



## **Reactive transport of radionuclides in fractured chalk aquifers: Implications for nuclear repository planning**

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As the world continues to produce power at nuclear facilities, a permanent solution for waste storage has not yet been determined. Deep geological repositories are currently being designed as a permanent disposal solution, but it is important to first determine the potential interactions between any leaked waste and the local lithology before any safety assessment of such a repository can be made. In such designs, bentonite backfill is intended to sorb any leaked radionuclides and prevent their release into the environment. However, when colloidal-sized particles of bentonite are eroded from the backfill, radionuclides sorbed to them have been shown to be transported at a rate equivalent to or even greater than dissolved species, which are subject to retardation through sorption and diffusion. The impact of colloidal presence on radionuclide transport is highly dependent on the surrounding geochemistry, including ionic strength, competing cation concentration and pH. Therefore, it is imperative to investigate the potential mobility of leaked radionuclides under local conditions.

This research investigates the mobility of various radionuclides and their chemical analogues under conditions that are representative of the northern Negev Desert, Israel, where a future geological repository is currently in the planning stages. The study employs a series of laboratory-scale experimental studies in order to predict the mobility of Cs, U(VI), Ce and Re through fractures in chalk, which have been shown to be the main conduits for water and its pollutants in the region. A tracer cocktail containing Re, U(VI), Cs and Ce and the fluorescent dye uranine was injected into a naturally-fractured chalk core in a background solution of filtered groundwater pumped from an observation well located in a local chalk aquifer. Breakthrough curves indicate that while Re, present as  $\text{ReO}_4^-$  (a chemical analogue for  $\text{TcO}_4^-$ ) acts as a conservative tracer similar to the uranine, all other metals behave differently according to their speciation. Cesium, which has in the past been shown to undergo marked colloid-facilitated transport, was nearly immobile due to sorption to minor minerals in the chalk, even in the presence of colloids. Uranium was unaffected by colloidal presence as well, but exhibited greater, albeit retarded, transport due to its complexation with Ca and  $\text{HCO}_3^-$  forming ternary  $\text{CaUO}_2(\text{CO}_3^-)^{2-}$  species. Cerium seemed most mobile in the absence of bentonite colloids through precipitation with  $\text{HCO}_3^-$  and transport as an intrinsic colloid; however, when bentonite colloids were present, the Ce mobility dropped significantly, and the recovery was decreased by an order of magnitude.

Collectively, these data are useful in helping to predict the potential mobility of various radionuclides relevant to nuclear disposal under conditions relevant to the creation of a geological repository in southern Israel.