COLLOID-FACILITATED TRANSPORT OF RADIONUCLIDES
THROUGH THE VADOSE ZONE

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1 Project Abstract

Radioactive and hazardous wastes stored in the underground tanks at the Hanford site have leaked into the vadose zone. Many of these waste streams were highly caustic. Waste sediment interaction has resulted in a wide array of dissolution and precipitation reactions, resulting in secondary solids that have sorbed or coprecipitated with contaminants. Characterization activities in the tank farms have clearly shown that the waste plumes are being driven to depth in the vadose zone by the infiltration of low-ionic strength meteoric waters and the leakage of dilute Columbia River water from ubiquitous process-water supply lines. This scenario of concentrated, reactive waste, followed by low ionic strength water, encourages colloid mobilization. Other, less electrolyte-concentrated waste streams, like cribs and French drains, are also conducive to \textit{in situ} colloid mobilization, when meteoric water dilutes and displaces the waste plumes. The goal of this project is to elucidate the role, and quantify the relevance, of colloids in facilitating the transport of contaminants in the Hanford vadose zone. We will focus on (1) thermodynamic stability and mobility of colloids formed by reactions of sediments with highly alkaline tank waste solutions, (2) colloid-contaminant interactions, and (3) \textit{in situ} colloid mobilization and colloid-facilitated contaminant transport occurring in both contaminated and uncontaminated Hanford sediments. As contaminants to study colloid-facilitated transport, we have selected Cs, Eu, and Am. We will consider two different types of colloids that can potentially facilitate the movement of radionuclides: newly-formed colloidal materials due to reactions of tank waste with subsurface sediments, and native colloidal material present in the sediments. The newly-formed colloidal phases, identified as zeolites and feldspathoids, may not be stable when geochemical conditions change at which they were formed. We will determine the thermodynamic stability of the zeolites and feldspathoids under conditions representative for the Hanford subsurface. The interactions of Cs, Eu, and Am with newly-formed and native colloidal particles isolated from the sediments will be investigated with batch sorption and spectroscopic techniques. In column tests using representative sediment samples from the Hanford site, we will examine the potential for \textit{in situ} mobilization of colloids. Waste plume displacement by typical meteoric and pore water will be simulated in packed columns as well as in undisturbed soil monoliths. Experiments will be carried out under variably saturated, steady-state and transient water flow to study the effect of water content and flow-interruptions on colloid mobilization and transport. We will use X-ray tomography and NMR to visualize colloidal movement in the porous media. We will also study colloid mobilization from selected contaminated sediment samples from the Hanford site. Thermodynamic stability, sorption, and column studies will be analyzed with a two-phase reactive transport model in which relevant processes for colloid-facilitated transport of radionuclides will be incorporated. The results of the proposed research will lead to a better understanding of colloid-formation, colloid-contaminant-soil interactions, colloid migration, and colloid-facilitated transport in the vadose zone. The experiments proposed here use conditions specific to various waste streams at the Hanford site, and the results are therefore directly applicable to clean-up strategies and procedures for Hanford contamination problems. We will provide conclusive evidence under what conditions colloid-facilitated transport can be expected at the Hanford site, and what the quantitative magnitude of this transport process will be.