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# Bacterial and fungal transformations of minerals, metals and metalloids

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‘Geomicrobiology’ can be defined as the impact of microorganisms on geological processes, and includes weathering of rocks and minerals, transformations of metals and related substances, and biogeochemical cycling of these and other elements and nutrients. The weathering activities of microorganisms, both biophysical and biochemical, affect rock and mineral structure and composition, which in turn leads to alterations in the chemical speciation of metals and other rock and mineral components. Microorganisms are intimately involved in metal biogeochemistry whether arising from environmental sources or anthropogenic activities. The balance between metal mobilization and immobilization varies depending on the organisms and physico-chemical conditions. This presentation will outline some mechanisms of microbial metal transformations and their environmental and biotechnological significance with particular reference to metal precipitation mediated by sulfate-reducing bacteria (SRB) under anaerobic conditions, and chemoorganotrophic transformations mediated by free-living and mycorrhizal fungi. The importance of growth habit, e.g. biofilm growth, explorative filamentous mycelium, and applications in environmental biotechnology will also be highlighted.

In anaerobic habitats, sulfate-reducing bacteria (SRB) are key participants in biological metal cycling. While most interest has focussed on metal sulfide precipitation by mixed sulfate-reducing communities, SRB can also reduce metalloid oxyanions. We have found that SRB can mediate formation of elemental sulfur in the presence of selenite. Co-precipitation of S and Se appears to be a generalized ability of SRB, and the sulfur-selenium deposits formed nanometer-scale aggregates within the biofilm. We have also quantitatively determined SRB biofilm interactions with metabolic substrates and Cd. A mathematical model of bioprecipitation confirmed

that rates of sulfate reduction and flocculation were key variables in the biofilm system. In terrestrial environments, fungi contribute to the dissolution of mineral aggregates through excretion of $H^+$, organic acids and other ligands, or through redox transformations of mineral constituents. X-ray absorption spectroscopy has revealed that mobilized zinc, copper and lead were oxygen-coordinated within fungal biomass to carboxylate and phosphate ligands. Fungi also immobilize metals (and radionuclides including actinides like uranium) by sorption processes and biomineralization. Fungi play a role in the transformation of limestone minerals through the formation of “mycogenic” fabrics such as secondary calcite ($CaCO_3$) and whewellite/weddelite ($CaC_2O_4.H_2O$, $CaC_2O_4.2H_2O$): metabolism-dependent and -independent processes play integral roles. Main mechanisms of metal mobilization by free-living and mycorrhizal fungi are acidification and ligand-promoted dissolution. However, if oxalic acid was produced, metal oxalate minerals resulted. Such processes can occur in the root region of plants growing on toxic metal minerals.

This presentation will detail the above examples of metal-mineral transformations by microorganisms, emphasizing the multidisciplinary of the approach needed for understanding, and highlighting the significance of microorganisms as agents of geochemical change.