Characterizing In Situ Redox Conditions by Electrochemical and Geophysical Methods

MIRANDA J. BRADLEY[1], EDMUNDO PLACENCIA-GOMEZ[2], JIM E. SZECSODY[2], PAUL G. TRATNYEK[1]*

[1]Oregon Health and Science University, 3181 SW Sam Jackson Park Rd, HRC3, Portland, OR 97239, USA (*correspondence: tratnyek@ohsu.edu)

[2] Pacific Northwest National Laboratory, P.O. Box 999, Richland, WA 99354, USA

The use of subsurface Permeable Reactive Barriers (PRBs), in situ chemical, or microbial reduction has proven effective for both organic and inorganic contaminants, but the useful life of the materials used may vary widely depending on site and contaminants present. The objective of this study is to characterize the relationships between ferrous iron surface phases, contaminant reactivity, and complex conductivity; changes in complex conductivity that can be measured by Electrochemical Impedance Spectroscopy (EIS) or the analogous Spectral Induced Polarization (SIP) geophysical technique can then be used to predict PRB longevity. To determine geochemical and geophysical effects of treatment with a reductant, sediments were exposed to sodium dithionite; a strong reductant with well-documented effectivity and relatively nontoxic reaction products.

Characterization of dithionite-treated and untreated sediment from the Umatilla basin in northcentral Oregon was performed using composite electrodes with an agarose binder. Samples were analyzed by EIS and modeled using an equivalent electrical circuit. Dithionite treatment resulted in changes in conductivity and capacitance; these effects were seen more clearly once the raw data was fit to a two-interface model. The interface between sample and electrolyte showed a marked decrease in charge transfer resistance and an increase in charge loading capacitance with dithionite treatment.

In addition to the Umatilla sediment samples, four iron oxide-coated model sands were characterized. Preliminary results show that the two-interface model can also be applied to the model sand system, and the effect on the solid interface impedance is quantified. These model sands have been added to a growing catalog of pure mineral samples that have been characterized by this method.

EIS characterization results were consistent to a great extent with measurements taken by SIP methods as expected. This moves us toward our goal of developing a fundamental understanding of the relationship between changes seen through EIS and/or SIP and changes in the redox properties of materials that control abiotic attenuation.