In-Situ Generation of Iron-Chromium Precipitates for Long Term Immobilization of Chromium at the Hanford Site

University-Led Research

E. Butler (PI) (ecbutler@ou.edu), L. Chen, L. Krumholz, A. Madden—*U. of Oklahoma*; C. Hansel—*Harvard U.*

In situ Cr immobilization involves either microbial or abiotic reduction of Cr(VI), followed by precipitation of the much more insoluble Cr(III), typically in the form of a Fe(III)-Cr(III) (Fe-Cr) precipitate when Fe minerals are present. Numerous geochemical variables can impact the solubility of such Fe-Cr precipitates, including the rates of Cr(VI) reduction and Fe-Cr precipitation, particle size, and the Fe:Cr ratio. Poorly crystalline minerals, typically formed upon rapid precipitation, tend to be more soluble than highly crystalline minerals that are precipitated more slowly. Reoxidation of Cr(III) to Cr(VI) by manganese (Mn) oxides is well known, with the reaction taking place between dissolved Cr(III) and the solid Mn(III/IV) oxide surface. This means that many factors that influence the solubility of Fe-Cr precipitates also likely influence the rate of Cr(III) oxidation by Mn oxides.

The overall objective of this research is to determine the factors that most strongly influence the solubility of Fe-Cr precipitates formed in microbial and abiotic systems. Specific objectives are to: (1) measure the rates of Cr(VI) reduction by Fe(II) minerals and microorganisms (in separate microcosms) and measure the equilibrium solubility of the resulting Fe-Cr precipitates; (2) characterize the size, crystal structure, and composition of selected Fe-Cr precipitates that vary in solubility; and (3) measure oxidation rates of dissolved Cr(III) in equilibrium with Fe-Cr precipitates by birnessite. Abiotic systems will contain FeS or dithionite-reduced iron-rich nontronite. Microbial systems will contain one of three pure cultures of Cr(VI)-reducing bacteria isolated from the Hanford site, along with small quantities of hematite, Al-substituted goethite, or iron-rich nontronite as a source of Fe. Work to date includes preliminary experiments with pure cultures of Cr(VI) reducing bacteria and preparation/purification of Fe(III) oxides and clay minerals.

We hope that this research will lead to a more systematic understanding of how specific methods for in situ Cr immobilization in the presence of Fe (e.g., microbial reduction in the presence of Fe(III) oxides or abiotic reduction by Fe(II) minerals) affect the structure and solubility of the resulting Fe-Cr precipitate, and, in turn, how these properties affect the rate of reoxidation of Fe-Cr precipitates to Cr(VI) by birnessite. This knowledge will lead to a better understanding of how to generate Fe-Cr precipitates in situ that will be oxidized to Cr(VI) to the smallest extent over long time periods.