

Poster #202

Hydrologically Driven Process Coupling Between Biogeochemical Cycles and Solute Transport in Transiently Saturated Sediments at the Riverton Site (WY)

Kristin Boye¹, Vincent Noël¹, Chava Bobb², Emily L. Cardarelli², William L. Dam³, Raymond H. Johnson⁴, Ravi Kukkadapu⁵, Malak Tfaily⁵, Ljiljana Pasa-Tolic⁵, Scott Fendorf², Christopher A. Francis², Kate Maher² and John R. Bargar¹

¹ SLAC National Accelerator Laboratory

² Stanford University

³ Department of Energy Office of Legacy Management, Grand Junction, CO

⁴ Navarro Research and Engineering, Inc., Grand Junction, CO

⁵ Environmental Molecular Sciences Laboratory, Richland, WA

Contact: Kristen Boye [kboye@stanford.edu]

Water quality in shallow alluvial aquifers is strongly impacted by solute exchange with overlying capillary fringe sediments during seasonal and synoptic water table excursions. During the past three years, we have cored sediments at floodplain sites exhibiting persistent groundwater U plumes within the upper Colorado River Basin. Our examinations of the biogeochemical interactions between sediments and groundwater have indicated the importance of organic matter concentration and sediment texture for governing the retention of U in naturally reduced zones (NRZs) through microbially mediated reduction of U, Fe and sulfate, coupled to organic C oxidation and organic matter complexation. Importantly, our observations imply that the persistence or transiency of reducing conditions is a key regulator of U, Fe, S, and C chemical speciation and reactivity, and governs the partitioning of elements between immobile (solid) and mobile (soluble, colloidal) phases. These observations have focused our attention within the new SLAC SFA science plan on the coupling of hydrological conditions (saturation state and transport mechanisms/directions/rates) to biogeochemical cycles that govern contaminant and nutrient mobility in floodplains.

The U-impacted Riverton (WY) site serves as a model floodplain to investigate the impacts of hydrologically driven biogeochemical processes on groundwater chemistry and quality. Here, we have observed strong reversal in the vertical transport of U in response to spring flooding (downward transport and release to groundwater) and summer drought (evapotranspiration-driven upward transport and precipitation with evaporite minerals). Further, we have observed strong redox cycling of Fe, S, and U in sediments in response to saturation, resulting in U alternately partitioning into solution (oxidized conditions) and onto the solid phase (reducing conditions). Thus, a conceptual model emerges, where hydrologically-initiated biogeochemical redox transformations drive a seasonal cycle of U shuttling vertically with water movement and between different solid phase hosts (evaporite minerals, redox minerals, clays, and organics), pore water, and groundwater. The timing, thresholding conditions, and relative rates of processes are key pieces of information required to mechanistically link hydrological and biogeochemical processes in order to predict U mobility. Our future work at the Riverton site will examine the microbial community composition and activity, pore- and groundwater chemistry, sediment mineralogy, and organic matter composition at molecular to mm scales as a function of depth and time in relation to water saturation and transport mechanisms. Here, we will present preliminary results from exploratory investigations of these aspects within the capillary fringe and plans for future research at the Riverton floodplain.