Complex Electrical Resistivity for Monitoring DNAPL Contamination

Project ID: 70012

Stephen R. Brown, New England Research

David Lesmes and John Fourkas, Boston College

Research Objectives

Nearly all Department of Energy (DOE) facilities have landfills and buried waste areas. Of the various contaminants present at these sites, dense non-aqueous phase liquids (DNAPL) are particularly hard to locate and remove. There is an increasing need for external or non-invasive sensing techniques to locate DNAPL's in the subsurface and to track their spread and monitor their breakdown or removal by natural or engineered means.

Empirical studies suggest that distinct signatures of certain DNAPL pollutants can be identified by measuring the complex electrical resistivity of the contaminated soil. We propose to bring the field measurement of complex resistivity as a means of pollution characterization from the conceptual stage to practice. For this purpose we will document the detectability of clay-organic interactions with geophysical measurements in the laboratory, develop further understanding of the underlying physical and chemical mechanisms, and then apply these observations to develop field techniques to monitor the remediation of organic pollutants. This proposed work is driven by the following simple hypothesis: as organic compounds are removed (e.g., biodegraded or extracted through engineered remediation) the complex resistivity will change according to the new chemical make-up of the soil/groundwater system. Thus complex resistivity measurements can be used as an effective monitoring tool to indicate the progress of remediation activities.

Research Progress and Implications

This report summarizes work after 5 months of a 3-year project. A primary task of this work is to determine the magnitude and robustness of the effects of organic solvent contamination on the complex resistivity properties of soils. Therefore, we must first develop a measurement technique and carefully document its capabilities and reliability. To date we have designed and built a laboratory system (sample holder, electrodes, electronics, and data analysis software) for the measurement of the complex electrical resistivity properties of soil contaminated with organic solvents for frequencies in the range 0.02-10,000 Hz. Using resistor and brine standards we have been performing measurement accuracy, repeatability, and noise immunity tests of this system. At the present time we can safely resolve complex resistivity phase angle changes of about a milliradian over the entire frequency range. We are now prepared to try to reproduce the 100 milliradian phase angle anomalies in toluene contaminated clays presented by Sadowski and Olhoeft. We have also been performing an extensive literature search of complex resistivity phenomenon in soil systems. We now have in hand a theoretical framework for the effect of soil microgeometry parameters on frequency dependent resistivity to which we can compare our new results.

Planned Activities

- **Remainder of FY 2000:** Design and build a portable, benchtop, field usable complex resistivity system for contaminated soils. Begin laboratory parameter studies on idealized systems. Perform complex resistivity laboratory studies of baseline soil samples and samples contaminated by various organic solvents.

- **FY 2001:** Assess feasibility of field measurements: noise studies including baseline field noise test and sand box experiments. Collect data at a small-scale field site.
- **FY 2002:** Modeling: Analysis of laboratory data to identify distinguishing characteristics of complex resistivity contaminant signatures and develop algorithms to identify them. Use commercial resistivity inversion and imaging software to create images of subsurface distribution of contaminants from small-scale field tests.

Information Access

None at this time.