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EDITORIAL

# Mining and the environment

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Metal ores and coal are mined in large quantities: for non-ferrous metals alone, total global annual production amounts to approximately $50\times10^6$ t (50 Mt, Lottermoser 2010). Mining products are vital and indispensable to our modern society and contribute significantly to our wealth. Currently, the monetary value of global copper and gold production amounts to about €100,000 million/year for each of these metals. On the other hand, mining and the mineral processing steps associated with them generate huge amounts of wastes, some of which are chemically reactive. Whereas the annual production rates of metals or coal can be determined fairly well, appraising the amount of mining waste deposited in a country or continent is a very challenging task, and any estimates are necessarily rough. A country-by-country inventory for the European Union in 1999 assessed the quantity of stored waste rock—mainly overburden material—as 4,700 Mt and that of the processing wastes or tailings as 1,200 Mt (BRGM 2001). In the opinion of the authors of this study, the quantities reported represented lower limits to the actual quantities involved. The authors also noted that differences in the national regulations of the 13 EU member countries resulted in a degree of uncertainty in the data collected. Globally, material flows of mine waste by far exceed those of waste from non-mining industries and of municipal waste.

Heaps of waste rock covering land surfaces is estimated to require about 1 to 3 ha/Mt of solid waste. These piles may generate dust and discharge fine particles into surface waters, and they also deface the local landscape: open-pit mining operations, for instance, leave large cavities in the scenery. Leachates from overburden and gangue materials that do not contain a substantial amount of sulphidic minerals create seldom a chemical water quality problem. By contrast, deposits of processing wastes (tailings) often have a severe impact on all types of natural waters. The extraction of non-ferrous metals from sulphidic ores has been going on for a long time. Because such ores contain pyrite in notable concentrations, the tailings also contain pyrite, often in a finely milled form. Pyrite, and to a smaller extent additional other pyritic minerals, are oxidised when they come into contact with air. Together with percolating water, this produces a leachate containing sulphuric acid, known as acid mine drainage (AMD) or acid rock drainage. The acid produced by the oxidation of sulphidic minerals dissolves various other minerals that may contain heavy metals, arsenic and other hazardous elements. AMD, its acidity and the resulting elevated concentrations of noxious substances represent the key issue when assessing the risk to natural waters and soils posed by mine tailings. Coal deposits also contain pyritic minerals. Hence, the outflows from underground mines and open-pit lakes often turn acidic. Physically unstable tailing dams are at risk of bursting during heavy rainfall, potentially causing a disastrous mudflow. Such events attract widespread attention in the media, whereas the chronic impacts of AMD are hardly ever reported on.

The formation of AMD is a slow process that continues even after mining operations have ceased. Therefore, the outflows from abandoned mines and tailings—several thousands of orphaned sites exist in the EU—also need to be investigated. The monitoring data gained need to be assessed in relation to the risk that contamination poses to ecological and human health. Such results and monitoring data represent one starting point for remedial measures. Often, such measures are very costly, and a natural attenuation approach is sometimes the only feasible solution. The most important key point for remediation is understanding the biogeochemical behaviour of the constituents of the tailings both in general and under the specific climatic and hydrological conditions prevailing at a particular site.

Severe failures in tailing handling have resulted in environmental disasters such as the Ajka red mud spill in Hungary in 2010 (Mayes et al. 2011) and the Baia Mare and Baia Borse

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cyanide spills in Romania in 2000 (Baia Mare Task Force 2010). These disasters attracted much attention in the world media and alerted the scientific community to the environmental problems associated with mining operations.

For this special issue of Environmental Science and Pollution Research (ESPR), entitled "Mining and the Environment—Understanding Processes, Assessing Impacts and Developing Remediation", contributions were solicited from those who had made an oral or poster presentation at the symposium on "Mining and the Environment", held at the 4th EuCheMS Chemistry Congress in Prague on 28 August 2012. In addition, scientists working on the environmental impacts of mining, mainly from Europe, were invited to report on their most recent results.

This special issue contains a collection of 35 publications from research institutions in 22 countries. The authors discuss important problems, basic approaches and new remediation concepts relevant to the topic. This updated compilation of knowledge is addressed to the broader scientific community interested in environmental issues.

The articles in this special issue on Mining and the Environment are grouped into three sections as described below. For full article titles and authors. see the table of contents.

## Assessing effects and risks

- Seventeen publications assess the impact of mining operations and waste on different ecosystems based on measured environmental concentrations (monitoring data). Many articles originate from southwestern and eastern Europe and reflect the various states of knowledge concerning pollution conditions in countries with distinct recent economic and industrial histories.
- Three research articles present methodological approaches to evaluate the risks of mine waste pollution. Both specific approaches and holistic perspectives are presented.

## Understanding chemical and biological processes

- Six papers report on the progress that has been made in understanding the numerous chemical and biological processes occurring in mine waste. This knowledge provides a basis for fostering more environmentally compatible mining operations.

## Management and remediation

- Two reviews and four research articles deal generally with the topics of management and remediation, while three contributions discuss specific treatment procedures.

As touched upon by several authors in this special issue, the discussion on mining and the environment represents an introduction to the much broader and even more multidisciplinary topic of "Mining and Sustainability". Interested readers are referred to a relevant report published by the International Institute for Environment and Development (Burton 2012).

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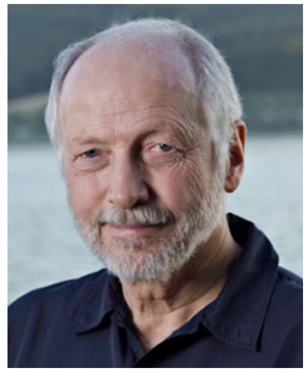

**Walter Giger** holds a PhD degree in Chemistry from ETH, the Swiss Federal Institute of Technology in Zurich. He is a Scientist Emeritus at Eawag, the Swiss Federal Institute of Aquatic Science and Technology, and a Professor Emeritus at ETH Zurich. He is an expert on organic contaminants in the aquatic environment and in the evaluation of chemical, physical and biological processes determining the environmental fate of chemicals. Between 1990 and 2007 Walter Giger was Associate Editor of the journal *Environmental Science and Technology* published by the American Chemical Society. Since 2009, Walter Giger is chairing the Division of Chemistry and the Environment of the European Association for Chemical and Molecular Sciences (EuCheMS) and he is Consulting Editor of the journal Environmental Science and Pollution Research. Walter Giger has been appointed as a Highly Cited Researcher in the field of Environmental Sciences. In 2008 the American Chemical Society named him a Legend of Environmental Chemistry and the journal Environmental Science and Technology honoured him with a tribute issue.