The Need for Sustainable Remediation

Use of Organic Amendments

Mineral-Based Amendments

Assisted Phytoextraction

Bioremediation

Nanoparticles for Remediation
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Sustainable Soil Remediation

Guest Editor: Mark E. Hodson

Volume 6, Number 6 • December 2010

The Need for Sustainable Soil Remediation
Mark E. Hodson

Organic Amendments for Remediation: Putting Waste to Good Use
David L. Jones and John R. Healey

Mineral-Based Amendments for Remediation
Peggy A. O’Day and Dimitri Vlassopoulos

Assisted Phytoextraction: Helping Plants to Help Us
Filip M. G. Tack and Erik Meers

Bioremediation: Working with Bacteria
Blanca Antizar-Ladislao

Nanoparticles for Remediation: Solving Big Problems with Little Particles
Nicole C. Mueller and Bernd Nowack
WE’VE COME A LONG WAY

The theme of this issue makes me think back on the relationship between geochemistry and soil science and how it has evolved. When I started working on weathering processes and clay mineral formation back in the 1960s, there was remarkably little communication between geochemists and soil scientists. From a geochemist’s perspective, soil scientists (with a few very notable exceptions) were not interested in the same set of questions as us. They were concerned with nutrients and organic matter, whereas geochemists studied silicate mineralogy and major element chemistry. We had almost no attention to biology. Geochemistry, in this context, was an inorganic science. Furthermore, to geochemists, the terminology of soil classification, in the United States at least, seemed an impenetrable barrier. As an extreme example, I was involved in a PhD thesis in France many years ago on the subject of chemical weathering. A boundary was drawn at 60 cm depth below the ground surface. Below 60 cm was the proper domain of the geology department; above 60 cm was the realm of soil science/geography, and the student was not supposed to discuss or present data from it.

How things have changed in the last two decades! We have all become aware that this compartmentalization was a barrier to scientific understanding and that geochemists need to become involved with issues of environmental sustainability. The idea that we could put biology in a separate compartment and more or less ignore it now looks ridiculous. Much of the impetus for this change of attitude came from rising concerns about environmental issues. Concern over acid deposition (“acid rain”) in the 1980s and 1990s forced us to study, understand, and integrate all the processes that occur as rainwater passes through soil and into streams and lakes. Geochemists, soil scientists, geomorphologists, hydrologists, plant ecologists, microbiologists, environmental engineers, and numerical modelers came together to try to fit the pieces of the puzzle together. I say “try” because we still have a long way to go. Funding agencies (NSF in the United States and corresponding agencies in Europe) have recognized the need and, commendably, funded programs such as the Critical Zone Observatories (Elements, October 2007) to foster this integrated approach. The barriers between the disciplines are fading and we are all widening our horizons. In fact the concept of “disciplines” is fading: where does geochemistry end and microbiology begin?

This issue of Elements exemplifies some of the involvement of geochemistry and mineralogy in environmental issues of critical importance. Geochemistry and environmental chemistry have become intertwined over the years. Contaminant migration is strongly affected by adsorption on mineral surfaces. Our understanding of surfaces, adsorption processes, and contaminant migration on the field scale comes largely from the geochemical/environmental chemistry community, and geochemical codes such as MINTEQ and PHREEQC are the workhorses for modeling contaminant migration.

Another important topic is the adhesion of microbes to mineral surfaces: will microbes stay in place or be transported by infiltrating water? What electron acceptors and donors are present and how reactive are they? We need expertise in both mineralogy and microbiology. Geochemists and mineralogists have become deeply involved in environmental questions, and we should become more involved, particularly in projects that bring together the various disciplines involved in understanding Earth surface processes. The future habitability of our planet depends on understanding and managing its surface layers.

Tim Drever

* Tim Drever was the principal editor in charge of this issue.
THIS ISSUE

When it comes to soil remediation, sustainability makes a lot of sense. We cannot afford to condemn soils, as in the dig-and-dump approach, mentioned by guest editor Mark Hodson. We need to preserve this precious resource to feed the ever-increasing world population. The authors of this issue share with their readers the accomplishments and challenges of sustainable soil-remediation research. Many good ideas turn out to be challenging under the wide range of possible field conditions, and much research is still needed to bring these promising concepts to maturity. It is also abundantly clear that the ideal scenario would be to avoid polluting this resource in the first place, as there is a risk and a cost attached to any remediation scenario.

Six Years Old!

With this issue, Elements closes its sixth year of publication. In 2010, we published 38 thematic articles and 2 perspective articles, contributed by 64 coauthors from 13 countries. We have now covered 35 topics in the Earth sciences, and there seems to be no shortage of ideas for the future. Our lineup is complete till the middle of 2012. We have many proposals on hand, and we always welcome new ones. The next two pages offer a preview of the exciting topics we are going to cover next year. We work hard at selecting topics so that there is something for everyone in this mix of review and leading-edge science.

Thanks

We thank the guest editors (names in bold) and the authors of volume 6 who have made a special effort to bring their science to the non-specialist audience of Elements: Blanca Antizar-Ladislao, Håkon Austrheim, Wolfgang Bach, Costanza Bonadonna, Andreas Bott, Peter R. Buseck, James A. D. Connolly, Reid F. Cooper, Edward Derbyshire, Volker Dietze, Benjamin R. DiTrollio, Patricia M. Dove, Adam J. Durant, Niles Eldredge, Johann P. Engelbrecht, Guenter Engling, John M. Ferry, Gretchen L. Früh-Green, Santiago Gasso, Andras Gelencsér, Robert Gieré, Benjamin C. Gill, Vicki H. Grassian, Bernard Grobety, Robert M. Hazen, John R. Healey, Grant S. Henderson, Mark E. Hodson, Tim Holland, Claire J. Horwell, Bjørn Jamtveit, Timm John, David T. Johnston, David L. Jones, Penelope L. King, Namhey Lee, Timothy W. Lyons, Charles W. Mandeville, Timothy J. McCoy, Scott M. McLennan, Erick Meers, Nicole Métrich, Ron L. Miller, Frank J. Millero, Nicole C. Mueller, Daniel R. Neuville, Bernd Nowack, Peggy A. O’Day, Clive Oppenheimer, Giulio Ottonello, Dominic Papineau, Roger Powell, Andrew Putnis, Xavier Quérol, Pascal Richet, Surenda K. Saxena, Hendrik Schatz, Peter Stille, Henrik Svensen, Dimitri A. Sverjensky, Filip M. G. Tack, Alan B. Thompson, Dimitri Vlassopoulos, and Pierpaolo Zuddas. We also acknowledge the contribution of reviewers, copy editors, and proofreaders who toil in the background.


Pierrette Tremblay, Managing Editor
David Vaughan, Hap McSween,
and Tim Drever, Principal Editors

Back issues of Elements for the classroom

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of stellar evolution, planetary system formation, alteration in asteroidal and cometary interiors, and the accretion history of the Earth, including the origin of Earth’s volatile and organic material.

- A cosmochronological view of the Solar System
  Dante S. Lauretta
- Presolar history recorded in extraterrestrial materials
  Ann Nguyen (Johnson Space Center) and Scott Messenger (ESC/G Jacobs Technology)
- The asteroid–comet continuum: In search of lost primordiality
  Matthieu Gounelle (Museum National d’Histoire Naturelle, Paris)
- Organic chemistry of carbonaceous meteorites
  Zita Martins (Imperial College London)
- Stable isotope cosmochronology
  Douglas Rumble (Geophysical Laboratory), Ed Young (UCLA), Anat Shahar (Geophysical Laboratory), and Weifu Guo (Geophysical Laboratory)
- Chronometry of meteorites and the formation of Earth and Moon
  Thorsten Kleine (Westfälische Wilhelms-Universität Münster) and John F. Rudge (University of Cambridge)

**IRON IN EARTH SURFACE SYSTEMS**

Guest Editors: **Kevin G. Taylor** (Manchester Metropolitan University) and **Kurt O. Konhauser** (University of Alberta)

Iron is the fourth most abundant element at the Earth’s surface. As an essential nutrient and electron source/sink for the growth of microbial organisms, it is metabolically cycled between reduced and oxidized chemical forms. This flow of electrons is invariably tied to the reaction with other redox-sensitive elements, including oxygen, carbon, nitrogen, and sulfur. The end result of these interactions is that iron is intimately involved in the geochemistry, mineralogy, and petrology of modern aquatic systems and their associated sediments, particulates, and pore waters. In the geological past, vast iron sediments, the so-called banded iron formations, suggest that iron played an even greater role in marine geochemistry, and these deposits are now being used as proxies for understanding the chemical composition of the ancient oceans and atmosphere. This issue will explore not only the modern expression of iron cycling but also its record in Earth’s history.

**GLOabal waTER suSTAINABILITY**

Guest Editors: **Janet Hering** (Eawag), **Chen Zhu** (Indiana University), and **Eric H. Oelkers** (CNRS, Toulouse)

The term water resources refers to natural waters (vapor, liquid, or solid) that occur on the Earth and that are of potential use to humans. These resources include oceans, rivers, lakes, groundwater, and glaciers. The Earth has plenty of water, over $1.4 \times 10^9$ km$^3$. However, 97% of global water is saline seawater. Of the 3% that is freshwater, nearly 70% is locked in the polar icecaps and glaciers. The majority of nonglacier freshwater is groundwater (98%). Surface freshwater (rivers and lakes), which has historically served most human needs, constitutes only a small fraction of the Earth’s water resources.

Water interacts with minerals, soils, sediments, and rocks, and hence studies of Earth materials have a direct bearing on water resources. Studies of the acquisition, mobility, and fate of elements and isotopes in water provide valuable signals for tracking water cycles at regional and global scales and are essential for the development of remediation technologies for contaminated water.

- Societal needs for water and our dependence and influence on water
  Eric H. Oelkers, Janet Hering, and Chen Zhu
- Millennium Development Goals for water supply and sanitation: Geochemical aspects of water quality and treatment
  Richard Johnston, Michael Berg, Annette Johnson, Elizabeth Tilley, and Janet Hering (Eawag)
- Groundwater as a critical yet vulnerable resource
  Frank W. Schwartz and Motomu Ibaraki (Ohio State University)
- Hydrogeochemical processes and water resource management
  Chen Zhu and Frank W. Schwartz (Ohio State University)
- Water conservation, efficiency, and reuse
  Henry Vaux (University of California–Riverside)
TOURMALINE: FROM GEMSTONE TO GEOCHEMICAL INDICATOR

Guest Editors: Darrell J. Henry and Barbara L. Dutrow (Louisiana State University)

From the Vikings’ sunstone to a modern piezometric pressure sensor, tourmaline is an intriguing mineral with a new degree of significance. Tourmaline was considered by 18th century physicists as the key to a grand unification theory relating heat, electricity, and magnetism, but new studies define its role as an indicator of Earth’s processes. With its plethora of chemical constituents and its wide stability range, from near-surface conditions to the pressures and temperatures of the mantle, tourmaline has become a valuable mineral for understanding crustal evolution. Tourmaline encapsulates a single-mineral thermometer, a provenance indicator, a fluid-composition recorder, and a geochronometer. Although also prized as a gemstone, tourmaline is clearly more than meets the eye.

• **Tourmaline: Nature’s DVD**
  Darrell J. Henry and Barbara L. Dutrow

• **From polarity to piezometry:**
  Tourmaline crystallography and applications
  Frank C. Hawthorne (University of Manitoba) and Dona Dirlam (Gemological Institute of America)

• **No element left behind:**
  Tourmaline isotopes
  Horst Marschall (University of Bristol) and Shao-Yong Jiang (University of Nanjing)

• **Tourmaline as a guide to ore deposits**
  John Slack (U.S. Geological Survey) and Bob Trumbull (GFZ, Potsdam)

• **Tourmaline in sedimentary, igneous, and metamorphic systems**
  Darrell J. Henry, Vincent van Hinsberg (Oxford University), and Barbara L. Dutrow

• **Tourmaline as a gemstone**
  Federico Pezzotta (University of Milan) and Brendan Laurs (Gemological Institute of America)

Since the dawn of civilization, humankind has been extracting metals and minerals for the production of goods, energy, and building materials. These mining activities have created great wealth, but they have also produced colossal quantities of solid and liquid wastes, known collectively as “mine wastes.” Mine wastes represent the greatest proportion of waste produced by industrial activity. In fact, the quantity of solid mine wastes and the quantity of Earth materials moved by fundamental global geological processes are of the same order of magnitude—approximately several thousand million tons per year. Therefore, the large-scale production, secure disposal, and sustainable remediation of mine wastes represent problems of global significance. Over the past 10–15 years, novel geochemical, mineralogical, microbiological and toxicological techniques have led to a much better understanding of the character, weathering mechanisms, long-term stability, ecotoxicology, and remediation of mine wastes. This issue of *Elements* will bring readers up to date with these current findings and will highlight new frontiers for mine waste research.

• **History and significance of mine wastes**
  Karen Hudson-Edwards

• **Chemistry and mineralogy of metallic mine wastes**
  Heather Jamieson

• **Chemistry and mineralogy of coal and oil sands mine wastes**
  Kim Kasperski and Randy Mikula (Natural Resources Canada)

• **Acid mine drainage and other mine waste waters**
  Kirk Nordstrom (USGS)

• **Ecotoxicology of mine wastes**
  Geoff Plumlee (USGS)

• **Recycling, reuse, and rehabilitation of mine wastes**
  Bernd Lottermoser and Graeme Spiers (Laurentian University)

**Volume 7, Number 5 (October)**

TOURMALINE: FROM GEMSTONE

Organizing melt in the crust:

Crustal melting and the flow of mountains

When the continental crust melts

How does the crust get really hot?

Reconciling melting experiments with thermodynamic calculations

Melted rocks under the microscope:

Crustal melting and the flow of mountains

Microstructures and their interpretation

Organizing melt in the crust:

From granulite and migmatite to granite

• **When the continental crust melts**
  Edward W. Sawyer, Michael Brown, and Bernardo Cesare

• **How does the crust get really hot?**
  Christopher Clark (Curtin University), David Healy (University of Aberdeen), Simon Harby (Edinburgh University), and Ian Fitzsimons (Curtin University)

• **Reconciling melting experiments with thermodynamic calculations**
  Richard White (University of Mainz), Gary Stevens (University of Stellenbosch), and Tim Johnson (University of Mainz)

• **Melted rocks under the microscope:**
  Microstructures and their interpretation
  Marian Holness (University of Cambridge), Bernardo Cesare, and Edward W. Sawyer

• **Crustal melting and the flow of mountains**
  Rebecca Jamieson (Dalhousie University), M. Unsworth (University of Cambridge), Nigel Harris (Open University), Claudio Rosenberg (Free University of Berlin), and Karel Schulmann (Strasbourg University)

• **Organizing melt in the crust:**
  From granulite and migmatite to granite
  Michael Brown, Fawna Kothonen (Curtin University), and Christine Siddoway (Colorado College)

**Volume 7, Number 6 (December)**

MINE WASTES

Guest Editors: Karen Hudson-Edwards (Birbeck College, University of London), Heather E. Jamieson (Queen’s University), and Bernard Lottermoser (University of Tasmania)

Abandoned tailings pile in the city of Potosi in the Bolivian Andes

Since the dawn of civilization, humankind has been extracting metals and minerals for the production of goods, energy, and building materials. These mining activities have created great wealth, but they have also produced colossal quantities of solid and liquid wastes, known collectively as “mine wastes.” Mine wastes represent the greatest proportion of waste produced by industrial activity. In fact, the quantity of solid mine wastes and the quantity of Earth materials moved by fundamental global geological processes are of the same order of magnitude—approximately several thousand million tons per year. Therefore, the large-scale production, secure disposal, and sustainable remediation of mine wastes represent problems of global significance. Over the past 10–15 years, novel geochemical, mineralogical, microbiological and toxicological techniques have led to a much better understanding of the character, weathering mechanisms, long-term stability, ecotoxicology, and remediation of mine wastes. This issue of *Elements* will bring readers up to date with these current findings and will highlight new frontiers for mine waste research.

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  Bernd Lottermoser and Graeme Spiers (Laurentian University)
Vladimir Vernadsky was one of the giants of geochemistry. Considered the founder of the field of biogeochemistry and a true pioneer in “whole Earth” studies, he realized by 1945 that “Man under our very eyes is becoming a mighty and ever-growing geological force.” In the intervening 65 years, his “ever-growing force” has become a tidal wave. The global population has been increasing exponentially since the beginning of the industrial revolution, and as a result has increased by nearly a factor of three between 1945 and today (see figure). Current projections anticipate a population exceeding 9 billion by 2050. This explosive human population growth has been fueled by ancient hydrocarbons and has come with high costs. Most Earth scientists are concerned with the implications of the rapid accumulation of greenhouse gases in the atmosphere. The consequences include a climate state without polar ice, acidifying oceans, and increasingly variable water fluxes. The rate and extent of these and many other negative climate-related impacts, and how to mitigate them, have caused a vigorous discussion on climate change that is in the news on a nearly daily basis.

However, as a society we are much less aware of another major impact of this rapid increase in human population. Without seeking to minimize the significance of climate change, I point out that land-use impacts associated with the dramatic post–industrial revolution population increase currently exceed climate impacts at most scales. Prominent among these land-use issues is soil degradation, which is highly consequential for the obvious reason that we rely on soil to grow our food.

History teaches us that inattention to soil conservation can have disastrous consequences. One emblematic example of many that could be cited took place in the United States. Until the early 19th century, prairie grasses with deep root systems covered the central plains of the United States. These deeply rooted grasses held the soil in place and served as a water storage system that afforded drought resistance. In 1838, John Deere, a blacksmith, developed a plow that would cut through the dense prairie-grass roots, opening up the plains to extensive wheat farming. Wheat farming flourished, particularly during the late 1920s, aided by increased mechanization and a series of wetter than average years. But when an intense drought affected the region in the 1930s, billions of tons of topsoil blew away, creating the “dust bowl.” The exodus of population from the region was the largest migration in American history. By 1940, 2.5 million people had emigrated from the plains states. This dust bowl episode led to a focus on soil conservation practices and eventually to approaches such as no-till agriculture. Despite improvements brought about by conservative agricultural practices, soil erosion by water and wind on cropland in the United States was still over 1.7 billion tons per year in 2007.

Soil degradation can also occur via chemical processes, including salinization, which is the accumulation of salts in soil. Salinization occurs in irrigated arid and semi-arid regions where rainfall is insufficient to leach salts from the root zone. Many agricultural crops have limited tolerance for elevated soil salinity, rendering impacted soils unsuitable for farming. Salinization is currently a major concern in several regions of the world, including parts of western and southern Australia and the San Joaquin Valley in the western United States. Taken to its extreme, salinization has played a role in the fall of civilizations. Mesopotamia has been called the cradle of civilization. One of the earliest city states in this region, with a dense population, full-time bureaucracy, military, and economically stratified society, was Uruk.

Founded around 5000 BCE, it flourished until around the third millennium BCE. At about 2900 BCE, it may have been the largest city in the world. Uruk’s complex society was possible because of sedentary agriculture that produced an excess of food. Today the site of this former center of early civilization is a desolate desert landscape, the result in large part of irrigation practices and climatic conditions that led to salinization of the soils.

These historical examples illustrate how reduced soil fertility as a result of land-use practices has had deleterious impacts on regional-scale societies. However, the population explosion of the 20th century and beyond has made soil degradation a global problem with foreboding consequences. Humans are causing widespread physical degradation of soil by sealing, compaction, and erosion. One analysis describes the sealing of soil by buildings and roads in western Europe and compaction of soil in eastern Europe by Soviet-era intensive tillage as major concerns. However, it is the loss of soil fertility by soil erosion due in large part to conventional agricultural practices that is a problem of global consequence. Mainly as a result of agriculturally induced erosion, humans may now be an order of magnitude more important at moving sediment than the sum of all natural processes. An extensive compilation of soil formation and erosion rates documents that soil production by natural weathering processes and geologic erosion are approximately in equilibrium. In stark contrast, soil erosion by conventional agriculture is up to several orders of magnitude more rapid than these natural processes. By one estimate, between one-third and one-half of the ice-free Earth surface has already been transformed by human action. The United Nations–sponsored GLASOD (Global Assessment of Human Induced Soil Degradation) study estimated that about 15% of the Earth’s ice-free surface is afflicted by some form of land degradation. A more recent assessment using a different methodology likewise documents extensive land degradation. All these matters because we will require more land to feed our expanding population. The estimated areaal increase in cropland required to feed the increased population on the planet between now and 2050 is roughly the size of Brazil.

There is no doubt that the combined impacts of humanity on the planet justify Vernadsky’s prophetic characterization of our species as a mighty geologic force. In fact, I am sure that if he were alive today, he would endorse the suggestion that we have entered a new geologic era, the Anthropocene. But it is not enough just to understand the scope of civilization’s transformation of the planet. We should also heed the warning of one of America’s great conservationists, Aldo Leopold, who wrote in 1933, “The reaction of land to occupancy determines the nature and duration of civilization.”

Martin B. Goldhaber, USGS mgold@usgs.gov

Rajeshwar Dayal Tyagi, research professor at the INRS – Eau Terre Environnement Research Center, Québec City, Canada, is the recipient of a 2010 Global Honour Award for Applied Research from the International Water Association. The award recognizes his work on the bioconversion of wastewater and sewage sludge into high-value-added products. These prestigious awards are given every two years in recognition of projects from around the world that promote effective, sustainable approaches to water management. The Global Honour Award recognizes the importance of Prof. Tyagi’s research in developing environmentally friendly and cost-effective processes for treating wastewater, wastewater sludge, and residual biomass to produce enzymes, bioinsecticides, bioherbicides, biofungicides, bioinoculants, and bioplastics. Along with his research team, Prof. Tyagi has made significant advances in environmental biotechnology by creating valuable products from such waste materials, which are normally difficult and expensive to dispose of. Further, using this biomass as raw material can reduce the cost of producing increasingly sought-after biomaterials by 40–60%. Tyagi’s work was also recently honored by the American Academy of Environmental Engineers, who awarded him the University Research Grand Prize in May 2010.

The Royal Society of Canada (RSC) is the senior national body grouping distinguished Canadian scholars, artists and scientists. It consists of nearly 2000 Fellows—men and women who are selected by their peers for outstanding contributions in the natural and social sciences, arts, and humanities. Its primary objective is to promote learning and research in the arts and sciences.

Four Earth scientists were recognized at the Society’s Induction and Awards Ceremony on November 27, 2010.

RSC Bancroft Medal to Frank Hawthorne

Frank C. Hawthorne (Department of Geological Sciences, University of Manitoba) is the recipient of the Bancroft Medal, awarded every two years for publications, instruction and research in the Earth sciences that have conspicuously contributed to public understanding and appreciation of the subject. Frank Hawthorne has investigated some of the most fundamental problems in mineralogy and has made major contributions to our understanding of the factors affecting atomic arrangements in minerals. He is well known for his ability to synthesize knowledge and present the essentials in a clear and succinct fashion to the broader community.

Rodney C. Ewing is recognized as the world’s leading scientist on the geochemistry of uranium and the role of uranium in all aspects of nuclear power, from nuclear reactor processes to safe storage of radiogenic waste. With his intellectual capabilities and scientific expertise, he has made major and fundamental scientific advances in Earth and environmental sciences. He has tirelessly pursued geological solutions to the problem of nuclear waste disposal, almost single-handedly impressing on the materials science community and government agencies the importance of this approach. His work represents the most creative and sustained scientific initiative in this field since its inception.

Donald B. Dingwell is renowned for establishing the experimental investigation of melts and magma as a vital component of Earth sciences, with implications for Earth evolution, element enrichment, volcanic mitigation, and the physical chemistry of the liquid state.

Guy Narbonne is a paleontologist who is internationally recognized for his research on the origin and early evolution of animals. His descriptions of the biology, life strategies, ecology and history of Ediacaran biota have profoundly influenced our understanding of evolution during this critical period in Earth history.
Blanca Antizar-Ladislao is a lecturer in environmental engineering at the University of Edinburgh. She received her PhD from the Technion Institute of Technology (Israel), MSc and BSc from Coventry University (UK) and BEng from Universidad de Cantabria (Spain). She was a research associate at Imperial College London (UK), Marie Curie research fellow at the Universidad Católica Portuguesa (Portugal), Senior Ramon y Cajal researcher at the Universidad de Cantabria (Spain) and lecturer at University College London (UK). Much of her research has involved the integration and optimization of sustainable, environmental (bio-)remediation technologies in groundwater, soil, sediments and wastes. She is also interested in the assessment of the carbon and water footprints of current environmental technologies.

John R. Healey is a senior lecturer in forest ecology at Bangor University (UK) and co-director of the Centre for Integrated Research in the Rural Environment, jointly with Aberystwyth University. A major focus of his research is ecosystem restoration of forests, heathlands and grasslands. A major objective of his work is to improve environmental sustainability through increasing the efficiency of carbon sequestration, nutrient cycling and waste utilization, while enhancing other ecosystem services and biodiversity conservation.

Mark E. Hodson is a professor of environmental geochemistry and mineralogy at the University of Reading. He is also director of the University’s newly formed Soil Research Center. His current research interests cover three interrelated strands: mineral weathering, remediation of contaminated land, and earthworm ecology (particularly the secretion of calcite by earthworms and their evolution and tolerance mechanisms at metal-contaminated sites). He is a recipient of the Mineralogical Society’s Max Hey Medal and the European Association of Geochemistry’s Houtermans Medal. He is on the editorial boards of Environmental Pollution and Applied Geochemistry.

David L. Jones holds a Professorial Chair in Soil and Environmental Science at Bangor University (UK). He focuses his research on understanding below-ground processes, with a specific interest in nutrients and human pathogen behavior in soil-plant-microbial systems. Current applications of his work include the use of wastes for land restoration, implementation of strategies for controlling E. coli O157 in agricultural systems, carbon sequestration in grasslands and ways to improve nutrient-use efficiency in cropping systems. He has published more than 180 scientific journal articles and has advised government on their waste and climate change policies.

Erik Meers graduated with an MSc in biotechnology, followed by an MSc in environmental technology, both at Ghent University (Belgium). In 2005 he completed his PhD research in the field of phytoremediation. He has been active as a co-investigator in both academic and industrial research. Since 2009 he has been a visiting professor at Ghent University, while also being the technology development manager for the Belgian branch of a multinational renewable energy producer (Eneco). He has founded two technology-driven spin-offs (Innova Manure and Innova Energy) and has published over 50 peer-reviewed papers, 50 conference proceedings and 30 symposia contributions.

Nicole C. Mueller holds an MSc in environmental sciences from ETH Zürich and is currently working as a researcher in the Environmental Risk Assessment and Management Group at Empa (Switzerland). She is involved in the FP7 projects NanolImpactNet and ObservatoryNano and in 2008 published (with B. Nowack) the first exposure modeling of engineered nanoparticles in the environment.

Bernd Nowack is the leader of the Environmental Risk Assessment and Management group at Empa, the Swiss Federal Laboratories for Materials Testing and Research. He obtained an MSc and a PhD in environmental sciences from ETH Zürich. His general interest is the study of anthropogenic pollutants in the environment and their interactions with biota. His research combines the development of analytical techniques, laboratory investigations, field studies, and modeling. Current projects deal with engineered nanomaterials: qualitative risk assessment, quantitative exposure modeling, the release of nanomaterials from products, and the behavior and effects of such materials in the environment.

Peggy A. O’Day is a professor and founding faculty member at the University of California, Merced. She received her BS from the University of California, Davis, her MS from Cornell University, and her PhD from Stanford University. She was a faculty member of Arizona State University for nine years before joining UC Merced in 2003. Her research currently deals with field and laboratory studies of environmental contaminants and remediation, in particular arsenic and mercury, and the application of spectroscopic and microscopic methods to determine speciation, distribution, availability, and reactivity of metal and metalloid contaminants in natural systems.

Filip M. G. Tack is a professor in the biogeochemistry of trace elements at Ghent University, Belgium. He is director of the Laboratory of Analytical Chemistry and Applied Ecochemistry, and is currently chairman of the Centre of Environmental Sanitation, which coordinates studies related to the environment at Ghent University. His current research involves the study of the occurrence, chemical speciation and behavior of trace metals in riparian zones and dredged sediment disposal sites, treatment of waste water using plant-based systems, and management/remediation of widespread, moderate metal contamination using phytoremediation and phytostabilisation.

Dimitri Vlassopoulos is a senior associate with Anchor QEA, LLC, in Portland, Oregon, where he practices environmental and water resources consulting, specializing in the development of in situ remediation strategies for contaminated waters, soils, and sediment. His areas of interest include biogeochemical reactive transport modeling, applied isotope hydrology and geochemistry, and environmental forensics. He received a BS in geology from Concordia University, MS degrees from McGill University (geological sciences) and the California Institute of Technology (geochemistry), and a PhD in environmental sciences from the University of Virginia.
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Elbaite crystal, 4.6 cm tall from Nuristan, Afghanistan.

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