Assessing the potential of geophysical methods to detect subsurface changes in iron-mineral chemistry

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In this study the geophysical methods nuclear magnetic resonance (NMR), spectral induced polarization (SIP), and magnetic susceptibility (MS) were examined to determine the sensitivity of each method to monitor *in situ* iron redox processes within natural sediments. Laboratory column and field experiment were conducted using sediments and infrastructure from the Rifle Intergrated Field Research Challenge site (IFRC), located at a former uranium ore-processing facility in Rifle, Colorado. Although removed from the site by 1996, leachate from spent mill tailings has resulted in residual uranium contamination of both groundwater and sediments within the local aquifer.

Laboratory measurements were collected on columns packed with Rifle sediments and amended with acetate intended to stimulate microbial reduction. Laboratory results indicate limited change in NMR relaxation time values and a slight decrease in the MS values after amendment, suggesting that the magnetic mineral magnetite was not produced. SIP values increased within the amended columns corresponding to the expected formation of iron sulfide minerals.

Continuous borehole measurements were collected using the NMR Javelin logging tool developed by Vista Clara. Measurements were collected in previously amended sediments during spring runoff, at which time oxidation of the sediments was expected due to increases in dissolved oxygen. Following runoff, injection of acetate into aquifer sediments occurred designed to mimic the laboratory biostimulation experiment. The results from the field study indicate that borehole NMR measurements are capable of detecting changes in iron geochemistry as a result of the oxidation of previously amended sediments. However, the subsequent addition of acetate failed to alter the NMR signal suggesting exhaustion of the bioavailable iron pool.