Poster #22-16

Influx of Oxidants into Reduced Zones: Microbiological Controls Governing Metal Oxidation and Reduction

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BER Program: SBR
Project: University Award

Subsurface sediments are heterogeneous due to burial of soil horizons and organic matter. The high concentration of sediment-associated organic matter generates zones that are “biogeochemical hotspots”. These organic-rich deposits are recognized to drive metal/radionuclide reduction and trap reduced chemical species (i.e. (Fe(II)) including contaminants such as uranium (U(IV)). Thus reduced regions play a significant role trapping contaminants preventing mobility in groundwater. The existing paradigm describes oxidation of reduced metals/radionuclides upon the influx of dissolved oxygen and/or nitrate into reduced zones. However in contrast to the existing paradigm results from prior field and laboratory results demonstrated that low concentrations of oxidants directly injected into a reduced aquifer sediments stimulated reduced conditions and a decrease in groundwater uranium concentrations. We hypothesize that the influx of low oxidant concentrations into reduced zones results in the production of dissolved organic carbon (DOC) as a result of organic carbon decomposition and/or stimulation of microbial/viral activity. Whereby, the production of DOC drives reducing conditions leading to further metal/radionuclide reduction (U immobilization). However, elevated concentrations of oxidants above a “tipping point” will drive net metal/radionuclide oxidation, resulting in an increase in aqueous U concentrations. Here a series of bioreactor based experiments amended with naturally reduced organic-rich sediment from Riverton, WY are amended with U. Experiments are ongoing to monitor carbon, iron, and uranium geochemistry as well as the microbial community. This research will identify and describe the phenomena related to oxidation and reduction of metals/radionuclides in reduced regions of aquifers upon the influx of oxidants such as dissolved oxygen and/or nitrate.