Hydrogeophysical quantification of plume-scale flow architecture and recharge processes

S.S. HUBBARD[1], D. WATSON[2], G.S. BAKER[3], J. CHEN[1], M. KOWALSKY[1], E. GASPERIKOVA[1], D.B. GAINES[3], M. SMITH[3] AND S. BROOKS[2]

[1]Lawrence Berkeley National Laboratory, (sshubbard@lbl.gov)
[2]Oak Ridge National Laboratory
[3]University of Tennessee

The impact of large episodic, seasonal, and annual recharge on remediation and natural attenuation of subsurface contaminants is not well understood and could represent a significant factor, especially at humid DOE sites. We explore this topic at the ORNL IFRC, where recharge adjacent to the source (S-3 ponds) and along the length of the groundwater plume is hypothesized to be the main hydraulic driver for groundwater flow and dilution of contaminants along the pathway. Analysis of wellbore datasets near the source region and at the distal end of the plume suggests that many processes may contribute to the system response as low ionic strength and neutral pH rainwater interacts with the acidic, high ionic strength contaminated groundwaters near the S-3 source region. These geochemical processes occur within a multi-scale hydrological template, which includes perched water bodies, matrix diffusion, and fast-path preferential pathways. Our efforts to date have focused on extensive hydrogeochemical and geophysical data acquisition and on the development of joint inversion and coupled modeling approaches. Our overall objective is to use these datasets and inversion approaches to quantify system responses to recharge and the associated implications for natural attenuation.

We present and test several approaches for integrating multi-scale, hydrogeological, geochemical, and geophysical ORNL datasets to quantify major flowpaths and recharge-induced responses in the ORNL subsurface, including (1) a Bayesian procedure that permits the joint inversion of surface seismic refraction and wellbore data in the quantification of aquifer architecture, (2) a coupled hydrogeochemical-geophysical numerical modeling approach to explore the sensitivity of time-lapse electrical tomographic (ERT) methods for elucidating recharge-related processes, such as changes in moisture or nitrate concentration due to rainfall, and (3) time-lapse surface seismic refraction datasets for monitoring rainfall-induced vadose zone processes.

Bentonite nanoparticle mediated radionuclide migration under simulated glacial melt-water intrusion in fractured rocks

F. HUBER[1]*, F. ENZMANN[2] AND T. SCHÄFER[1,3]

[1]KIT, Institute for Nuclear Waste Disposal (INE), P.O. Box 3640, 76021 Karlsruhe, Germany (*correspondence: Florian.Huber@kit.edu, thorsten.schaefer@kit.edu
[2]University of Mainz, Institute for Geosciences, 55099 Mainz, Germany (enzmann@uni-mainz.de)
[3]Institute of Geological Sciences, Department of Earth Sciences, Freie Universität Berlin, Berlin, Germany

One of the reference scenarios in the Swedish safety case is the possible occurrence of dilute groundwaters during glaciation down to repository depth potentially causing erosion of the bentonite buffer and backfill [1]. To investigate the consequences of such a hydro-geochemical disturbance to the far-field environment and the potential impact on the long term safety of the deep geological repository, a detailed laboratory program was started. Migration studies on bentonite colloid/nanoparticle (size distribution ranging from 100-150nm) and radionuclide mobility in a natural fracture under variation of the residence time (flow velocity) are conducted. In parallel, computational fluid dynamic (CFD) simulations of the column experiments implementing computer tomography (CT) data in order to obtain a most realistic 3D geometry of the natural fracture have been realized. Five models have been generated with increasing geometrical complexity on basis of the CT dataset. All models have been used to simulate the conservative tracer (HTO) transport experiments to investigate the influence of fracture geometry on the flow and transport behavior. Modeling results disregarding matrix diffusion indicate that the fracture geometry alone causes the observed pronounced tailing. The results of the migration experiments show bentonite nanoparticle immobility and a low recovery (< 5%) of associated radionuclides (Am (III), Pu (IV) and Th (IV)) under geochemical conditions expected to favor bentonite stability. Np (V) and Tc (VII) show a partly retarded breakthrough with Np recoveries of 72-76% and Tc recoveries ~79-100%. In the Np case thermodynamic calculations indicate the stability of Np (IV) under the established geochemical conditions. The unexpected low nanoparticle recovery is discussed with respect to the critical coagulation concentration (Ca-CCC ~1mmol/L) found.

[1] SKB (2006) Technical report TR-06-09, Svensk Kärnbränslehantering AB, Stockholm, Sweden.