

Sorption and Co-Precipitation of Oxyanions and Natural Organic Matter in Dynamic Systems: Impacts on Contaminant Removal and Ferric Hydroxide Morphology and Electronic Structure

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Environmental contamination associated with mining is often thought of as a legacy environmental issue, yet recent concerns over persistent contaminants highlight the truth, namely, what may have seemed like a legacy issue remains a potential emerging concern for the future. Indeed, metals may change their speciation, but cannot be destroyed. Metals are valuable economic resources, and demand is expected to grow in the foreseeable future. In aquatic systems, the fate of metal ions is often controlled by their reactions with soil minerals and organic matter. Thus, it is essential to have at our disposal models that can be used to predict the interactions of metal ions with these media. Surface complexation models have become a common tool for predicting metal ion fate and transport. However, in dynamic systems sorption/desorption processes are often entangled with geochemical cycling that impacts both redox and mineral phase solubility.

This talk will discuss ongoing work to experimentally determine the fate of ferric hydroxide (FHO) and co-occurring contaminants (i.e., anions, oxyanions, and natural organic matter (NOM)) and to model/predict the interactions between these contaminants within natural and engineered systems. FHO precipitates rapidly in dynamic geochemical systems forming small particles with high surface area, resulting in high adsorption capacities for heavy metals, oxyanions, and natural organic matter (NOM). This research leverages resonant x-ray scattering and x-ray absorption spectroscopy to investigate the structural and morphological properties and the electronic structure of FHO nanoparticles formed from different ferric salts (FeCl_3 , $\text{Fe}(\text{NO}_3)_3$, and $\text{Fe}_2(\text{SO}_4)_3$) and in the presence of oxyanions (arsenate, arsenite, chromate, and boric acid) and NOM. We show differences in the size and coordination environment of freshly precipitated FHO particles depending on the background electrolyte, oxyanions and NOM present and relate these to metal ion sorption properties. This study lays the groundwork for understanding the interactions between adsorption and precipitation in dynamic, complex waters such as those present in legacy mine sediment systems for which redox cycling plays a key role.