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Unraveling contaminated subsurface complex and dynamic behavior: A scale-dependent perspective

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The uranium plumes present at the United States Department of Energy's (DOE) Hanford site (WA) and Rifle site (CO), have not attenuated as previously expected and predicted due, most likely, to subsurface complex behavior and multiple sources of contaminant uranium. At the Rifle site, both oxidized and naturally reduced zones are present in the subsurface. The naturally reduced zones usually contain high U concentrations, and are likely significant contributors to the groundwater contamination. We have conducted hypothesis driven research to generate the necessary scientific information needed to: 1. Understand and overcome the physical and mineralogical subsurface heterogeneities; 2. Unravel mineral – fluid interface complexity and dynamics by identifying and estimating the role of key geochemical and hydrological reactions and processes controlling contaminant uranium behavior under a variety of conditions; 3. Develop conceptual models and apply predictive models of contaminant behavior to support development, implementation and monitoring of effective and sustainable remediation approaches. In this talk, results from research efforts, such as wet chemical extractions of different types, as well as, batch and hydraulically saturated and unsaturated column experiments of different types, will be presented. These results were combined with those of a variety of techniques such as XRD, μ-XRD, SEM-EDS, SEM-FIB, TEM-SAED, Mössbauer spectroscopy, EMPA, μXRF and XANES. Collectively, these results provided information about the extent and rates of geochemical (sorption/desorption, dissolution/precipitation and redox) and hydrological reactions and processes which control and/or significantly affect the fate of uranium and other co-contaminants that are present in these contaminated subsurface media.