Multiscale Investigations on the Rates and Mechanisms of Targeted Immobilization and Natural Attenuation of Radionuclides and Co-Contaminants in the Subsurface

Session: Oak Ridge IFRC (Principal Investigator: Scott Brooks)

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The Oak Ridge Integrated Field Research Challenge (ORIFRC) project comprises an integrated multi-disciplinary, multi-institutional research program whose goal is to provide an improved scientific understanding and predictive capability of subsurface contaminant fate and transport through experiments and observations at scales ranging from the molecular to the watershed. The influence of coupled processes on U, Tc, and co-contaminant NO_3^- fate and transport are being quantified along numerous contaminant pathways using subsurface manipulations and the assessment of natural attenuation processes throughout the watershed. These investigations are being integrated with multi-scale numerical simulations to address several coupled processes and assess their impact on contaminant transport. The research is identifying and quantifying key reactions, previously not addressed, that control contaminant fate and transport. The research approach is designed to enable the understanding gained and models developed to be broadly applicable to individual DOE sites.

The overall goal of the project is to advance the understanding and predictive capability of coupled hydrological, geochemical, and microbiological processes that control the in situ transport, remediation and natural attenuation of metals, radionuclides, and co-contaminants at multiple scales ranging from the molecular to the watershed. The specific objectives of this research are to: (i) quantify recharge pathways and other hydraulic drivers for groundwater flow and dilution of contaminants along flow pathways and determine how they change temporally and spatially during episodic events, seasonally, and long term; (ii) determine the rates and mechanisms of coupled hydrological, geochemical, and microbiological processes that control the natural attenuation of contaminants in highly diverse subsurface environments; (iii) explore novel strategies for enhancing the subsurface stability of immobilized metals and radionuclides; (iv) understand the long-term impacts of geochemical and hydrologic heterogeneity on the remobilization of immobilized radionuclides; and (v) improve our ability to predict the long-term effectiveness of remedial activities and natural attenuation processes that control subsurface contaminant behavior.

Significant progress towards our original project objectives has been achieved in the past five years and recent results are highlighted in the associated ORIFRC posters. Concurrently, new observations have raised new questions regarding the hydrogeological constraints on biogeochemical contaminant and nutrient transformations in coupled groundwater-surface water systems. These observations present new research challenges for

the future that are summarized in operating hypotheses addressing (i) the structure of the subsurface flow network including shallow lateral storm flow and deeper flow paths, (ii) material property controls on the biogeochemical reaction path(s) followed along a flow path, (iii) controls on the concentration, speciation and reactions across the groundwater-surface water interface, (iv) dynamic mixing of distinct water sources and process kinetics, (v) disequilibrium and system response caused by external forcings that alter flow networks.