Role of Microenvironments and Transition Zones in Reactive Subsurface Biogeochemistry: The PNNL SFA

PNNL SFA (Principal Investigators: John Zachara & Jim Fredrickson)

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The PNNL Scientific Focus Area (SFA) is investigating fundamental, Hanford-inspired subsurface science issues through integrated, multi-disciplinary research on the role of microenvironments and transition zones in biogeochemical reactive transport processes. The long-term goals of the SFA are to: i.) develop an integrated conceptual model for microbial ecology and its influence on biogeochemical processes in a complex and hydrologically dynamic subsurface water system; ii.) determine scale transitions of coupled processes from the laboratory to field, causes for scale dependency, and up-scaled parameters for process models; and iii.) advance understanding of field-important electron transfer processes at the molecular and microscopic scale to yield improved process models and their coupling.

Cohesiveness and integration are achieved through focus on vertical redox transition and horizontal groundwater-surface water interaction zones in the field. The Hanford 300A site offers extensive biogeochemical research opportunities as it contains: a dramatic redox interface, a fluctuating water table, a spatially dynamic zone of groundwater-river mixing within the aquifer, and a hyporheic zone where groundwaters discharge to surface water. Findings and concepts from 300A research drive cross-scale SFA investigations that include: field-scale investigation of biogeochemical processes and microbial ecology; laboratory investigations of coupled process interactions at the pore and macroscopic scale; and mechanistic studies of impactful biogeochemical processes.

Future research will emphasize biogeochemical cycling and reaction rate measurements across 300A vertical and horizontal subsurface transition zones, identifying sources of electron donor and their fluxes in different field system compartments, ecological processes controlling microbial community composition and biogeochemical function, and laboratory investigations of key underlying macroscopic and molecular biogeochemical processes. A stochastic multi-scale modeling approach will be implemented that integrates field and smaller scale measurements to understand and predict the behavior of the complex 300 A field system.