Geostatistical Modeling of Physical and Geochemical Properties for Reactive Transport Modeling, Rifle IFRC

Rifle IFRC (Principal Investigator: Philip Long)

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A coordinated effort has provided initial 3D models of physical and reactive properties for Plot C at the Rifle IFRC. Lithofacies identifications were performed using geologic log data. A rotated grid was defined that is parallel to the main transport direction during biostimulation experiments. Geostatistical modeling of the lithofacies data has been used to generate 250 realizations of the lithofacies on that grid. The petrophysical model developed for Plot A has been used to generate initial grids of hydrologic and reactive properties that will be used for preliminary reactive transport modeling. Laboratory and field measurements have been performed at Plot C and will be used to update the petrophysical model. Preliminary assessment of particle size data from Plot C indicates a good correspondence between geologic log data and particle size distributions. Electromagnetic borehole flowmeter data have been collected in Plot C and calibrated using slug-test data to provide estimates of the absolute hydraulic conductivity. The distribution of EBF hydraulic conductivity within lithofacies indicates slightly higher hydraulic conductivity for the Sandy Gravel lithofacies relative to Muddy Gravel lithofacies. Additional particle size data is being generated to allow for broader comparison of particle size variation with geophysical log data and estimation of petrophysical properties.

We are also working on integrating geochemistry and mineralogy data into the geostatistical model, as well as metal loading data obtained in different sediments and size-fractions separated from them. We have been working with sediments from both oxidized and naturally reduced subsurface zones at La Quinta (Plot D) and Plot C experimental plots. A variety of wet chemical extractions and characterization techniques such as XRD, SEM/EDS, EMPA, μ-XRF, XANES, EXAFS and Mössbauer spectroscopy are being employed in size-fractions separated from the sediments. A series of extraction techniques confirmed the presence of significant amounts of aqueous U(VI), acid volatile sulfide (AVS), co-contaminants such as As, Zn, V, Cr, Cu and Se, and a remarkable assortment of potential host minerals (sorbents and/or electron donors), including Fe oxides (hematite, magnetite, Al-substituted goethite), siderite, reduced Fe(II) bearing clays, sulfides of different types, Zn sulfide framboids and multi-element sulfides. Multi-contaminant, micron size (ca. 5 to 30 μm) areas of mainly U(IV) and some U(VI), and other co-contaminants were present in some sediments, suggesting complex micron-scale (i.e., particle size dependent) system responses to transient redox conditions. We are currently studying phase distribution and contaminant loadings in different particle sizes separated from the sediments.

Collectively, the results improve our understanding of uranium in relationship to complex subsurface behavior caused by physical and mineralogical subsurface heterogeneities; help to unravel mineral-fluid interface complexity and dynamics by identifying key geochemical and hydrological reactions and processes controlling U and other co-contaminant behavior under a variety of conditions; and provide necessary information to develop robust geostatistical models to characterize the complex subsurface sediments and provide the input needed for reactive transport models.