Subsurface colloids with relevance for trace element behavior in the Critical Zone

RUBEN KRETZSCHMAR[1]

[1]Soil Chemistry Group, Institute of Biogeochemistry and Pollutant Dynamics, CHN, ETH Zurich, Switzerland. E-Mail: kretzschmar@env.ethz.ch

The behavior of trace metals and radionuclides in the Critical Zone can be affected by the presence of mobile mineral and/or organic colloids, including nanoparticles. It is therefore important to understand the formation, mobility, transport, and stability of environmental colloids and nanoparticles in unsaturated and saturated porous media such as soils, saprolites, or sediments. Subsurface colloids formed under oxic conditions in soils mostly consist of submicron to nanometer-sized particles of oxides, clays, and natural organic matter, often forming mineral-organic complexes with distinct properties. Negative surface charge and coatings of organic matter can effectively stabilize mineral particles in the pore water, thereby enhancing their mobility with water percolating through the vadose zone. Colloid deposition on stationary surfaces are important mechanisms of particle immobilization. Almost three decades of research has improved our understanding of how these processes depend on flow rate, degree of water saturation, surface properties, solution chemistry, and other factors.

In recent years, we are investigating the formation of colloids in water-saturated soils under sulfate reducing conditions. We found that chalcophile trace metals, including Hg, Cu, Pb, Cd and Zn, can form metal sulfide nanoparticles in the pore water. These particles can either be freely dispersed or associated with bacterial cells [1]. For copper, formation of metallic Cu(0) nanoparticles on bacterial cell surfaces was observed, and the Cu(0) particles were shown to incorporate elemental Hg(0). However, Cu(0) is rapidly converted to Cu_xS upon onset of sulfate reduction. The physico-chemical properties and mobility of metal sulfide nanoparticles formed in natural subsurface porous media are to date not well understood and subject of our current research. This keynote will present an overview of our past and current research on subsurface colloids and their potential impact on trace metals.

[1] Hofacker, A.F., Voegelin, A., Kaegi, R., Weber, F.-A., and Kretzschmar, R. (2013): Temperature-dependent formation of metallic copper and metal sulfide nanoparticles during flooding of a contaminated soil. Geochim. Cosmochim. Acta 103, 316–332.