

Biogenic evolution of microscale heterogeneity: Impact on contaminant dynamics

S. FENDORF, C. M. HANSEL, S. G. BENNER,
K. L. REVILL, P. S. NICO, AND B. C. BOSTICK

Dept. of Geological and Environmental Sciences, Stanford
University, Stanford, CA 94305 USA
(fendorf@stanford.edu)

Soils and sediments are complex assemblages of organic and inorganic material which are seldom at sustained equilibrium. Coupled biological, chemical, and physical factors dictate the evolutionary pathways of the system and result, generally, in (extreme) heterogeneity from macro- to micro-scale. Here we demonstrate the complexity that develops within simple systems composed of one reactive solid-phase and a single bacterial strain. Reductive dissolution of ferrihydrite by dissimilatory iron reducing bacteria under hydrodynamic conditions results in a complex mineral assemblage dominated by the production of goethite and magnetite—only minor quantities of green rust were noted. The principal bacterial role is in supplying an Fe(II) source: Fe(II) concentration is the dominant factor controlling the biomineralization pathway. At low Fe(II) concentration (less than 0.4 mM at pH 7), goethite is the dominant product, with magnetite being the major product at higher ferrous iron concentrations. Abiotic experiments confirm the role of Fe(II) in the mineralization process.

While similar minerals are produced in biologically active and inactive experiments, their distribution and crystal properties differ appreciably. Biogenic solids are constrained in morphology and crystal size, generally being mono-domainic and less than one-tenth the size of minerals formed under comparable abiotic conditions. Moreover, under biologically active conditions, both magnetite and goethite nucleate on ferrihydrite, leading to mixed-mineralogical assemblages. Further additives of the biological systems are exopolysaccharides (EPS) that coat and bridge minerals.

The fate of contaminants such as chromium and uranium will be impacted dramatically as a consequence of reductive biomineralization. Adsorption properties will be modified appreciably with the shift in mineralogy and the development of reactive ferrous iron bearing phases (solution, surface, and solid) will have important ramifications on reductive stabilization. For example, owing to the formation of dissolved, surface associated, and green rust bearing Fe(II), chromate reduction proceeds at a rapid rate and leads to the formation of a sparingly soluble phase. Uranium, in contrast, is controlled by competing processes, retention within magnetite zones and enzymatic reduction to U(IV).

Total Gaseous Mercury Exchange Between Air and Water Surface over Baihua Reservoir in Guiyang, China

XINBIN FENG, SHUNLIN TANG, LIHAI SHANG, HAIYU
YAN

State Key Laboratory of Environmental Geochemistry,
Institute of Geochemistry, Chinese Academy of Sciences,
Guiyang, China
(xinbin.feng@mail.gyig.ac.cn)

The exchanges of mercury between surface and air are of significance in the biogeochemical cycling of Hg in the environment, but there are still few reliable data on air/surface exchange in aquatic systems. Field measurement campaigns over lake water surface at Baihua reservoir in Guiyang, Southwestern China were conducted to measure mercury flux using a dynamic flux chamber technique coupled with automatic mercury vapor-phase analyzer from October 30 to November 4, 2001. The dynamic flux chamber is made of quartz glass, and has low blanks. Water samples were collected, and dissolved gaseous mercury (DGM), reactive and total mercury concentrations in water were measured using gold trap pre-concentration and AFS detection method. Meanwhile meteorological parameters, such as wind speed, wind direction, intensity of solar radiation, air and water temperature, and relative humidity, were monitored using a portable weather station.

Water surface is a net atmospheric mercury emission source even at cold season (autumn), and the average mercury emission rate is $3.0 \text{ ng m}^{-2} \text{ h}^{-1}$. It is shown that lake water is super-saturated in terms of dissolved gaseous mercury, which is the driving force of mercury emission from water to the air. The DGM, which is mainly in form of Hg^0 , could be formed in many processes in the water system. Demethylation, bacterial reduction from water and sediment, reduction by humic and fulvic acid in water, and photo-induced reduction in water are so far the possible processes suggested to be responsible for the formation of DGM in aquatic system. We observed a strong positive correlation between wind speed and mercury emission rate, suggesting that strong wind facilitate mercury evaporation process from the water system.