ABSTRACT: Geochemical, spectrographic, microbiological and hydrogeologic studies at the ORIFRC site indicate that groundwater transport in structured media may behave as a system of parallel flow tubes. These tubes are preferred flowpaths that enable contaminant transport parallel to bedding planes (strike) over distances of 1000s of meters. A significant flux of groundwater is focused within an interval defined by the interface between the competent bedrock and overlying highly-weathered saprolite, commonly referred to as the "transition zone." Characteristics of this transition zone are dense fractures and the relative absence of weathering products (e.g. clays) results in a significantly higher permeability compared to both the overlying clay-saprolite and underlying bedrock. Several stratabound low seismic velocity zones located below the transition zone were identified during geophysics studies and were also determined to be fractured high permeability preferred contaminant transport pathways during subsequent drilling activities. XANES analysis of precipitates collected from these deeper flow zones indicate 95% or more of the U deposited is U(VI). Linear combination fitting of the EXAFS data shows that precipitates are ~51±5% U(VI)-carbonate-like phase (e.g., liebigite) and ~49±5% U(VI) associated with an iron oxide phase; inclusion of a third component in the fit suggests that up to 15% of the U(VI) may be associated with a phosphate phase or OH` phase (e.g.,schoepite). Although precipitates with similar U(VI)-carbonate and/or phosphate associations were identified in the transition zone pathways, there were also U(VI) complexes adsorbed to mineral surfaces that would tend to be more readily mobilized. Groundwater in the different flow tubes has been determined to consist of different water quality types that vary with the solid phase encountered (e.g., clays, carbonates, clastics) as contaminants migrate along the flow paths. This lateral and vertical variability in geochemistry, particularly pH, has a significant impact on microbiological community composition and activity. Ribosomal RNA gene analyses coupled with physiological and genomic analyses suggest that bacteria from the genus *Rhodanobacter* (a diverse population of denitrifiers that are moderately acid tolerant) have a high relative abundance in the acidic source zone at the ORIFRC site. Watershed-scale analysis across different flow paths/tubes revealed strong negative correlation between pH and the absolute and relative abundance of *Rhodanobacter*. Recent studies also confirmed that the ORIFRC site hosts a diverse fungal community, with significant differences observed between acidic (pH <5) and circumneutral (>5) wells. The lack of nitrous oxide reduction capability in fungi, and the detection of denitrification potential in slurry microcosms suggest that fungi may have a heretofore underappreciated role in biogeochemical transformations, with implications for site remediation and greenhouse gas emissions. Further research is needed to determine if these organisms can influence U(VI) mobility either directly through immobilization or indirectly through the depletion of nitrate. In conclusion, additional studies are required to quantify the processes (e.g., solid phase reactions, recharge, diffusion, microbial interactions) that are occurring along the groundwater flow tubes identified at the ORIFRC so predictive models can be parameterized and used to assess long-term contaminant fate and transport and remedial options.