women and minorities are especially encouraged to apply.

News From the GS Business Office

2006 Membership Drive

If you have not done so, please take a moment now to renew your membership to the Geochemical Society. Membership includes your subscription to Elements. For 2006, we have also added on-line only options for GCA and G-cubed journals. For more member benefits as well as membership applications, please visit http://gs.wustl.edu/join/

GS Award Nominations Needed

Once again nominations are needed for the Goldschmidt Medal, Clarke Medal, Patterson Award, Treibs Award and GS/EAG Geochemical Fellow Awards. Please take the time to consider the accomplishments of your valued friends and colleagues, by so honoring them. With your help, we can ensure that all of geochemistry is recognized, and all geochemists are considered!

For detailed information on nomination requirements, please visit the Geochemical Society web site at: http://gs.wustl.edu/archives/nominations.html

Community Job Listing

The Geochemical Society now has a webpage to announce geochemical related job openings. The web address is http://gs.wustl.edu/announce/joblist.html. If you have a job you would like to post on this page (at no cost), please send it to office@gs.wustl.edu

GS Advocacy Initiative

More than 70 scientists from many natural and social science disciplines traveled to Washington DC for a two-day talk with Congressional members and their staffs about the importance of the National Science Foundation to the nation and society. The scientists were gathered together by the Coalition for National Science Funding (CNSF), a coalition composed of scientific, engineering, and professional societies, universities, and corporations. The geo-sciences were well represented, and the Geochemical Society was represented by Professor Daniel deB. Richter, a biogeochemist from Duke University's Nicholas School of the Environment and Earth Sciences. Richter is optimistic that the Coalition can grow to become a significant voice in national science policy, and eventually succeed in achieving a doubling of NSF's budget over a five year period.

Seth Davis

Best regards,

Seth Davis
Business Manager

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GS Announces a Contest to Design a New Logo

The Geochemical Society is seeking a fresh face!

When the Geochemical Society began 50 years ago, our organization adopted the hand-drawn logo shown nearby. As we look forward to the next 50 years, it is time to update our widely-used emblem with a fresh look. If you have been wishing for an opportunity to put your graphic arts creativity to work in a high-impact way, here is your chance— The GS is announcing a contest to produce a new logo for our society!

Most modern logos or emblems share similar qualities— easy to use in electronic as well as traditional media with simple styles and readily represented in black/white or color formats. Logo should be scalable and not be too detailed so that it works well at low resolution, Logo may include The Geochemical Society or GS somewhere in the design but this is not mandatory. Creativity, originality, aesthetics, use of space and color will all be used in the selection process. Please keep these suggestions in mind while designing your entry.

A cash prize of $500 USD will be awarded to the winner. Plus the winner will have the pleasure of seeing his/her creative juices displayed by the GS for years to come as our society continues to grow in size and impact.

Deadline for entries is January 5, 2006 and the winner will be announced March 2006. To enter, please send your submission(s) as an electronic file. Preferred formats are .eps or illustrator. It would be advantageous to provide your entry in both b/w and color versions. Flash format also welcome.

Send your entries and your contact information directly to **office@gs.wustl.edu**. You may submit as many entries as you wish. The winning entry becomes the property of the Geochemical Society. By submitting an entry, you agree to grant GS exclusive, royalty-free license to use your logo entry for purposes of the contest. The winner will be required to sign a notarized affidavit releasing intellectual rights to the Geochemical Society.

If you have questions regarding this contest, please contact Seth Davis at **office@gs.wustl.edu**.

Goldschmidt 2006

16th Annual V.M. Goldschmidt Conference 2006

27 August – 1 September 2006
Melbourne Exhibition and Convention Centre, Melbourne, Australia
www.goldschmidt2006.org

Conference topics shall highlight important issues, facilitate open discussion and provide fresh perspectives. Please visit the conference website for more details and to register for this not to be missed conference. A program summary is provided below.

Theme 1: Advances in techniques in geochemistry
Trevor Ireland, Andrew Berry
S1-01: Nuclear methods in geochemistry
S1-02: Reactions and processes at mineral surfaces and boundaries
S1-03: Determining coordination and structure with synchrotron light
S1-04: Techniques for Earthtime and CRONUS
S1-05: Techniques for isotopic and abundance measurements of light elements
S1-06: Techniques for heavy stable isotope analysis
S1-07: Techniques for nanoscale geochemistry
S1-08: Noble gases in the 21st century

Theme 2: Mineral deposits and ore geochemistry
Andy Barnicoat, Chris Heinrich
S2-01: Quantitative hydrodynamic and thermodynamic modelling of hydrothermal processes
S2-02: Fluid-melt-mineral interactions in nature and experiments
S2-03: Element mobility in the regolith: ore body formation, dispersion and discovery
S2-04: Geochemical and isotopic techniques – applications to ore deposits and exploration
S2-05: Sources and mobility of metals across scales: from veins to the lithosphere
S2-06: Sulfide Mineralogy and geochemistry; to mark the publication of Vol 60 in the Reviews in Mineralogy and Geochemistry series
S2-07: Geochemistry of Platinum Group Elements and their ores

Theme 3: Solar system formation
Herbert Palme, Marc Norman
S3-01: Chronology of the early Solar System (including an additional workshop on construction of a time scale for the early solar system)
S3-02: Stellar and Nebular Processes
S3-03: Planetary Formation and Differentiation
S3-04: Geochemistry of Planetary Surfaces
S3-05: Cosmochemistry of Habitable Planets

Theme 4: Convecting Mantle
Bernie Wood, Janne Blichert-Toft
S4-01: Experimental constraints on upper mantle processes - a special symposium honouring Prof. David H Green
S4-02: Messages from the past—the signature of ancient subduction
S4-03: Early Mantle evolution
S4-04: Mantle-core interactions
S4-05: Perovskite and post-perovskite- stability, geochemical and geodynamical consequences
S4-06: Melting at ridges
S4-07: Volatiles in the mantle
S4-08: Plumes and large igneous provinces
See also S5-07

Theme 5: Lithosphere evolution
Roberta Rudnick, Greg Yaxley
S5-01: The deepest lithosphere and beyond: Diamonds and related research - a session in honour of Jeff W. Harris
S5-02: Earth Evolution 4.5 to 3.5 Ga: Deciphering the Earliest Global Systems
S5-03: Geochemical and geophysical probing of continental dynamics
S5-04: Precambrian ophiolites and greenstone belts: insights into mantle dynamics and lithosphere evolution
S5-05: Processes of mantle refertilisation and modification
S5-06: Ross Taylor symposium – celebrating Ross' career and contributions
S5-07: Shen-su Sun Symposium – Geochemical reservoirs and mantle convection (jointly with theme 4)
S5-08: Continental Crust Subduction and Recycling
S5-09: Granites and mantle-crust interaction

Theme 6: Subduction processes
Tim Elliott, Richard Arculus
S6-01: Fluid loss during early (< 2 GPa) subduction
S6-02: "Deep" fluid release from the slab
S6-03: Mantle melting in subduction zones
S6-04: Unscrambling differentiation
S6-05: Mineralisation at subduction zones
S6-06: Subduction zone evolution in 4-D

Theme 7: Geochemical constraints on timescales and mechanisms of tectonic processes
Derek Vance, Joerg Hermann
S7-01: Accessory phases and trace elements: links between geochronology and petrology
S7-02: Up and down: Geochemical constraints on paleotopography and tectonic geomorphology
S7-03: Fast and furious versus slow and steady: rates of tectonic and magmatic processes
S7-04: Extreme metamorphism
S7-05: Light elements in the continental crust
S7-06: Fault systems: their geochronology and geochemistry

Theme 8: Biogeochemistry and the origin and evolution of life
Malcolm Walter, Mike Russell
S8-01: Mediation across the abiotic-biotic transition at the dawn of life
S8-02: Quantum aspects of life
S8-03: Novel isotopic tracers of biogeochemical processes
S8-04: Compound specific isotope analysis and its contributions to palaeoreconstruction
S8-05: Major episodes of extinction, radiation and biogeochemical change
S8-06: Microbe-mineral interactions
S8-07: Life's signatures and products up to 2.0 Ga
S8-08: Possible biogeochemistries of Mars
S8-09: Timescales of human evolution

Theme 9: Aquatic geochemistry and fluids in the crust
John Mavrogenes, Sue Brantley
S9-01: Fluid immiscibility in High T systems
S9-02: Supercritical behaviour
S9-03: Water-rock interaction in aquifers: reactions, rates, controls
S9-04: Low-temperature geochemistry in surface environments
S9-05: Nanoscale size effects on geochemical processes: reactivity, kinetics, and pathways

Theme 10: Surface processes, low temperature systems and landscape evolution
Paulo Vasconcelos, Rod Brown
S10-01: Geochemistry, chronology and global consequences of terrestrial weathering
S10-02: Low temperature thermochronometry: models, methods and applications
S10-03: Terrestrial cosmogenic nuclides: surface process rates and/or dates?
S10-04: Biogeochemical cycling of elements in the surficial environment
S10-05: High resolution palaeoclimate chronologies and proxies
S10-06: Synchrotron applications to environmental mineralogy
S10-07: Mobility, availability and toxicity of pollutants
S10-08: Geochemistry of wine

Theme 11: Ocean chemistry and circulation; climate and environment
Rachael James, Malcolm McCulloch
S11-01: Deep-Sea Carbonate Systems
S11-02: Marine biogeochemical forcing of Earth's atmosphere on short and long timescales
S11-03: Ocean chemistry: past, present and future
S11-04: Geochemical proxies for the past marine environment
S11-05: Continental input of dissolved material to the oceans: control and fate
S11-06: Absolute and relative chronologies of climate change

General Symposia
G-01: Analytical geochemistry
G-02: Atmospheric geochemistry
G-03: Biogeochemistry
G-04: Computational geochemistry
G-05: Cosmochemistry
G-06: Crystallography
G-07: Environmental geochemistry/mineralogy
G-08: Experimental geochemistry/petrology
G-09: Geochronology
G-10: Hydrology/Hydrogeochemistry
G-11: Hydrothermal geochemistry
G-12: Igneous geochemistry
G-13: Isotope geochemistry
G-14: Marine geochemistry
G-15: Metamorphic geochemistry
G-16: Mineral deposits

The Renaissance of V.I. Vernadsky

By Thilo Behrends

В.И. Вернадский

In The Geochemical News No. 120, Nathan Yee and Carla Koretsky presented the biographies of 10 outstanding Geochemists as an attempt to assemble a list of the 10 most notable Geochemists of the 20th century. With great interest I read the biographies of these exceptional scientists and the article aroused my curiosity in the history of geochemistry and its protagonists. I guess Nathan and Carla achieved their goal when I started to think about who else would deserve to be listed in a top ten list when I had finished the article. All the presented scientists were born, or spent at least an important part of their carrier, in Anglo-American countries and all were male. Have there been no women? Who of the Japanese Geochemists has to be included in the top ten list? What about scientists from Eastern Europe? In particular the last question kept me busy. How many important scientific achievements in the former USSR have not reached the western scientific community because of the impermeability of the iron curtain? How many outstanding East European scientist were not noted or their names forgotten in the western countries due to political and lingual barriers?

Vladimir Vernadsky, (1863 - 1945), the patriarch of biogeochemstry and founder of systematic biosphere studies..

When exploring the history of Geochemistry in Russia the first name one comes across is Vladimir Ivanovich Vernadsky (1862-1945). The Vernadsky Institute for Geochemistry and Analytical Chemistry in Moscow is named after him. He is considered to be the father of geochemistry, biogeochemistry, radiogeology and cosmochemistry in Russia [1]. L. Margulis states in the foreword of the English version of V.I. Vernadsky's book *The Biosphere* that "*Just as all educated westerners have heard of Albert Einstein, George (Gregor) Mendel, and Charles Darwin, so all educated Russians know of V. I. Vernadsky"* (MARGULIS, 1998). However, for most people in the West V.I. Vernadsky is largely unknown, although he was connected to and cooperated with leading Western European scientists and spent part of his carrier in France and Germany. K. E. Bailes pointed out in Vernadsky's biography that Vernadsky "…*was to remain to the end of his life a strong advocate of close scientific ties with other countries, traveling abroad almost every summer in order to stay current with Western developments, until he was forbidden to do so by the Soviet government in the mid-1930s"* (BAILES, 1990). Hence, in his lifetime, his scientific and philosophic thoughts were spread across the Russian borders. Although he predominately wrote his books and articles in Russian, some of his work was published in French, English, German, and Japanese in his lifetime. In the early 1950's Vernadsky was mentioned in the major books on geochemistry, but then his name apparently became forgotten outside the Warsaw Pact countries (MARGULIS, 1998). After his death, even in the Soviet Union of the late Stalin era, Vernadsky's name threatened to be buried into oblivion. However, with the onset of de-Stalinization the fame of Vernadsky experienced a renaissance. With a significant time-lag the "Silent Vernadskian Revolution" also started to reach the Western World. Important milestones in this development have been the publication of V. I. Vernadsky's biography by K. E. Bailes in English (BAILES, 1990) and the publication of the complete annotated English translation of Vernadsky's book *The Biosphere* in 1998 (VERNDADSKY, 1998). The first shortened and bowdlerized English translation of this book had already appeared by 1986, published by Synergetic Press, Biosphere 2's publishing arm. A recent highlight of the (re-) awakening of interest in Vernadsky in the West is the introduction of the Vernadsky medal by the European Geophysical Society in 2003[2], which was then presented to P. Westbroek.

Vernadsky's biography

The biography of Vernadsky has been in large part transcribed from chapter 1.1 of G. S. Levit's PhD thesis on the theoretical system of V. I. Vernadsky (Levit, 2001) and from the biography of Vernadsky by K. E. Bailes (Bailes, 1990). Vernadsky was born in 1863 in Saint Petersburg. His father, I. Vernadsky, was a professor of economics and statistics in the Alexandrovsky Lycee. From 1881-1885 Vernadsky was a student of the physical-mathematical faculty (natural-scientific section) of St. Petersburg University. The most influential of his teachers was V. Dokuchaev, who was a founder of modern soil sciences and of a large naturalist school. V. Dokuchaev became the supervisor of Vernadsky's master and doctoral theses. Dokuchaev's integrative approach of considering soil formation as a product of different environmental factors, including the interactions between living and dead matter, might have laid the cornerstone of V. I. Vernadsky's theory of biosphere. In 1888 V. I. Vernadsky left St. Petersburg to study mineralogy in Munich. He then moved to Paris in 1889 where he worked with Le Chatelier, who helped him to find his dissertation subject in the field of silicate mineralogy. One year later Vernadsky settled in Moscow, where he started a twenty-year professorship in crystallography and mineralogy at Moscow University. In this period, Vernadsky founded a new scientific school detached from soil sciences and mineralogy. His first major scientific book *The Fundamentals of Crystallography* was published in 1903. In 1909 he read *The Data of Geochemistry* by F. W. Clarke, which stimulated him to turn to geochemistry. Only a few years after Becquerel and the Curies discovered radioactivity Vernadsky organized the first radiological laboratory in Russia in 1909, inspired by the work of J. Joly whom he met at a conference sponsored by the British Association for the Advancement of Science. Also of importance for his scientific development was his meeting with the geologist E. Suess in 1910 in Vienna (Austria). E. Suess had introduced the term *biosphere* in his book *Das Antlitz der Erde* (The Face of the Earth) and was, by the way, the grandfather of H. E. Suess whose biography was presented in Nathan and Carla's article. In 1911, in protest against political repressions, Vernadsky resigned, together with other professors of Moscow University, and moved to St. Petersburg where he headed the newly established mineralogical laboratory of the Academy of Sciences. One year later Vernadsky was elected as an ordinary member of the Academy of Science.

In addition to laboratory work and theoretical statements, one of Vernadsky's major activities in the period until the 1917 Revolution and the beginning of the Civil War was carrying out and organizing expeditions to the more remote parts of the Russian Empire in order to find new mineral deposits. Before World War I his major interest was mapping and finding radioactive minerals, while after the beginning of World War I the major goal was the exploration of strategic minerals, which were until then imported from Germany. Vernadsky became the moving force behind the creation in 1915 of a commission within the Academy of Sciences, the Commission for the Study of the Natural Productive Forces of Russia (KEPS). Their assigned tasks were to strengthen the nation's defense during WWI, explore and develop mineral resources, and establish new scientific institutes.

> ***"Soon man will have atomic power at his hands. This is a power source which will give him a possibility to build his life just as he wishes. Will he be able to use this force for good purposes and not for self destruction? A scientist must feel responsibility for the results of his studies!"***

In 1917, afflicted by tuberculosis, and finally after the Bolsheviks came to power in Petrograd (St. Petersburg) Vernadsky moved to the Ukraine, where he took part in the organization of the Ukrainian Academy of Sciences. He was elected as the first president of this Academy in 1918. In his Ukrainian period he elaborated the basic principles of biogeochemistry and founded the first biogeochemical laboratory in the history of natural science in a former sugar plant laboratory. One major objective of this laboratory was studying the chemical compositions of different types of organisms. In the communities of the Civil War Vernadsky was down in Typhus, Ukraine, and his family became stranded in Crimea in 1919, which was at that period under White rule, but was taken by the Red Army in the following year. While his son, G. Vernadsky, who later became professor of Russian history at Yale, was evacuated, V. Vernadsky, his wife and daughter remained and were transferred to Moscow. Later, on his way to Petrograd in order to resume his position in the Academy of Sciences, Vernadsky was arrested and thrown into prison, but due to the intervention of the permanent secretary of the Academy of Sciences, S. Oldenburg, and other outstanding personalities he was released after three days.

In 1921-22 Vernadsky organized the Radium Institute based on his radiological laboratory in the Academy. At the end of 1921 Vernadsky received an invitation to teach geochemistry at the Sorbonne, the University of Paris. He left in 1922 and stayed in Paris until the Academy of Science exerted pressure on Vernadsky to return to Russia in 1925. Based on his lectures at the Sorbonne he published *La Géochemie*, which was later translated into Russian, German, and Japanese. During his stay in Paris he also conducted research at Marie Curie's institute and developed the basis of his book, *The Biosphere.* This was published in 1926 in Russian after Vernadsky had returned to Leningrad (St. Petersburg, Petrograd). Back in Leningrad, Vernadsky organized a Living Matter Research Group within the KEPS. On October 1, 1928, the Group was officially reorganized into a Biogeochemical Laboratory (BIOGEL), which moved to Moscow in 1934 and later became the Vernadsky Institute of Geochemistry and Analytical Chemistry of the Academy of Sciences.

Nataliia and Vladimir Verndasky, 1910 (used with permission from Bailes, 1990)

The BIOGEL increased from about 10 to around 30 scientists in the next decade and by the start of Word War II the BIOGEL was recognized as a highly productive and creative part of the Academy of Sciences. In the first period of work the main activity of Vernadsky's laboratory was to determine the average composition of various individual species. Later, the BIOGEL began to work on the determination of rare and radioactive elements in different organisms. One of the scientists working at the BIOGEL was Vinogradov, the later president of the Vernadsky Institute of Geochemistry and Analytical Chemistry. In continuation of Vernadsky's approach he published in a series of papers his fundamental work on the composition of sea organisms and established his reputation as one of the Soviet Union's leading oceanographers. In the late 1930's the BIOGEL developed strong ties with the ministries for health and agriculture and fulfilled a number of research projects for them. In this context, scientists in Vernadsky's laboratory studied chemical deficiencies or excesses in the environment and the effects of imbalances on the health of local inhabitants. Conclusions from these investigations were first presented in 1936 at a meeting of the Moscow Therapeutic Society entitled *Biogeochemical Provinces and Illnesses*. In this presentation, Vernadsky and Vinogradov demonstrated that endemic illnesses resulted from the environmental lack, or oversupply, of certain chemical elements, such as iodine, strontium, barium, and calcium. The third main activity of the BIOGEL was related to Vernadsky's strong interest in radioactivity. During the 1930's the institute began to map the radioactivity of the Soviet Union's surface and they tried to determine the age of geological strata using radioactive methods. Vernadsky was particularly concerned with locating Soviet deposits of radium and other radioactive elements. In 1932 Vernadsky and his student Khlopin began to build the first cyclotron in the Soviet Union. Although insufficient material support and technical difficulties caused severe problems in both getting and maintaining an operational cyclotron, the instrument was used to train the Soviet Union's leading atomic physicists, including I.V. Kurchatov, the man who eventually led the project building the Soviet Union's first atomic weapons after World War II. In 1935 the BIOGEL became the site for the construction of the first apparatus in the USSR for making heavy water. Another important contribution of Vernadsky to the Soviet Union's transformation into an atomic superpower was his active part in setting up a Uranium Commission during WWII. The role of the Uranium Commission was to ensure the supply of sufficient uranium for research and for development of a nuclear programme.

After the German invasion of the USSR in June 1941 Vernadsky and his wife were evacuated to a health resort in Kazakhstan. In 1943 his wife Nataliia died and Vernadsky returned to Moscow where he published his last work *A Few Words About the Noosphere*. On 6 January 1945 Vernadsky died from a cerebral haemorrhage at the age of 82.

In 1936 he had begun to work on two books *The Chemical Structure of the Earth's Biosphere and Its Environment* and *Scientific Thought as a Planetary Phenomenon*. Vernadsky intended to express his thoughts and scientific work in these two books, the first mostly scientific, the latter more philosophical. Vernadsky completed these works, although he did not write the final chapter of *The Chemical Structure.* Both books were published decades after Vernadsky's death and can be regarded as his scientific and philosophic legacy.

"Whichever phenomenon one considers, the energy liberated by organisms is principally (and perhaps entirely) solar radiation. Organisms are the intermediaries in the regulation of the chemistry of the crust by solar energy."

As Vinogradov pointed out in his homage on the occasion of Vernadsky's 100th birthday (Vinogradov, 1963), Vernadsky's intellectual interests were extremely broad: mineralogy and crystallography, geology and radiogeology, geochemistry and biogeochemistry, chemistry and biochemistry, pedology and hydrology, meteoritics, and the history of science and philosophy. He belonged to the founders and pioneers of several of these disciplines and his original contributions to many of those fields had an important impact on their development. His work lived on in the schools of geochemistry, mineralogy, radiogeology, and biogeochemistry he created, and in the research institutes, laboratories, commissions, and committees he founded. In addition to his intellectual and scientific achievements, Vernadsky's more practically-orientated activities, in particular those related to the discovery and exploration of mineral resources, have been of major importance for the development of the Soviet Union. The industrial revolution in the late 1920's and early 1930's and the rising of the USSR to a nuclear superpower after World War II significantly profited or might only have been made possible by Vernadsky's efforts in exploring industrially-significant and radioactive minerals. Vernadsky's practical contributions were motivated by his patriotism. The scientific, economic, social, and cultural development of Russia was one of his major concerns. However, his patriotism did not make him a silent and passive follower of the ruling powers and he openly expressed his critical attitude towards the Tsarist and Stalinist regimes, in particular when he believed scientific progress was being encumbered by the sovereigns. In his awareness of the societal and economic implications of his applied research, Vernadsky also realized the possible negative consequences of industrialization and putting radioactivity under human control. In his opening speech of the Radium institute he stated:


Vladimir Vernadsky, 1890s.

"Soon man will have atomic power at his hands. This is a power source which will give him a possibility to build his life just as he wishes. Will he be able to use this force for good purposes and not for self destruction? A scientist must feel responsibility for the results of his studies!"

He also was very upset when he discovered hazardous and wasteful mining activities during his expeditions. The experience of the "*terrible plundering of its* [Ural's] *richness"* led him to start a campaign to put the Lake Ilmen area (one of the areas in Ural rich in radioactive minerals) under state protection. This campaign succeeded and Lenin placed the Lake Ilmen area under governmental protection, thus creating the first nature preserve or national park in Soviet Russia.

Of his philosophical and scientific legacy, Vernadsky's theory of the biosphere is plausibly the contribution which accounts for most of the recent interest in Vernadsky's work, in particular in the Western scientific community. In his book *The Biosphere* the major conceptual ideas about the biosphere are elaborated and in the following section some of its aspects will be illuminated.

The Biosphere

Following Vernadsky's systematic division of the Earth into spherical segments, the biosphere is one of the paragenetic envelopes of the Earth. Envelopes are defined as subunits of concentric regions, called concentres; the biosphere forms one of the envelopes of the Earth's crust. Different criteria can be used to classify envelopes. Envelopes can be separated based on prevailing thermodynamic conditions, characteristic chemical compositions, etc. The paragenetic envelopes are distinguished based on the occurrence of atoms in specific modes, which in turn are characterized by *1. a thermodynamic field, specific for each mode 2. a particular atomic configuration 3. a specific geochemical history of the element's migration; and 4. relationships, often unique to the given mode, between atoms of different chemical elements (paragenesis)*. Within this systematic the existence of chemical elements in living matter should be regarded as one particular mode of occurrence. Elements are extensively cycled within the biosphere and the flux of elements leaving or entering the biosphere is small compared to the internal fluxes. It is important to notice that Vernadsky's biosphere comprises dead (inert) and living matter, and includes soils, lakes, oceans, sediments, and the troposphere. This implies that living organisms are an integral part of the Earth's upper crust and the lower atmosphere. This conceptual idea differs, for example, from Goldschmidt's view of the biosphere as the sum of living organisms *senso stricto*. According to Vernadsky, vadose minerals, the minerals belonging to the biosphere, differ from minerals from other (deeper) paragenetic envelopes, e.g. the magmatic envelope, in so far that their mode of occurrence is a consequence of the activity of living organisms. The formation and transformation of vadose minerals is a product of the free chemical energy created in the biosphere by the transformation of cosmic radiation, in particular the utilization of solar radiation by photosynthesis. In a section about the role of living matter in the oceans Vernadsky lists prominent examples for the action of living matter on mineral formations, including deposits of calcium carbonates, of calcium phosphates, and of biogenic silicates. He further states that the largest known concentrations of manganese and iron in the Earth's crust resulted from biochemical reactions and he also conceives banded iron formations as a product of biogenic origin.


V. I. Vernadsky (right front) at the Russian Academy of Sciences. Leningrad, 1920s.

> ***"[I believe] in the strength of the human reason and suppose that the team scientific thought will overcome the negative results of the technogenesis and will secure, in future, the rational transformation (and not annihilation) of the natural components of the biosphere, for a maximum satisfaction of the material and spiritual demands of the mankind which is growing quantitatively"***

Vernadsky concludes "*that the deposits of marine mud and organic debris are important in the history of sulfur, phosphorus, iron, copper, lead, silver, nickel, vanadium, and (according to all appearances) cobalt, and perhaps other rarer metals*" (he also mentions barium, strontium and uranium earlier in this context).

Regarding the interaction between dead and living matter Vernadsky not only focuses on the solid Earth but also emphasizes the effect of living organisms on the composition of the atmosphere. Vernadsky points out that the "*gases of the entire atmosphere are in an equilibrium state of dynamic and perpetual exchange with living matter*". He refers to a presentation of J. B. Dumas and J. Boussingault given at a conference at Paris in 1844 when stating that living matter can be taken as an "*appendage of the atmosphere*". Thus Vernadsky anticipates the idea of J. Lovelock that the composition of the atmosphere is an indicator for life, which later led to the development of the

Gaia theory by Lovelock and Margulis. Margulis and Lovelock were not aware of Vernadsky's work when they introduced the Gaia theory but they later acknowledged Vernadsky as "*their most illustrious predecessor*" (Grinevald, 1998). Vernadsky did not elaborate explicitly in his book *The Biosphere* the idea that the biota create and control the abiotic environment, which is the central concept of homeostasis in the Gaia hypothesis. However, Vernadsky points out that the ozone layer, which is protecting life on Earth from harmful UV radiation, originates from the oxygen produced by photosynthesis, and by this Vernadsky gives an example of how living organisms create an ambient environment on Earth. A comprehensive comparison between Vernadsky's biosphere theory and the Gaia theory can be found in G. L. Levit's PhD thesis (Levit, 2001).

Besides qualitative aspects of processes in the biosphere, Vernadsky also aims at a quantitative understanding of these processes. The numbers he derives for the quantity of free oxygen on Earth, the global net primary production, or for the total biomass on Earth vary significantly from recent data but the approach of creating global budgets of biogeochemical cycles was very innovative when *The Biosphere* was written and is still a major subject of present biogeochemical research. Vernadsky uses quantitative considerations in particular to illustrate the effect of the totality of living matter on element migrations on a global scale and to support his idea of living matter as a major geological force on the Earth's surface. In addition to budget calculations Vernadsky derives an expression for the "*kinetic geochemical energy of living matter*". The kinetic geochemical energy of an organism is related to its mass and its speed of transmission. The latter depends on the size of the organism and the optimal number of generations per day and is normalized to the surface area of the Earth. Vernadsky frequently refers to the geochemical energy in *The Biosphere* especially to emphasize the enormous biogeochemical potential of microorganisms. The third quantitative section in *The Biosphere* is devoted to calculations on the fraction of total solar energy used by photosynthesizing organisms to produce biomass. In the context of these calculations Vernadsky argues that it is an inherent characteristic of the biosphere that living matter is distributed on the Earth's surface in a way that solar radiation is completely captured. In order to optimize the utilization of solar energy and to create a sufficient surface, green biomass appears in different forms in different biotopes. On land, plants have to develop three-dimensional structures in order to create a sufficiently thick film for optimal use of solar radiation. In oceans, primary production is dominated by phytoplankton because it can easily distribute over the depth of the photic zone. He further concludes that the biomass on Earth did not vary considerably over geologic time. This conclusion is a consequence of the assumptions that solar radiation was constant over geological time, that usage of solar radiation is always optimized in the biosphere, and that the efficiency of photosynthesis did not vary. The constancy of biomass over geological time is a part of the empirical generalizations Vernadsky formulates at the beginning of *The Biosphere*:

1) During all geological periods there have never been traces of abiogenesis (direct creation of a living organism from inert matter).

2) Throughout geological time no azoic geological periods have ever been observed.

3a) Contemporary living matter is connected by a genetic link to the living matter of all former geological epochs.

3b) The conditions of the terrestrial environment during all this time have favored the existence of living matter and conditions have always been approximately what they are today.

4) In all geological periods the chemical influence of living matter on the surrounding environment has not changed significantly; the same processes of superficial weathering have functioned on the Earth's surface during this whole time, and the average chemical compositions of both living matter and the Earth's crust have been approximately the same as they are today.

5) From the unchanging processes of superficial weathering, it follows that the number of atoms bound together by life is unchanged; the global mass of living matter has been almost constant throughout geological time. Indications exist only of slight oscillations about the fixed average.

6) Whichever phenomenon one considers, the energy liberated by organisms is principally (and perhaps entirely) solar radiation. Organisms are the intermediaries in the regulation of the chemistry of the crust by solar energy.

Based on our current idea of a coevolution of life, environmental conditions, and the geochemistry at the Earth's surface, Vernadsky's uniformitarian view appears obsolete. However, it should be noted that Vernadsky emphasizes that his principles are generalizations derived from facts known at the time and that they are not hypotheses, which go beyond known facts and must be consistent with other dominant theoretical constructions of nature. In particular, he argues against cosmogonic models including a lifeless era in the Earth's past or abiogenesis during some hypothetical cosmic period because they "*originate outside science, in the realms of religion and philosophy*". This implies that he does not exclude the possibility of abiogenesis *per se*, but he rejects the occurrence of abiogenesis as long as no supporting facts are known.

At first glance Vernadsky's substantive uniformitarianism seems to be in contradiction with the evolution of living organisms. However, the constancy of total biomass over geologic time does not exclude that the spatial distribution of the biomass changed in the past and is still changing. In his discussion about the limits of life he points out that the ability of adaptation allows living organisms to displace the limits of animated space and to penetrate into more extreme environments. As an example he mentions that the "*conquest of the air is a new phenomenon in the geological history of the planet*". He considers the "*ozone screen as the potential upper limit for life, which actually stops well below this atmospheric limit*". With respect to the lower limit he writes: "*In a manner analogous to the situation at the upper limit of the biosphere, life is descending slowly but ineluctably to greater depths*". Regarding the lower limit of life he emphasizes the role of anaerobic bacteria in the oxygen free zones of the Earth's crust. Vernadsky perceived the implications of the tremendous progress in the field of microbiology on the understanding of biogeochemical cycles in natural environments, in particular stimulated by the work of S. Vinogradsky. In *The Biosphere,* Vernadsky extensively discusses the different roles of chemo- and photoautotrophic bacteria in the biosphere and he highlights the importance of anaerobic bacteria in biogeochemical processes occurring in subsurface environments in several sections. The appreciation of the importance of microorganisms in element transformations at the Earth's surface is another example of Vernadsky's scientific foresight, which Vinogradov considers to be Vernadsky's greatest gift (Vinogradov, 1963).

Coming back to the discussion of the limits of life Vernadsky notes that the potential of mankind to transcend traditional limits of life is in line with the continuous expanding of the frontiers of the biosphere. Vernadsky understands humanity as another form of life establishing itself as a geological force. This concept is further elaborated in Vernadsky's later work in which he addresses the ability of humans to transfer elements and concentrate them in the biosphere to an unprecedented extend. His last work was dedicated to the noosphere, the following stage in the evolution of the biosphere driven by humanity as the dominating force. In this article he expresses his believe "*in the strength of the human reason and suppose that the team scientific thought will overcome the negative results of the technogenesis and will secure, in future, the rational transformation (and not annihilation) of the natural components of the biosphere, for a maximum satisfaction of the material and spiritual demands of the mankind which is growing quantitatively*" [3].

References

Bailes K. E. (1990) *Science and Russian Culture in an Age of Revolutions. V, I, Vernadsky and his scientific School, 1863-1945*. Indiana University Press, Bloomington.

Grinevald J. (1998) *Introduction of The Biosphere*. Springer, New York.

Levit G. S. (2001) *Biogeochemistry-Biosphere-Noosphere. The Growth of the TheoreticalSystem of Vladimir Ivanovitch Vernadsky*. VWB - Verlag für Wissenschaft und Bildung, Berlin.

Margulis L. (1998) *Foreword of The Biosphere*. Springer, New York.

Verndadsky V. J. (1998) *The biosphere (Translation of the Russian The Biosphere by D.B. Langmuir)*. Springer, New York.

Vinogradov A. P. (1963) Centenary of V. I. Vernadskii's birth. *Geokhimiya* **3**, 211-214.

Vinogradov A. P. (1963) Centenary of V. I. Vernadskii's birth. *Geokhimiya* **3**, 211-214.

Footnotes

[1] **http://www.geokhi.ru/eng/vernadsk.html**
[2] **http://www.copernicus.org/EGU/egs/award6x.htm**
[3] **http://www.tstu.ru/eng/kultur/nauka/vernad/uchver.htm**

Sealab 2005: Spotlight on Chris German

In June, *Angelina Souren* had a long conversation with *Chris German* at his office at the National Oceanography Centre, Southampton (NOCS) – which prior to May used to be called the Southampton Oceanography Centre (SOC) – in the UK.

Chris German is a marine geochemist and an expert on hydrothermal vents. For the past five years, he headed the fluid flow group within NERC's Challenger Division for Seafloor Processes. He was also an Honorary Visiting Professor at the University of Southampton linked to the Graduate School of SOC and the School of Ocean and Earth Science – a position he still retains. Both are part of the NOCS, which currently houses some 450 research scientists, lecturing and support staff as well over 600 undergraduate and post-graduate students. Over the summer of 2005, however, Chris, his wife Romey, son Jamie and their two dogs and a cat have all relocated to Woods Hole. Chris' impending departure was a good opportunity to interview him for the Geochemical News. He had already sold his house and was staying at a campsite as his visa for the States – of course – was taking longer than expected.

Chris has always been highly driven. He likes what he does for a living, and it shows. It gets noticed. He received an MBE (Members of the Order of the British Empire) – for services to Marine Research – from Buckingham Palace in 2002. Two years earlier, Chris and Dr. David Vaughan of the British Antarctic Survey were selected by the Royal Institution as Scientists for the New Century.

How it all began

How did you end up in science? Are any of your relatives in science as well?

My older brother was the first of our family to show an aptitude as a chemist and went straight into teaching the subject, following university. But as he progressed through the education system, he became first a Headmaster of an inner city school in the west Midlands and has since progressed to helping run the Local Education Authority. My father was an engineer and my mother a school teacher specialising in special needs teaching. Adding in my sister and sister-in-law, that makes four past or present school teachers in my family – so I guess I was pretty sure I wanted to do something different from that.

Of course, the other major influence I had, growing up, was that one of my grandfathers was in the Navy in the early 20th century and both of my grandfathers, my own dad and both my uncles. So every male in my family for two preceding generations spent at least some time working at Chatham dockyard, three to four miles from where I grew up.

I read somewhere that you initially did not want to have anything to do with the sea. How did you end up at sea anyway?

I am still not quite sure myself. From a very early age, I enjoyed chemistry. It was something I was interested in and had an ability to do. However, I was also pretty good at languages and for a long time, I quite fancied the idea of becoming a diplomat. Certainly some of the teachers at my school were quite keen to steer me to the arts.

But somewhere around age 15, 16, it became clear that science was where I was headed. In the UK system, you specialize quite strongly from age 16 on. I studied Maths, Physics and Chemistry to the exclusion of all else and when I got accepted to Cambridge to read Natural Sciences, Plan A was to end up as a chemical engineer working in the petrochemical industry.

The trouble was, at Cambridge the Natural Sciences course (Tripos) required that you take up an additional 4th subject in Year 1. I chose geology– and to make a long story short, that is how I ended up in geochemistry. Several people were particularly instrumental in my transition from a chemist to a marine geochemist during the next 3 years.

First of all, both my mum and my brother had an interest in geology when I was a very young teenager. But where we grew up, in North Kent, that meant that my full exposure to geology pre-university had been wandering at low tide through the mud-flats of the Thames estuary, looking for fossilized tree ferns. Not the sexiest pastime for a teenager! My entire 1st year at Cambridge compounded many of these prejudices, being tutored by a man who had devoted his life to Thames Valley gravel!

But then, around Christmas of my 2nd year a new tutor arrived from Australia, Steve Sparks (now a professor at the University of Bristol). By that time, I had turned away from ideas of pursuing chemical engineering and had enjoyed some parts of 1st-year geology enough to be studying a hard-rock petrology/geochemistry course in Year 2. The first term had been pretty dry - lots of crystallography and mineralogy, but after Christmas we started doing more petrology and it was at the same time that this new tutor arrived. He was a very bright young guy and arranged all sorts of things for us. I was lucky enough to be one of the few to have him as an undergraduate tutor as well as having him oversee my transition at the end of that year, from being a chemist with a minor in geology to becoming a geologist. He helped support that and present it to the head of the department, who had to oversee the transition. That was Ron Oxburgh, now Lord Oxburgh, who has more recently been Rector of Imperial College in London and, in the past year CEO of Shell. But back then, they were just the grown-ups who came out to see me during my honours mapping project.

Chris received an MBE (Members of the Order of the British Empire) for services to Marine Research from Buckingham Palace in 2002.

Two years earlier, Chris and Dr. David Vaughan of the British Antarctic Survey were selected by the Royal Institution as Scientists for the New Century.

That brings me to the next person responsible for helping drag me into the earth sciences: Jon Blundy who is also now at Bristol. I got to spend three months in the Italian Alps to do my mapping with him. He had just finished top of his undergraduate degree class in Oxford and was starting a PhD with Steve in the Adamello Massif – also one of Ron's favourite stomping grounds at that time. It was his first field season where he showed remarkable tolerance of my profound ignorance and also drove me around a lot. By combining their considerable talents, I would say that those three successfully helped me transform from a competent chemist to an okay but fairly average geologist.

Not the stuff he expected

In my final year as an undergraduate, I had to be pretty careful which courses I chose, given that I hadn't taken a lot of conventional geological courses in Year 2 (little things like sedimentology, paleontology that the majority consider quite important). Instead, the plan was that I stick to what I knew and concentrated on courses in petrology with a view that

Previous page: The research submersible Alvin (photo credit NOAA)

my grades would be held up by an expected high grade in my particular forte - geochemistry. In those days, geochemistry was taught almost entirely by Keith O'Nions (now at Oxford) with some extra lessons on instrumental analysis and design by Jim Long, a specialist in hand-built ion probes.

"I had graduated from Cambridge on a Saturday, got home on the Sunday and started working at 6am Monday morning as a road sweeper.

"I was not actually allowed to sweep on the streets straightaway. For the first week, I was only allowed to work in back alleys..."

But disaster nearly struck – and now I am close to answering your question: over the summer between my second and third years, the department in Cambridge recruited a new member of staff who took on 50% of the geochemistry course. The person concerned – and ultimately responsible for just about all that followed was Harry Elderfield, who – for those who do not know - is very much a marine geochemist. That was not the stuff I thought I was going to be studying!

So, suddenly, 50% of the geochemistry course was marine-based, with lots of discussion of weathering and related 'soft-rock' stuff. This was exactly the stuff I had avoided in Year 2 so the message was clear – to come out with a decent degree at the end of the year I was going to have to work pretty hard. Again, however, I was fortunate that it was part of the Cambridge system that I had weekly tutorials, with Harry Elderfield and a fellow student, Libby, who was also cox for the University Boat Club. Every Wednesday, Libby would skip out of our tutorial early and head to the river. Harry and I then sometimes used to carry on for one or two hours. He was really generous with his time. I was very lucky as it was his first year that he was doing tutorials. I'm pretty sure he got wiser later on! Indeed, when I became his PhD student, suddenly I found that I was doing most of the tutorials for later generations of undergraduates. Hope I measured up!

Released on police bail

Another thing I remember from those days – and that not many readers other than Steve Sparks would know about – was that I had to be bailed out of jail during an undergraduate field trip that last year – guilty of over-enthusiastic souvenir-collecting!

That was in Bangor, North Wales. The first activity of the final year of the degree course was for everybody to meet up in North Wales for a one-week field course. On the first night, before we had even started, I went into town with a couple of friends and on the way home we ended up collecting various road signs. Our excuse was that they had been standing in bad spots where we bumped into them and we removed them for the sake of safety. I suppose an equally valid hypothesis could have had something to do with how we were walking, but I digress…

We had actually walked past the local police station, carrying these signs, but it was about two miles further up the hill when a police car stopped us. The officer took us down to the police station and put us in a cell. Another two hours later, they got Steve Sparks out of bed and it was about 2 in the morning, I think, by the time we got back to where we were staying. We were released on police bail, for the duration of the field course, and on the last evening, we had to report back. That's when they told us there wouldn't be any charges and thus we avoided a criminal record.

Working as a road sweeper

The rest of the year passed quite uneventfully. I managed to graduate with a strong 2.1, put in a late application for a PhD with Harry Elderfield and went home to wait for 2 to 3 months to hear whether that had been approved. In the meantime, I had graduated at Cambridge on a Saturday, got home on the Sunday and started working at 6am Monday morning as a road sweeper. I spent twelve weeks working on that job. I knew it wasn't forever, but I wanted to prove to myself, before I went any further in life, that I could do whatever kind of job it took to get by, in the future.

"I knew from undergraduate study that people had great ideas that they wrote about in the literature. But actually finding out that when you measure real-world samples, something as complex as the natural environment, actually obeyed proper chemical principles, seemed really pretty cute."

In fact, I only started as an apprentice road sweeper: I was not actually allowed to sweep on the streets straightaway. For the first week, I was only allowed to work in back allies, but once I had proved myself fit to be seen by the tax-paying public, I was even allowed to sweep in front of the local town hall, which had to be done twice a day. And pretty soon I got to play with some fun toys…

I never realized how much fun you could have with one of those machines that suck the drains dry. Quite often, you would have to rescue car keys for people who had accidentally dropped them down a drain. The most glorious was the week I spent on the refuse vans. Those vans had a driver and only two people loading the bins. As luck would have it, I was replacing someone on a team who routinely ran marathons. One of these two extremely fit men had gone on vacation. The other guy was twice as fast as me; they had to go much slower than usual.

After two months, with one month still to go, I got a call saying that my PhD had been approved. So after three months, I went back to Cambridge to start being a student all over again.

Boiling seawater dry

My PhD was studying trace metals in the Indian Ocean. The initial plan was to spend six months to a year preparing the project and then in the summer of 1985 go to the Indian Ocean.

Within about a month of starting my PhD, we found out that the whole cruise programme had been delayed by one year. So I actually had to wait two years before I could go out to sea and get the samples for my PhD.

My supervisor, Harry Elderfield, sat me down and explained that it was not really a problem at all as he had plenty of samples sitting on shelves, from Saanich Inlet. And he had a new post-doc arriving from Woods Hole, Hein de Baar (now at the Royal NIOZ in The Netherlands) who also had some interesting samples from the Cariaco Trench. So for my first year, I worked alongside Hein de Baar on the Cariaco Trench samples before he left and moved to The Netherlands. In my second year, I worked on the Saanich Inlet samples from Vancouver Island before I ever got to go to sea. In the summer of 1985, when everybody else in the lab was working on other topics, I ended up explaining to my geology friends that my project was about boiling seawater dry.

Of course, it was a lot more sophisticated than that, but in a nutshell, if you wanted to explain what you were doing when you wanted to determine dissolved Rare Earth Element concentrations (to an audience of geophysicists)... You start off with a litre of seawater and you end up with a very small precipitate, often a near-invisible amount, of something that you then measure on a mass spectrometer.

Black smokers

Someone who was also working at Cambridge in those days was Gary Klinkhammer. Gary was working on samples he had collected from the Mid Atlantic Ridge (MAR) in 1984, which provided the first evidence for hydrothermal activity anywhere in the Atlantic (Klinkhammer et al., Nature, 1985). In the summer of 1985, at the end of my first year as a PhD student, Gary, Harry Elderfield and Marvyn Greaves went on a second cruise and came back with the first discovery of black smokers on the Mid Atlantic Ridge.

So that is how I became interested in hydrothermal activity very early in my career. I spent two years not going to sea and, indeed, I was pretty sure I was not going to like going to sea so my PhD in marine geochemistry still looked pretty unhealthy to me. But I enjoyed what I was doing and when the chance finally came, I actually booked up for three months of ship time within a five-month window, in 1986. The plan was that when I finally went to sea that June, I was going to learn whether this really was the life for me – or not!

The real cruises for my PhD were actually from August to September and from October to November in the Indian Ocean, studying redox cycling and rare earth element geochemistry, in particular in the Arabian Sea. The first cruise, however, was to do studies at a brand-new hydrothermal site called TAG on the Mid-Atlantic Ridge. We arrived there about three to five days after the first Alvin dives to visit the site at the seafloor.

Have someone fly over and drop off a few spare parts, please

That first cruise, I volunteered for some responsibility on watches. Just about everything broke down and we could not figure out what we were going to do next. One of the major problems was that our Principal Scientist, Bill Simpson, then at the Institute of Oceanographic Sciences in the UK, had built a very large and complicated pumping system 'FIDO' (Filtration in the Deep Ocean), which was about twice the size of an ordinary CTD system, and just too heavy to be run from the ship's mid-ships winch. So eventually the winch overheated and broke down. We spent one entire night where we had the instrument deployed 3,500 metres below the ship within the Mid-Atlantic Ridge rift valley with cliffs that came up to 2000 metres within five miles either side of us. This was still in the very early days of GPS.

We had four hours per day when we actually knew where we were, and 20 hours a day when we were running on 'intelligent guesswork'. So, making sure we didn't crash into the cliffs was the first priority all that night

That, it transpired, was ***my*** job! I then learned something that I had never realized before: you can actually tack with a large research ship, using the ship's superstructure like a sail. So we were sailing up and down with a heading pointing towards the north. We had a ten-mile wide valley to work with, but we also knew our 'dead reckoning' might have us two or three miles out of position. So we drew a little five-mile corridor inside our map of the rift valley and tacked that ship north within our five-mile corridor, as slowly as possible, waiting for sun to come up the next morning.

On that cruise, we used to joke about whether we could call up Radio Shack or their equivalent and have them fly over and drop off a few spare electrical parts. But in truth, we ended up with nothing but a thin steel cable - the hydrowire – to deploy equipment from for the rest of the cruise – and only what was on-board ship to build our equipment with. Astoundingly, 48 hours later, and programmed with a very early Hewlett Packard calculator, we were ready to deploy a completely new system, built from scratch at sea. What is most impressive is the derivative of this system – the 'Stand Alone Pump' rapidly became a mainstay of, for example, the JGOFS Marine Geochemistry program and is still in frequent use in oceanography today.

On the longer term, this was not a particularly successful cruise. But on the short term, it gave me experience of being at sea and as far as that went, it was a fantastic experience. I got to see the whole process of how you have to reinvent your science programmes at sea, more often than people realize. What you end up doing is often not very close to what you had planned to do.

The second thing it taught me is how much a marine scientist relies upon the engineers they work with. That is what makes the difference. These are often the people who – when something goes wrong – determine if you are going to be able to get something successful out of your cruise anyway or if you really are just dead in the water.

I am happy to say that I took to going to sea pretty well. I routinely do get seasick for the first one to two days away from port, but once I get my sea legs it really is no problem and I start wondering why I stayed ashore so long.

I went off and did my other two cruises that summer, which were pretty much pre-programmed in that at certain coordinates, we were going to collect water samples from certain depths. There wasn't a great deal of spontaneity involved because, to address the questions posed, you first had to collect the appropriate data set which meant certain key samples had to be collected in exactly the right way from a certain pre-ordained number of locations.

What I really liked about the hydrothermal research that I just had a taste of, by contrast, was that you would go out and start to collect data and then have to start making value judgements on the fly, at sea, and continuously reinterpret your data as each day passes to see if yesterday's assumptions and conclusions remain valid. Maybe that is true of all research cruises but in hydrothermal work in particular, you often didn't know at all what (if anything) was going to be down there. There was a lot more potential, it seemed, for making real discoveries while you were actually out to sea.

My PhD was going well. I seemed to be enjoying the research and I seemed to be quite good at it. I was enjoying the analytical chemistry and I was particularly impressed, as we began to make very precise measurements of rare earth concentrations, how the very first data that I was generating appeared to help nature make scientific sense! For the Cariaco basin, we had an oxygen profile and we knew theoretically that there should be higher rare earth element concentrations below the oxic/anoxic interface than above it. But when we collected the data for the first six samples right across that interface, and I saw them all stacked up in a straight line, that was the first time when I realized that this was actually what research was about: I knew from undergraduate study that people had great ideas that they wrote about in the literature. But actually finding out that when you measure real-world samples, something as complex as the natural environment, actually obeyed proper chemical principles, seemed really pretty cute. That is what brought it home to me: that it was just ordinary people like me that actually went out and did this kind of work.

That was a fundamental breakthrough, between being taught geochemistry, and having spent years reading articles with polished plots in journals like GCA and then actually getting hands-on and generating a data set that you hope will end up in a paper like that.

One of the other memories I have of that time was something Gary Klinkhammer explained to me then and still influences a lot of the work I do now. We were a small geochemistry group in Cambridge in those days, at the Bullard Labs that were devoted almost entirely to marine geophysics – so much so that all the other PhDs in my year were geophysicists. The big difference was that they all went out to sea for a month in their first year, collected a data set and then spent the whole of the rest of their three years analyzing those data. In my case I spent a lot of time at sea and then took samples back to the lab where I had to process them for detailed geochemical analysis. You end up with six months of working on the interpretation of your data. I discussed that with Gary Klinkhammer and he said: 'Geochemistry won't ever really make the transition until the day when we are able to go out to sea, come home with the data and have as much time to think about the results as geophysicists have now.' Two decades later, as we are moving towards having in situ chemical sensors online, we are finally getting close to that ideal. It rang very true in 1984, 1985 and even now, it is still constantly at the back of my mind. One day soon we'll get there and the future of seafloor observatories will take off.

To MIT via WHOI

Towards the end of my PhD, I decided that I wanted to do post-doctoral research and I wanted to work on hydrothermal systems. It seemed that the obvious person on the planet to go work with was John Edmond who was a professor at MIT (sadly, passed away in 2001). He had been involved in the original discoveries of hydrothermal vents and his PhD student Karen von Damm (now at the University of New Hampshire) had just finished working up the first samples from the East Pacific Rise, surrounded (at least in my imagination) by tube worms, giant clams and all that stuff. Gary Klinkhammer who had been at Cambridge with me, had already left in 1986 and moved across to MIT as well. So I applied for a NATO post-doc grant and followed in his footsteps.

Along the way, however, I had also spent a lot of time with Mike Bacon, from WHOI, at a Royal Society meeting in London in 1987 and discussed some ideas with him about deep-ocean scavenging processes and how they might relate to hydrothermal systems. So I called Mike Bacon up and asked if I could still come along and do some of this stuff, if I could get the right samples. That summer I won a 'Travelling Student' award from the Royal Society and used it to go to sea twice. The first cruise contained my first Alvin dive. A big thrill. The second cruise was going back to the Mid Atlantic Ridge with Harry Elderfield as part of a larger UK-US collaboration. My particular role was to make first use of the UK's new 'Stand-Alone Pumps', the direct descendants of what I had seen built at sea two years earlier.

By the time I arrived at MIT in 1988 as a post-doc, it didn't seem like it would take long to learn just about all there was to know about hydrothermal activity. (I was very young, remember!) We knew that there were slow ridges like the Mid-Atlantic Ridge and fast ridges like the East Pacific Rise and we knew about one vent site on each for which the fluid compositions were actually very similar to one another. Analytically, two new things happened when I got to the US. First, there was the new technique that Mike Bacon's lab had just pioneered, using thorium and protactinium fractionation to study dissolved-particle interactions in the oceans. Also, just as I got to MIT, John Edmond and Ed Boyle took delivery of North America's first ICP-MS, a VG Plasmaquad. It was a very happy coincidence that suddenly there was this new machine. Before that I had only had about two days' worth of experience running some samples on a demonstrator machine at the VG factory in Cheshire, but in 1988 that turned out to be quite a head start on the majority! At MIT, I took a crash course in radiochemistry to learn radiochemical techniques.

"NASA have always spent about 10% of their research budget on explaining their scientific activities to the public. Few other programmes that I know of - or science colleagues I work with - would relish spending such a large slice of their 'science' budget this way. But when you look at the continuing support for NASA after several decades, you realise that this scale of outreach helps to bring back sufficient scientific investment to make sure you still get to do a thorough scientific job as well."

Faster than I could get settled at MIT, however, Mike Bacon contacted me from WHOI. I was still welcome to come down and work with him that winter, and be the first person to study Th-Pa fractionation in a hydrothermal system. However, the North Atlantic Spring Bloom Experiment that was part of the initial JGOFS (Joint Global Ocean Flux Study) program meant that I had to be out of his lab by 1 May 1989 because that is when the first JGOFS samples would start coming ashore. I still hate to remember how many hours I worked processing samples that season, but I'm told you don't miss much in winter in Woods Hole – ask me again next summer!

Up close and personal

In my second year at MIT, I got back to TAG with John Edmond. During that cruise I got to see a black smoker up close and personal for the first time, which was fantastic. I only had one dive on the cruise, but it was quite a daytrip! We sampled the black smokers and the white smokers – our primary objective. Then, since we were ahead of schedule, we also got to drive around collecting high-quality video footage at some of the key locations on the mound. With 20:20 hindsight, I realise that this was actually my first exposure to outreach and improving the public understanding of science. To be honest, however, at the time it was such a pleasure for me that I had a hard time convincing myself that it was perfectly okay to be a bit of a tourist. I went along with one of the most experienced pilots that Alvin has had, Dudley Foster. We got some great samples and also had a really good day out, basically.

During that same cruise, I received a fateful telex. I had been up late analyzing samples for vent fluid chemistry because when those samples come on board they are chemically unstable and you need to get a whole series of key parameters (alkalinity, pH, H_2S

concentration) measured as soon as possible. That was my primary responsibility for the whole cruise which meant I had to stay with it for as long as it took each night. One morning after finishing one of those groups of samples I slept in, and woke up for lunch to find a telex cellotaped to the outside of my cabin door, offering me a job back in the UK, at the IOS. Again, this was before the days of e-mail communication. So I tracked down the radio operator and through a flurry of exchanged telexes I persuaded the UK government that it was both in my and their interest that I finished my fellowship at MIT before moving back to the UK, although they had initially wanted me to head back immediately.

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When I first arrived at MIT, I was quite proud that I was self-funded on a NATO research fellowship, but when I attended my first AGU conference, people assumed I was a PhD student because of my age. I had just turned 25 that summer and I probably looked younger than that. Indeed, Erik Brown, now at the Large Lakes Observatory in Duluth even annotated our wall chart of the geological timescale at MIT with 'younger than Chris German' – but only because he was one of the few who was! This highlighted a notable contrast between the demands of the UK and US PhD systems and compounded the fact that to be a PI at MIT then, maybe still, you had to have earned a tenured position. So with my age and status against me, I decided that if I wanted to start my own research initiatives, the best thing to do at the end of my NATO post-doc was to head back to the UK where the advantage of my job at the IOS was that I could develop my own ideas and have my own say about what I was going to do.

24 bottles of seawater and 22 bottles of champagne

I met my wife Romey the last summer before I went to America, after eight years in Cambridge. Actually, I met her children first. I was sharing a rented house with, among others, her ex-husband. Their children Martin and Helen used to come and stay over on weekends. I sometimes ended up babysitting them and so their mother made it her business to find out who this strange person who was babysitting her children was. I think the earliest such occasion was Helen's fifth birthday party and we just hit it off from the word go. But I was just about to finish my PhD and to go to America so it was also about the worst possible timing you can imagine for starting a serious relationship! Especially as I then spent two of our first three and a half months after meeting each other at sea. Still, nothing worth doing comes easy, allegedly!

At the end of that summer, we agreed to see how things were after a year. It probably would have been a good test for our relationship, if we'd kept to it. The original deal was that Romey would come out the following summer and drive me from coast to coast on a rented

Harley. Maybe there was something about her driving that scared me…

Within about a month of arriving, we found we were calling each pretty regularly. I was not settling in brilliantly in the US; the work was going very well, but at a price: I was not getting out much and meeting anybody where I worked and things weren't so great for her as a single parent in Margaret Thatcher's Britain either. So at some point, when I couldn't see any other way of improving life generally, I took a gamble and said 'Well, you could always just marry me and we'd both be happy,' Romey paused for a while – seemed like quite a long while – without saying anything and then just replied 'Alright.' This may all sound rather scarily precipitous and, indeed, I think we often do look pretty spontaneous to people who don't know us. But the sad truth is that it's an optical illusion. What actually happens is that Romey and I do a lot of talking, thinking and planning about multiple possible futures. That means that when great opportunities come up, we often find we have already thought things through pretty thoroughly and rationalised quite a lot in advance. So then it just becomes obvious what we should do. Romey was working at a school in Cambridge at the time so had to wait to take a week's holiday before she could come over to America. It was the week of Thanksgiving.

The following December I went back to the UK. I was flying Pan Am the day after the Lockerbie bombing, with two suitcases, one with my luggage and the other with 24 1-litre bottles of trace-metal clean Black Sea seawater. As far as the bomb disposal experts at Logan Airport were concerned, however, they were just 24 canisters of what could just as easily have been plastic explosives! Fortunately, I had a letter from MIT explaining that I was taking the samples to Cambridge to do rare earth analyses. Equally fortunately, nobody spotted that I had a helpful colleague at MIT who thought ahead and prepared the letter for me for just this eventuality. During that trip, I visited my parents, Romey and the children where we broke the news we were planning to get married. Romey came back in March of that year and we got engaged in the Public Garden in Boston.

I flew back to the UK in May of that year and we were married in Cambridge. It was a pretty amazing week. We got married one Saturday, I had my birthday in the middle of that week, and the following Saturday was the graduation ceremony for my PhD.

We weren't shipping anything to the US, so we had told everybody that we didn't want any wedding gifts that we couldn't drink before we sold up and moved out. So we ended up getting 23 bottles of champagne. The rarest of the lot was a bottle of Russian (Crimean) champagne from the shores of the Black Sea (this was ***before*** the fall of the iron curtain), smuggled out by Kelly Kennison-Faulkner, now at Oregon State University. Along with all the booze, a particularly nice touch was that we also got an antique ice bucket from my old research group in Cambridge and we still have that. But none of the champagne.

By the time we moved back to the UK again in 1990, Romey was seven months pregnant, expecting Jamie. He was due on the Thursday that would have been Thanksgiving in the US (how cute), but instead he arrived a day late and the Newspaper Headlines from the day of his birth read 'Thatcher Resigns!' That's my boy!

Public outreach

How do you explain the public's fascination with the deep sea? It seems to me that there are two scientific topics that the general public is very interested in. One is the deep sea and the other is astronomy.

What connects the two is weird biology. Another thing they may have in common is the explorational aspect, which may be a bit of a dirty word in science. Nowadays, you can't often get someone to fund you if you just say 'I wonder what happens there.' Instead, you have to rethink your question and present it as 'I wonder if such and such a thing happens there.' If you just have raw curiosity, you can choose to go anywhere, but if you want to do it at the tax payers' expense, it seems reasonable that you should have to try a bit harder than that and explain ***why*** it is important to explore somewhere nobody has been to before.

Space exploration strikes me as the modern-day equivalent of building cathedrals: the people who make the plans and have enough influence to get a major program funded are not likely to be young enough to stick around and still be actively involved in working up the results of all their plans. Research cruises are not quite that bad. It takes about two years after submitting a proposal until you can get to sea and collect the data, and then another two to three years when you need to work on the results. You are looking at a cycle of three to five years for any expedition that you plan to the deep-sea environment. Perhaps that is also part of why the public likes both fields: the scale of the science is outside most people's daily lives.

To me, it looks like you are willing to communicate with the general public, more so than some of your colleagues.

I seem to have an ability to communicate in a way people understand. You have to be very careful, though. One of my first experiences was in the very early 1990s. I had a call from somebody from the Sunday Times who was running an article and who needed some extra quotes. One question was 'What about the story of the origins of life from hydrothermal vents? What do you have to say about that?' My exact quote was 'Well, it would be a lovely story if it was true, but I think the best you can really say about it is that at least all the ingredients are there.' The following Sunday, the back page of the main section of the Sunday Times said 'Chris German believes life originated at hydrothermal vents. 'All the ingredients are there.' he said.' It was at that point that I realized that you really have to be very careful and you really can't afford to relax and enjoy yourself too much when talking to the press. But I still do and I still get into trouble.

The other thing that I have become very aware of – and much more impressed by – is that outreach is rather like science in that, unless you throw enough money at a problem in the first place, to take it seriously and do things properly, you really can't get things done.

NASA have always spent about 10% of their research budget on explaining their scientific activities to the public. Few other programmes that I know of – or science colleagues I work with – would relish spending such a large slice of their 'science' budget this way. But when you look at the continuing support for NASA after several decades, you realise that this scale of outreach helps to bring back sufficient scientific investment to make sure you still get to do a thorough scientific job as well.

What struck me is that there is a lot more interest in science here in the UK than in Holland (where I am from). You can actually buy New Scientist at many supermarkets here. To me, that is pretty amazing.

I think that all probably comes down to the BBC, their natural history series and people like Sir David Attenborough. But there has been some very interesting new research I have learned of this year, in the US, on how to achieve effective outreach. This new study has identified that if you want to manage effective outreach with school-age children you really have only a couple of 'optimum' years to target. There is no point aiming outreach at school children who are too young because they won't have learned enough basic science to grasp the concepts. Certainly before age 10, they're not ready. By the time they become mid-to-late teenagers, however, it's just not cool anymore to be interested in anything scholarly anyway – even marine geochemistry. So one of the leading arguments now, which rings true to me, is that 12 to 14 is the age to aim for. Then working out how to get involved in outreach to school children suddenly becomes a lot clearer, because you only have one or two school years that you aim at and so you can really focus your efforts.

My son has just passed through that age group. He is 14 now, but last year he was studying plate tectonics in his geography lessons. He got a real buzz out of it. And what brought it home to him that here was a real 'happening' science was that his notebooks and mine from the same school year showed a lot of overlap up to the point when his teacher started teaching him about the eruption of Mount St Helen's. I was already at university when that erupted. We had a lot of fun working up a school project on Montserrat together last spring.

Future plans

What's next?

During the 1990s, I spent a lot of time – through InterRidge – examining the geologic controls of hydrothermal activity on the seafloor. One of the goals we set ourselves was to test whether there was any limit to how slow a ridge could be spreading and still host hydrothermal activity. Over five years or so we established that there is no ridge, no matter how slow it is spreading, that does not have hydrothermal activity. In fact, there isn't just some activity, there is plenty! But the exploration is not finished yet, because in the multi-disciplinary world that geochemistry lends itself so well to, you often need to study both geologically and biologically… And what still remains unanswered is how very geologically similar hydrothermal settings in different ocean basins can host quite huge differences in their biological communities.

This is the focus of a major new programme I am now involved in as Co-Chair. It is the Census of Marine Life program 'ChEss' – investigating the biogeography and biodiversity of chemosynthetic ecosystems. That may sound as if I am a marine biologist, but I am really still working on redox processes in the sea and their effect on geochemical cycles – near enough the exact same title as my original PhD thesis!

One of the next big programmes within this project is going to be to investigate what happens when a mid-ocean ridge and a subduction zone collide. From a biogeochemical perspective the Chile triple junction is probably the one place on earth where you can have every kind of low-oxygen marine environment together. We expect to be able to find cold seeps along the Chile margin and hydrothermal vents close by on the intersecting ridge. What's more, we can also expect to get thermal destabilisation of gas hydrates (already identified by seismics) as hot young lithosphere is thrust beneath the margin close to the triple junction. In addition, the whole of the Chile margin is also a whale migration zone. You may know that there are well established migration routes for Gray Whales, for example, between the Guyamas Basin and Alaska. But there is an equivalent migration in the southern hemisphere, off the coast of the Andes all the way down to the Southern Ocean with one of the Southern Hemisphere's most significant Blue Whale nursing and

feeding grounds just 200 km from the Chile triple junction itself. Why is this relevant? Whale falls to the seafloor set up sufficiently reducing conditions, locally, that these too can provide chemosynthetic ‘oases’ on the seafloor, similar to those provided by cold seeps and hydrothermal vents.

Biologically, there are some really interesting things to go and do there. If you look at all these different systems, there is no guarantee that any one species would be common to all of these different chemically reducing environments. They may, instead, be specially adapted for high temperatures or pressure. That is what we want to find out and right now, the only place you can get that information on this planet is at the Chile triple junction.

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Of course, the SE Pacific is a very remote place if you are starting from here. Not so long ago, an initial response from a programme manager might have been ‘That is a long way to go. Your ideas would be wonderful if where you wanted to work was somewhere close to the coast of Europe, for example, or just off Martha’s Vineyard.’ But it isn’t. It’s in the SE Pacific. The flip side of that is that you can make a virtue out of it.

It is a fascinating place. There is no reason why you can’t organise programmes to go there. If the science is important enough then, in terms of value-for-money for the tax payer, it is not necessarily more expensive to go there. Rather, if you are going to go there, you want to make sure that you (on the collective international scientific scale) stay there for a while and make the most of the opportunity.

Which brings me to my second major ambition for the years ahead. It has been known for more than 20 years, from He-3 enrichments in the deep-water column, that there is a major hydrothermal plume dispersing west across the Pacific Ocean away from the southern East Pacific Rise. One of the major results of the WOCE expedition (thank you, physical oceanography!) has been to demonstrate that there is no other hydrothermal input to the oceans that is nearly so significant along any other part of the global mid-ocean ridge.

So, as part of the new GEOTRACES programme being pioneered by Bob Anderson at Lamont in the US and Gideon Henderson at Oxford in the UK, my own priority is going to be helping to develop a process study that examines what really goes on within that hydrothermal plume. We know that gross hydrothermal fluxes to the ocean are large (on a scale similar to rivers). We also know that processes in hydrothermal plumes strongly modify those gross fluxes from the seafloor and that hydrothermal plumes interact with the entire volume of the ocean, on average, on timescales that are not much longer than that for thermohaline circulation.

So hydrothermal plumes might buffer ocean chemistry at some scale, for at least some tracers. A complication arises in that key processes in hydrothermal plumes – such as Fe oxidation – vary from one ocean basin to another. But we now know where most of the gross flux comes from so if we want to really get to grips with what the net impact might be of hydrothermal venting, there is one obvious place left to go.

Again, it is inconvenient for the average programme manager that the most important place on earth to work is not also convenient to a Scripps, a Woods Hole, an IFREMER or an SOC/NOC. But we shouldn't apologise that the world is such an interesting place. We just have to get ourselves organised and start presenting the compelling scientific arguments.

With the advent of MC-ICP-MS, we now have the ability to measure almost the entire periodic table then compared to the original GEOSECS program (and of course, back then, a complete ocean chemistry program was constructed blissfully oblivious to the importance of submarine hydrothermal activity!). Now we have a wealth of experts committed to GEOTRACES so that you can really aim to conduct one ambitious and really detailed study. Everyone contribute their own specialist measurements and by pulling all of that together, in conjunction with some dedicated dives for fluid-sampling at the source Southern East Pacific Rise vent-fields, we'll end up with a fairly complete hydrothermal/geochemical budget.

What are you going to do in Woods Hole?

I basically have six months to settle in when I first get to Woods Hole. I am going to be joining the Geology and Geophysics Department where I already held an adjunct position, although I do already enjoy quite a lot of overlap with other departments. During those six months I get to settle in and join the department, learn to find my way around and submit a few proposals to get my own research up and running. Then on the first of January, I will take over as the new Chief Scientist for Deep Submergence.

The Chief Scientist for Deep Submergence's job is to be a go-between the national deep Submergence Facility and the users themselves, the US research groups.

I will find out in practice what this actually entails. Crudely, the idea is that I make sure that the US research community gets good value for money, that the taxpayers' money is well spent, ensuring best use of the facility.

Since 1998, I have been heavily involved in getting the first ROV set up for research in the UK. One of the big reasons why I wanted to get an ROV in the UK was to have the ability to go beyond our former limitations which allowed us to go from making a map of the seafloor along a 200-km section of mid-ocean ridge and get to within less than 200 m of a new vent site and then have to stop. It is frustrating in a way that is hard to communicate to end up knowing exactly where a brand new site of hydrothermal activity is – probably inhabited by completely new species previously unknown to science – and then have to hand that information to somebody else in a completely different research group (and in the case of UK research, not even in the same country as you) who can then go down, land straight on the site, take photographs and actually get to see what is there. It makes a big difference, when you're that close, to be able to drop a submersible, manned or otherwise, over the side of the ship and finish the job properly.

What is your theory about why some people have their favourite elements?

Sometimes it is what you start with and the techniques you know. There can be a huge activation energy involved. I happened to get experience with TIMS early on in my career, and then I moved on to radiochemical techniques at Woods Hole and was also in on ICP-MS technologies from the start. So I haven't ever really been tied down to one analytical technique. Instead, I suspect people think that I just keep banging on mindlessly about hydrothermal systems and reveal any latent narrow-mindedness that way. Of course, that still puts me in a quite distinctive minority of people working in areas of ocean chemistry that do not have any obvious direct link to global warming, climate change and those things that are often easier to explain to the tax payer as being important.

I do think that it is probably right, that 90% of our population probably should be using the taxpayers' money to work on immediate problems. But there are other things out there. It is important that somebody keeps that 'extra 10%' alive in the oceans because whenever we come up with new tracers and we want to start using them for understanding ocean budgets, and particularly when using them within a climate change perspective, somebody somewhere has to understand the complete (and not just a part of) the marine cycle of whatever that new tracer is. Somebody somewhere has to be able to at least check that the hydrothermal contribution (for example) is not important.

With iron, for example, there is a reasonable chance that perhaps 50% of the dissolved iron in the deep ocean is hydrothermally sourced. It would not be very difficult for this to be true – you could precipitate 98 to 99.5% of the dissolved Fe estimated to be released from hydrothermal vents and the remaining 0.5 to 2% would still make the mass balance work. So what if hydrothermally sourced Fe was important as a productivity-limiting micro-nutrient once it is upwelled to the surface? This is probably pushing the limits and wouldn't take long to disprove, but it is still untested and probably worth investigation.

I have about 20 years of sampling left, and I see things in five-year chunks. There are two questions I have always been interested in, in my hydrothermal research. One is 'where does it occur and why?' which is a very geological question, but you use chemistry to answer those questions. The second question is ‘Is it important?’ Right now it strikes me that if I could get these next two big programmes – the Southern EPR and Chile Triple Junction projects – completed then I might, finally, think I have begun to get a pretty good overview of what’s going on. So that’s what I want to get done in the next five – or perhaps it’ll take ten – years. But you know how it is, things sometimes change in six months.

Personal preferences

I read somewhere that you are a vegetarian.

Yes, that came in 1986 or thereabouts. I had been thinking about it for a while and in 1986, I found myself at sea during that first research cruise with a like-minded fellow PhD student, Phil Newton. I think we were both a bit overawed by just how much meat we were being served up at sea (in those days fresh salad lasted no more than a fortnight at sea and after that it was coleslaw, potato or rice salad for the next three weeks) and that it couldn’t possibly be healthy. Since my father had had two major heart attacks in the preceding years, interspersed with major bypass surgery, it also seemed timely to do something preventive. The cumulative effect of this was that I became a vegetarian and have been ever since.

How does that work at sea, when they serve you so much meat?

On UK ships, it is not a problem at all. American ships vary from one to another. I remember my first trip on an American ship when I was served the main course, with roast beef and gravy. When I explained that I was a vegetarian, the steward said ‘no problem’. He took my plate away briefly, then brought it back with a hole in the congealing gravy where the meat used to be. Life has progressed a lot since then. On most ships now, it’s self-service and there is a lot more variety available. Of course, there are also vegetarian members of ships’ crews who have also confided that there is nothing quite like having the Chief Scientist be a vegetarian to help inspire the cooks to try that bit harder, too.

But one of the most interesting experiences I’ve actually had was on a Japanese research cruise aboard the RV Yokosuka. It turned out – I think as much to their surprise as to anyone else’s – that so much of the food that they served was in fact vegetarian – and pretty interesting too! Perhaps the French ships are most difficult, nowadays. There, I think asking for vegetarian food comes pretty close to an insult to the national pride. But the compensation for that is that they do serve excellent red wines with their meals!

What kind of music do you like?

Good question! The first band I saw live (and still rate) were The Jam. But I have one particular band that seem to have grown old with me at exactly the right pace – and that’s The Cure. Must be my naturally sunny disposition, I suppose. Some people argue that my sudden relocation to Woods Hole this year is all part of a thinly disguised midlife crisis, but I actually had that when I turned forty and Romey bought me a bass guitar. When I was a kid, my parents did their best to coerce me into a classical musical education so I was in the school choir and I played violin. I also used to play viola in the local youth orchestra. But I always half-joked, at university, that if ever I was going to get back into playing an instrument then one day I was going to get a bass guitar (4 strings good, 6 strings too many).

The turn of the century was a pretty rewarding time for me. I had received ‘early career’ honours for my Chemical Oceanography and Marine Geochemistry work from the Challenger Society in the UK and from the International Lithosphere Panel in the same year that I was selected for the award from the Royal Institution and then not much more than a year later I was in the New Year’s Honours list (the MBE). Instead of feeling pretty smug, I found myself worrying that I might have peaked too early – ‘too much too young!’

But I shouldn’t have worried, I soon found out that Robert Smith has already got there about a year ahead of me and written it down in the aptly titled ‘39’. I guess I must have obsessed a little too obviously about just ***how*** great the bass-line is in that track because when we went up to Oxford to meet up with our older kids on my 40th birthday, a year after the MBE, I also became the proud owner of a Fender Jazz Bass.

Now, armed with that and a 40W amp, any time life seems a bit too serious and the latest reviewer hasn’t quite seen the road to enlightenment that was spelled out so clearly for them in my near-faultless(!) proposal I find I have a very healthy way to unwind. Both my sons also play guitar and Jamie is also pretty good on keyboard and drums, so between us we can cover a lot of ground. In recent years the boys have introduced me to Radiohead – who we got to see live in Oxford – and Muse – at their homecoming in Bournemouth. I’ve tried but pretty much failed to get them into Placebo and Interpol recently – but in times of crisis I always revert to the Cure, and that’s still the music I write my best papers and proposals to.

And what books?

Something I picked up on somewhere – also gleaned from Harry Elderfield, I expect – was that the more quality literature you read, the greater the chance that it will impact on your own use of words. I have always been aware that when I was younger I studiously avoided reading more than the required minimum of the 'classics.' Now, I'm afraid that I routinely spend large amounts of cash on books before each time that I go to sea. Research cruises can be very intense experiences and sometime you just need a way to get away from the world when you are out at sea. And one easy way to do that is to just go and sit quietly and read a book somewhere. That way you can create a little bit of quality 'breathing-space' time and effectively just step off the ship for an hour of so. It can be a very helpful thing to do.

Nowadays you can actually go and buy many of the past classics for a pound each, as there is no copyright on them anymore. There are all kinds of books that I should have read in my teens, but I was too young to appreciate their importance. Now I am catching up. Last November, I read Hard Times by Charles Dickens while cruising between Fiji and Tonga! This year, sailing from the Cape Verdes, I read Robinson Crusoe for the first time. It was a bit daunting to read that the island he washed up on was en route back from South America to the Cape Verdes – especially as our final port was also on that route – in Ascension. On average, I aim to take at least one solid novel for every week at sea. The best exception to that rule was in 2001 when I spent 3 months at sea in the Indian Ocean. I started reading War and Peace at Heathrow on the outbound flight and finished it somewhere between Paris and Southampton airports on the final leg home. Of modern novelists I still haven't quite outgrown John le Carré but my particular favourite is probably Ian Banks (dour grim-reality Scotsman) with or without the middle 'M' he uses when writing science fiction.

One of my next ambitions when I get to the US is to learn Spanish. That is what my son is going to start learning at high school there, based on the fact that English, Spanish and Chinese are probably going to be the three key international languages of the coming decades. I suspect that I am already too old to make a success of Chinese, but I've done a bit of Latin in my time – enough to get by in Italian on a good day – so I am hoping to pick up enough Spanish that it will come in handy when I go to the Chile triple junction.

But I do also need to keep up with the Italian as well because, lest anybody thinks we're making another snap decision, Romey and I have already been thinking ahead and latest news is that is where we're going to retire: Northern Italy.

For more information, see these recent examples and references therein:

C.L.Van Dover, C.R.German, K.G.Speer, L.M.Parson and R.C.Vrijenhoek. Evolution and Biogeography of Deep-Sea Vent and Seep Invertebrates. Science 295, 1253-1257, 2002.
C.R.German and K.L.Von Damm. Hydrothermal Processes. In: 'Treatise on Geochemistry' (K.K.Turekian & H.D.Holland, eds.), Vol. 6 'The Oceans and Marine Geochemistry' (H.Elderfield, ed.), Elsevier, Oxford, 2003.
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C.R.German. Hydrothermal exploration and astrobiology: oases for life in distant oceans? International Journal of Astrobiology 3, 81-95, 2004.

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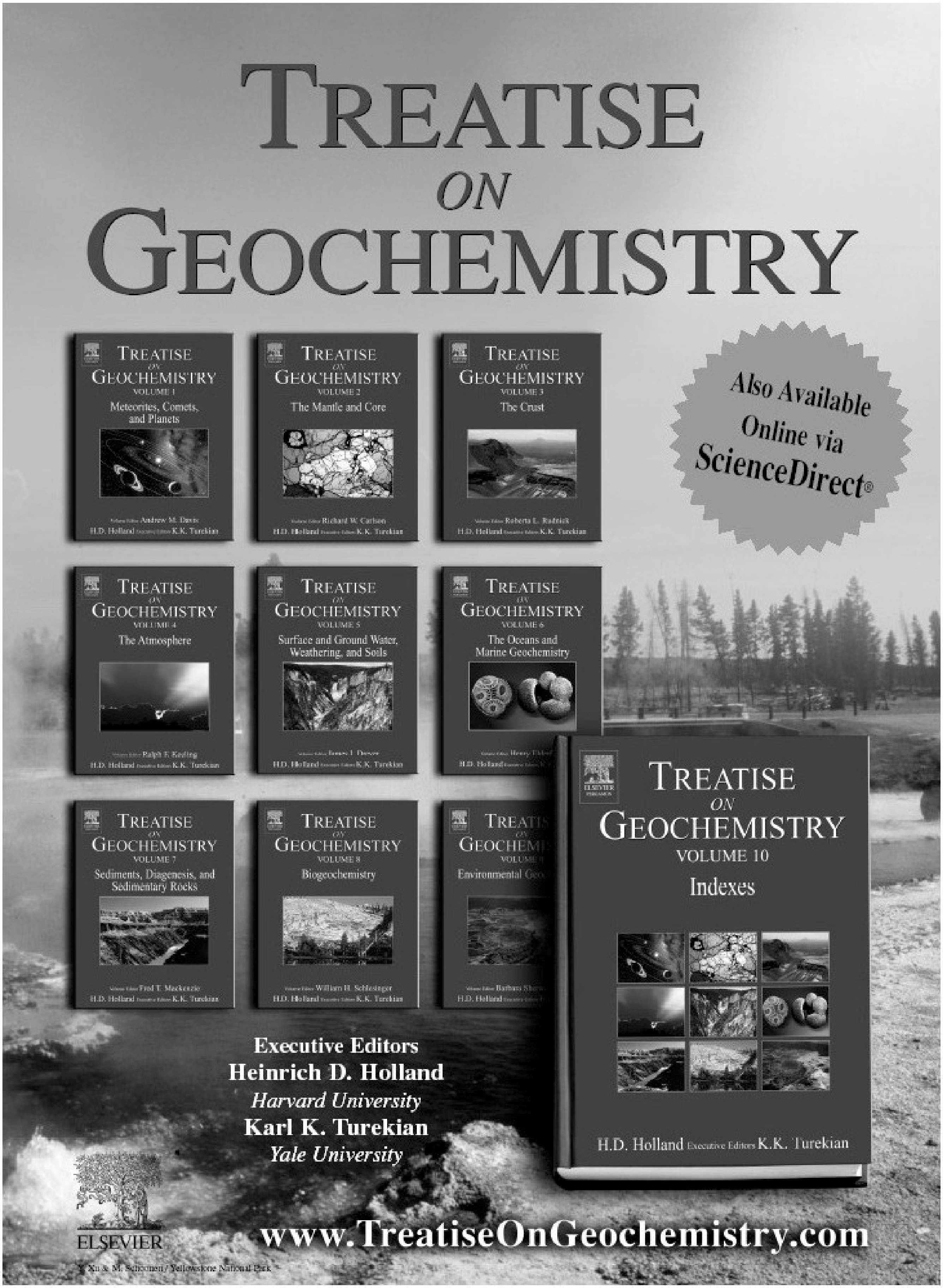
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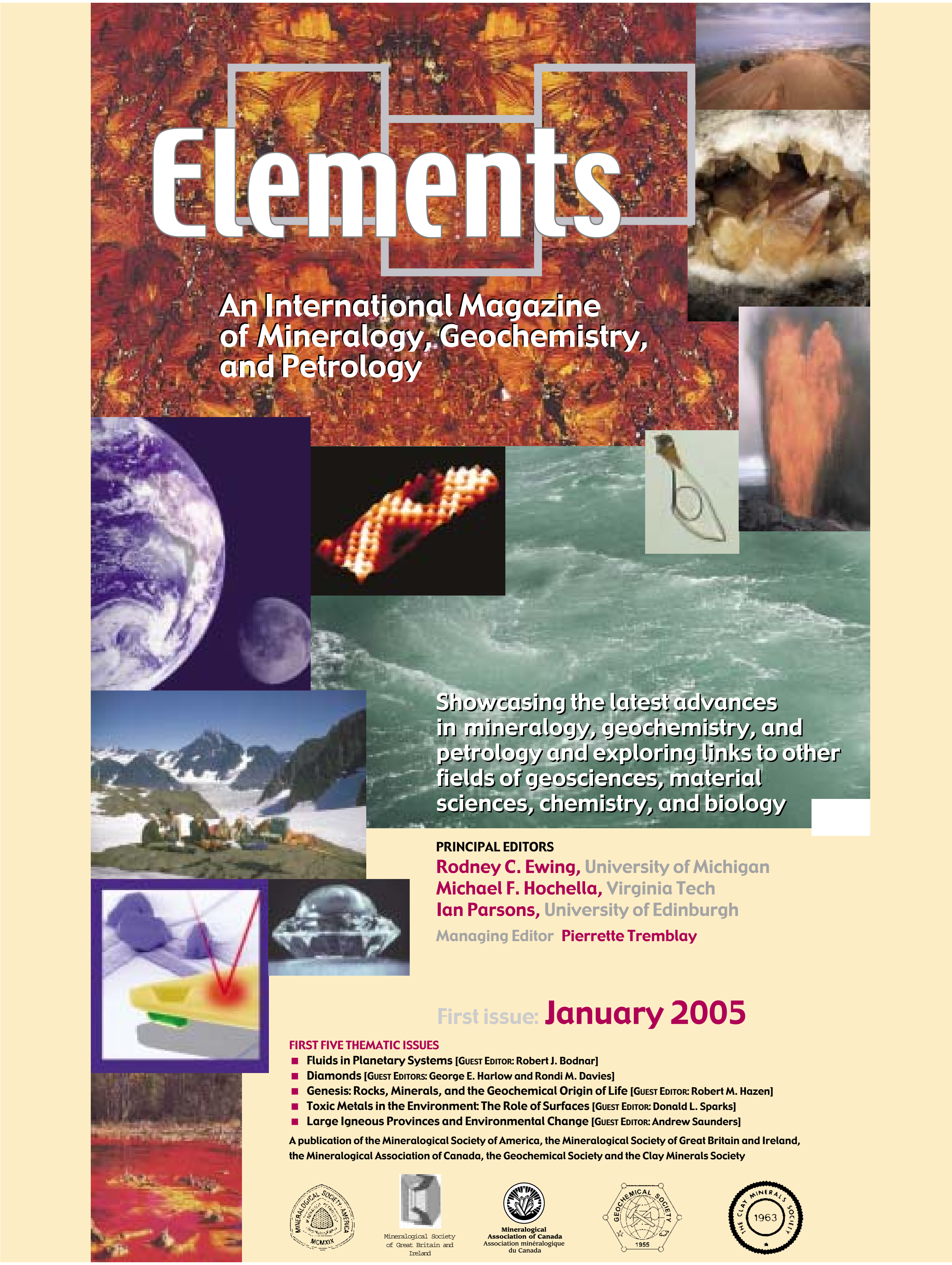
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