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**Characterizing Hydrogeological Properties
and
Monitoring Biogeochemical Processes
Using Geophysical Data**

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Successful remediation techniques often require the co-occurrence of contaminants, remediation amendments, and favorable hydrological, geochemical, and microbiological conditions. Due to natural heterogeneity, characterizing initial conditions and monitoring remediation processes using conventional borehole analysis techniques is extremely challenging. By combining spatially extensive (but indirect) geophysical measurements with sparse (yet direct) wellbore measurements, studies have illustrated the value of using geophysical approaches to characterize hydrogeological and geochemical heterogeneity needed to guide the design of or assess the results from remediation experiments. We have recently built upon this research to explore the feasibility of using time-lapse geophysical methods to monitor remediation processes in the presence of heterogeneity.

Here, we present the results of coupled laboratory and field-based geophysical studies that we have performed in conjunction with biostimulation experiments conducted at four different DOE sites. At the DOE Bacterial transport site in Oyster, VA, crosshole seismic and radar datasets were used to provide high resolution estimates of hydraulic conductivity (Hubbard et al., 2001) and sediment geochemistry (Chen et al., 2004). These data were used to parameterize a numerical model, which was then used to simulate Uranium loading and remediation via biostimulation (Scheibe et al., 2006). The study illustrated the impact of local-scale heterogeneity on contaminant distribution and remediation.

At the Uranium-contaminated DOE Field Research Center, located at the Oak Ridge National Laboratory, a joint inversion approach was developed that permitted the use of seismic tomographic data for estimating fracture distribution (Chen et al., 2006). These datasets were in turn used to understand the results of tracer and biostimulation experiments conducted at the site. At the Cr(VI)-contaminated 100H Site at the DOE Hanford Reservation in Washington, time-lapse seismic and radar tomographic methods were used to image the distribution of a slow release polylactate and to monitor the distribution of the amendment and changes in geochemical phase and pore fluid composition associated with a biostimulation experiment. This case study illustrates the value of using multiple types of geophysical datasets to investigate complex and dynamic systems. Finally, at the Uranium-contaminated Rifle UMTRA site in Colorado, surface- and borehole-based complex resistivity techniques were used to monitor changes in mineralogy associated with both iron and sulfate reduction processes that occurred in

response to biostimulation (Williams et al., 2005). This study illustrates the use of novel geophysical approaches to ascertain redox conditions necessary for sustained remediation.

Comparison of hydrogeophysical characterization and biogeophysical monitoring data at all four sites highlight the spatiotemporal complexity of subsurface responses to remedial manipulations and the control of heterogeneity on the transformations. These studies indicate that the wealth of information provided by geophysical methods hold for guiding remediation strategies and for assessing remediation performance. *This work was supported by the Office of Science, Office of Biological and Environmental Research, Environmental Remediation Science Division of the U.S. Department of Energy under Contract. No. DE-AC02-05H11231.*

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