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EAG Eminent Speaker: Cold war biogeochemistry: Microbes as architects for metal attenuation

K. Küsel

Friedrich Schiller University Jena, Institute of Ecology, Jena, Germany (kirsten.kuesel@uni-jena.de, +49-(0)3641-949461)

Legacy uranium mining in the area of Ronneburg, Germany, has resulted in extensive outflow of highly heavy metal contaminated ground and upcoming mine waters. Mine water flows along a grassland into a small creek and forms iron-rich precipitates yielding rust-colored terraces at the creek bank. These iron oxyhydroxides could have been formed by iron oxidizing bacteria (FeOB) or by chemical oxidation. Precipitates may serve as important biogeochemical interfaces, because heavy metals can adsorb or co-precipitate with Fe(II) or Fe(III) minerals. Thus, microbial Fe(II) oxidation but also the reductive dissolution of iron oxides can be important processes affecting the stability of metal contaminants.

Here we present a study on the potential for iron cycling processes and on indigenous bacterial communities in this acidic creek. Oxic and anoxic in vitro sediment incubations revealed iron oxidation and reduction rates of same magnitude, indicating active iron cycling regardless of pH. XRD and TEM comparing the suspended particle load of water samples with fresh creek sediment showed that amorphous particles likely formed first, then aged to become more crystalline iron oxyhydroxides, such as akaganeite and goethite. During this aging process some of the initially smooth, 50-300 nm spherical particles may have formed nano-sized needles, which could potentially provide high reactive surface area for chemical and biological reactions. Surprisingly, total and dissolved metal concentrations in creek water and sediment revealed that elements such as Mn, Si, Ni, or Zn stayed mostly in solution. Only some metals such as Cu, Cr, and U seemed to be particle-associated in the water, likely co-precipitated with or adsorbed onto freshly-precipitating minerals.

Pelagic and particle-associated organisms from water as well as fresh sediments were used for 16S rRNA gene cloning and sequencing and showed that members of the Proteobacteria (mainly Betaproteobacteria and Deltaproteobacteria) dominated bacterial communities. The relative fraction of FeOB-related clones was especially high in upcoming underground water and sediment of the adjacent creek site. Up to 80% of clones in sediment microbial 16S rRNA gene clone libraries had $\geq$97% sequence similarity to reported FeOM or FeRM, demonstrating a strong link to function, even on RNA level. Three novel moderately acidophilic FeOM strains, Thiomonas sp. FB-Cd and FB-6 and Bordetella sp. FB-8, were isolated from pH 6.3 sediment. FB-6 is likely involved in in situ iron oxidation as it has high similarity to a RNA-derived clone from this sediment. Our results demonstrated active microbial iron cycling in heavy metal contaminated creeks, which have important implications for understanding natural attenuation.