Model-based identification of physical and geochemical controls of uranium *in-situ* leaching

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Despite approximately 48% of the world's uranium production being derived from *in-situ* leaching operations in 2015, research underpinning the development of leaching processes has often focused on static hydrometallurgical and geochemical aspects of the recovery process while neglecting fluid flow and transport, or treating these physical processes separately. Here, a series of column experiments were used to examine uranium *in-situ* mobilization, transport and recovery under continuous-flow conditions and realistic sediment-to-solution ratios for acid and alkaline lixiviant systems. Uranium-containing sediments were collected from a deposit with well-defined stratified uranium mineralization layers, hosted within shallow unconsolidated sandstones. Uranium breakthrough occurred rapidly for acid and alkaline systems. Using the experimental data as constraints, process-based reactive transport models were developed to identify and quantify the physical and chemical controls for uranium recovery. The model simulations closely reproduced the temporal evolution of the experimental solution-composition and mineralogical transformations.

Based on the laboratory-scale results and information from downhole logs, a range of three-dimensional field-scale model scenarios were developed to predict and assess the impact of hydrogeological, geochemical and operational parameters on the overall uranium *in-situ* recovery efficiency. The modeling results illustrate that understanding the characteristics and reactivity of the gangue material plays an important role in predicting the recovery efficiency. Because of the complex interactions between the hydrogeological and geochemical/mineralogical heterogeneities, most uranium that will be recovered initially is predicted to be recovered from more permeable layers, whereas the leaching of less permeable layers with higher ore grades will be transport-limited.