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Characterization of Natural Attenuation in a uranium-contaminated site by means of Induced Polarization Imaging

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Field experiments at the U.S. Department of Energy's (DOE) Integrated Field Research Challenge site (IFRC) in Rifle, Colorado (USA) have repeatedly demonstrated the ability of microorganisms to reductively immobilize uranium (U) in U tailings-contaminated groundwater accompanying organic carbon amendment. At the same time, geophysical monitoring during such amendment experiments has proven that Induced Polarization (IP) datasets can provide valuable information regarding geochemical changes induced by stimulated microbial activity, such as precipitation of metallic minerals (e.g. FeS) and accumulation of reactive, electroactive ions (Fe[II]). Based on these findings, we present a novel, modified application of the IP imaging method. Specifically, we utilized an IP characterization approach to delineate areas where fluvially deposited organic material, within aquifer sediments, naturally stimulates the activity of subsurface microflora, leading to both the natural immobilization of uranium and accumulation of reduced end-products (minerals and pore fluids) capable of generating anomalous IP signatures. These so-called 'naturally reduced zones' (NRZ's) are characterized by elevated rates of microbial activity relative to sediments having a lower concentration of organic matter. As noted and based on our previous experiments at the site, the accumulation of metallic minerals represents suitable targets for the exploration with IP tomographic methods. Here, we explore the application of the IP imaging method for the characterization of NRZ's at the scale of the floodplain. We present imaging results obtained through the inversion of 70 independent lines distributed along the floodplain ($\sim$600 m^2). Imaging results are validated through comparisons with lithological data obtained from wells drilled at the site and laboratory analysis of sediment and groundwater samples. Our results show the applicability of the IP method for characterizing regions of the subsurface having a greater propensity for elevated rates of microbial activity, with such regions (themselves often highly localized within a larger sedimentary matrix) exerting an outsized control on contaminant (e.g. U) fate and transport.