Floodplain-scale hydrological, isotopic, geochemical, and geophysical states and fluxes at DOE's Rifle Integrated Field Research Challenge Site

Rifle IFRC (Principal Investigator: Philip Long)

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The objective of this research was compilation of a comprehensive inventory of geochemical and geophysical data providing insight into transport processes at DOE's Rifle Integrated Field Research Challenge (IFRC) site and its relation to surface water-groundwater interactions, aquifer heterogeneity, and uranium (U) plume dynamics. Over the past year and a half, we have assembled a spatially and temporally dense geochemical dataset (δD, $\delta^{18}O$, $\delta^{87}Sr$, $\delta^{34}S$-SO_4^{2-}, $^{234}U/^{238}U$, anions, cations, and inorganic/organic carbon) through bi-weekly to monthly sampling of Rifle groundwater and surface water bounding the site (e.g. springs, seeps, and Colorado River). We have interpreted this data within the context of floodplain scale surface and borehole geophysical measurements, including electromagnetic induction and magnetics data. Through data synthesis, we have developed a refined floodplain model that accounts for influx of U-bearing groundwater from off-site (i.e., non-tailings impacted) and the role that magnetic minerals may play in impeding natural flushing of U from the aquifer.

Analysis of groundwater and surface water samples from Dec-2010 to Mar-2012 for δD, $\delta^{18}O$, $\delta^{34}S$-SO_4^{2-}, U, and anion composition has been largely completed. Preliminary results suggest that recharge of the Rifle IFRC aquifer occurs primarily through influx of regional groundwater from the north, as evidenced by δD, $\delta^{18}O$, and $\delta^{34}S$ values shared between select surface water locations and Rifle groundwater. The isotopic composition of Colorado River water is distinct from most groundwater at the site, although seeps to the northeast of the site reflect infiltration from the City of Rifle's discharge lagoons, which receive treated drinking water sourced from the Colorado River. Geochemical data support a sharp water divide between this source term and regional groundwater infiltrating the majority of the Rifle site, with the latter containing naturally elevated levels of U (30-110ppb). Acquisition and processing of surface electromagnetic (EM) induction and magnetic data has been completed, with EM data suggestive of infiltration of spring/seep water from the north. Magnetic anomalies mapped using a surface gradiometer are corroborated by borehole magnetic susceptibility (MS) data, which reveal an elevated magnetic mineral volume fraction within the capillary fringe. Characterization of alluvial magnetite grains recovered during drilling operations reveals a close association of magnetite and U, with enrichment of up to 150mg/kg of magnetite.

Future research directions include (a) analysis of groundwater and surface water samples that continue to be collected, (b) identification of samples of interest for more-detailed analysis (e.g. $\delta^{87}Sr$, $^{234}U/^{238}U$), (c) acquisition of additional EM induction data at different time points, and (d) expansion of similar coupled geochemical-geophysical studies to the New Rifle former uranium mill tailings site in an effort to compare and contrast characteristics that control elemental fluxes within the two analogous – albeit spatially segregated – alluvial aquifers.