

Soil Interfaces in a Changing World

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New Analytical Approaches for Investigating Reaction Mechanisms at Carbon/Mineral and Metal(loid)/Mineral Interfaces

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Over the past few years a number of advanced analytical techniques, especially those involving synchrotron-based radiation, have provided environmental scientists important tools to investigate biogeochemical processes at mineral/microbe interfaces that involve nutrients such as C, N, and P as well as toxic metal(loids) such as As and Cr. Additionally, one can now measure in-real time, and at the molecular and atomic scales, the kinetics of meta(loid) transformations at mineral interfaces. Two applications of these techniques will be discussed in this presentation. Carbon near edge X-ray absorption fine structure (NEXAFS) spectroscopy and scanning transmission X-ray microscopy (STXM), complemented with Pyrolysis field ionization mass spectrometry (Py-FIMS), were employed to study the association of soil organic matter with minerals, particularly Fe-oxides along a landscape redox gradient. The association of organic matter (OM) with minerals has been increasingly recognized as a major process for protecting organic matter against microbial degradation in soils. Iron oxides are of particular importance given their abundance in soils and high reactive surface area. Iron is susceptible to redox variability along landscape gradients. Reductive dissolution of iron minerals governs the amount, form and transport of sequestered C, and thus terrestrial carbon cycling. Quick X-ray absorption spectroscopy (Q-XAS) was used to measure the rapid kinetics of As(III) and Cr(III) oxidation on manganese oxides. Manganese oxides are the most important oxidants of contaminants such as As and Cr in the soil environment. Yet the mechanisms for these reactions are poorly understood. The Q-XAS studies were augmented with macroscopic stirred-flow kinetic studies to provide a multi-scale assessment of the reaction mechanisms.

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