

## Studying the Effects of Acid Mine Drainage

New information from a study performed at the NSLS may one day help to mitigate the contamination caused by acid mine drainage, in which the breakdown of minerals in mines causes harmful materials to leach into waters and soils.

NSLS user scientists from Princeton University used infrared light and x-rays to study the interactions between two main components of acid mine drainage: two different positively charged iron ions, known as iron(II) and iron(III), and a negative sulfate ion (a sulfur-oxygen molecule). These substances are typically produced by the weathering of pyrite, a common mine ore.

"Acid mine drainage contaminates surface waters, groundwater, and soils in many locations around the world," said geoscientist Juraj Majzlan, the paper's lead author, now a faculty member at Albert-Ludwig-University of Freiburg (this work was performed when he was at Princeton).

"We studied how iron and sulfate interact in solution, such as how they combine to form various iron-sulfate compounds," he explained. "This is important, since the presence of iron-sulfate compounds affects the solubility of other harmful substances in water contaminated by acid mine drainage, such as trace metals and other ions, which contribute to its toxicity."

The work is published in the January 1, 2005 edition of *Environmental Science & Technology*.

Majzlan and Princeton geoscientist Satish C.B. Myneni, the paper's co-author, prepared two types of solutions, the first type containing sulfate and iron(II) and the second containing sulfate and iron(III). These solutions simulate the concentrations found in contaminated water. For each type, they prepared samples with varying concentrations of iron(II) and iron(III). They studied the solutions using infrared and x-ray "spectroscopy," a technique that measures how the light is absorbed by the solution. The absorption behavior of the solution provides scientists with structural and compositional information, such as the types of atomic clusters, known as complexes, that form within it.

Majzlan and Myneni focused on the sulfate ion, using it as an indicator. That is, they studied how the sulfate was altered in the presence of iron(II) or iron(III) and, based on any changes, inferred how it had interacted with the iron.

The researchers found that sulfate and iron(II) either interacted very weakly or did not form any complexes at all. However, they measured a significant distortion of the sulfate ion in the presence of iron(III). Upon further study, they determined that sulfate and iron(III) formed molecular complexes strongly bound together by hydrogen atoms.

This system serves as a model for acid-polluted waters. The sulfate-iron(III) complexes are small-scale versions of the mineral precipitates — solid materials that crystallize out of a liquid — that appear in acid-mine drainage. Based on the particular complexes that form in the sulfate-iron(III) solutions, the scientists can predict which precipitates are most likely to occur in acid mine drainage. One day, this information may assist in devising clean-up strategies for water contaminated by acid mine drainage.

This study was supported by the National Science Foundation and a Hess Fellowship from the Princeton University Geosciences Department.

For more information, see: J. Majzlan and S.C.B. Myneni, "Speciation of Iron and Sulfate in Acid Waters: Aqueous Clusters to Mineral Precipitates," *Environ. Sci. Technol.*, **39**(1), 188-194 (2005).

— Laura Mgrdichian



Juraj Majzlan



Satish Myneni



Examples of water contaminated by acid mine drainage.