SLAC SFA: Coupled Cycling of Organic Matter, Uranium, and Biogeochemical Critical Elements in Subsurface Systems

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The ability to predict subsurface transport and fate of redox-active radionuclides, contaminants, and biogeochemical critical elements ("BCEs", including C, N, S, and Fe) is hindered by a lack of knowledge of their speciation, reactivity, and biogeochemical pathways by which they are transformed. A growing body of evidence suggests that organic-rich sediments control the behavior of uranium and BCEs in contaminated floodplains at U.S. DOE legacy sites, particularly in the Western U.S. The stores of organic matter in these sediments fuel abundant microbial activity that converts organic carbon to CO_2 (via several intermediates) and transforms sulfate, iron, nitrate, and U(VI) to reduced species that drive further biogeochemical dynamics. Furthermore, in the presence of dissolved oxygen, microbial decomposition of organic nitrogen coupled to nitrification produces nitrate, a potent oxidant for U(IV) and other reduced species. The presence of NRZs and their attendant biogeochemical redox activity therefore are of intense interest for understanding and predicting radionuclide, metal, and BCE fate and transport.

The SLAC SFA is investigating biogeochemical redox processes that control subsurface uranium and BCE behavior in organic-rich fine-grained sediments common to river basins worldwide. We are using synchrotron, spectroscopic, microbial, stable isotope, electrochemical, and microscopy techniques, controlled laboratory experiments, and field sediments from multiple locations to obtain insights at a range of scales, from molecules and bacterial cells to river basins. Our project is providing process-level knowledge of globally significant BCE transformations, including natural organic matter, and uranium fate and transport in contaminated aquifers. These findings are helping to advance SRB modeling competencies at floodplain and regional scales.