

# Mobility of Uranium in Desert Sediments and Ground Water under Natural and Anthropogenic Influences, Tuba City, Arizona

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The occurrence and mobility of uranium are being studied in desert sediments and ground water near Tuba City, Arizona, in relation to a landfill with a ground-water plume containing uranium. Solids (dune sand, reworked dune sand, and sandstone bedrock) and ground water were analyzed to determine major element, metal, and uranium concentrations. High concentrations of salts (mainly sodium chloride, calcium carbonate, and sodium/calcium sulfate) consistently occur in caliche horizons in the unsaturated zone, along with slightly elevated uranium concentrations. Salt concentration zones are typical for desert soils in the arid southwestern United States and are thought to be caused by atmospheric deposition (including wind blown movement of sediments), reactions with local sediments, and concentration due to evaporation. These salts have generally not been associated with uranium in the past because the uranium concentrations are near the crustal abundance. However, the mobility of the elements in these salts (especially uranium) to the ground water under natural and anthropogenic influences is of great concern for people using this water for drinking.

The shallow ground-water geochemistry reflects the influence of these salt zones where much higher concentrations of sodium, calcium, chloride, sulfate, and uranium are found compared to the deeper ground water, which is dilute calcium-bicarbonate water. Dissolved uranium concentrations in the shallow ground waters generally range from 15 to 60 parts-per-billion (ppb) versus the deeper ground waters with less than 5 ppb. However, uranium concentrations in the landfill plume are as high as 250 ppb. We hypothesize that anthropogenic disturbances created conditions favorable for additional salt dissolution, with an associated release of uranium and other metals. During the Tuba City Landfill operations, unsaturated zone sediments and bedrock with high salt concentrations were deposited in waste trenches for use as cover material. This

potentially placed salt-bearing materials that had remained unsaturated for thousands of years into an area below the water table. Mobilization of uranium and other elements with distilled water and simulated landfill leachate has been confirmed through leaching of sediments and bedrock in the laboratory.

The mobility of uranium in the contaminant plume emanating from the Tuba City Landfill has very complex geochemistry. Uranium can be mobile under the oxidizing conditions in the surrounding ground water, but is expected to be less mobile in the core of an anoxic landfill plume. Laboratory sorption studies indicate that local sediments and bedrock, containing sand grains with iron-oxyhydroxide coatings, provide a strong sorptive control for uranium mobility, even under oxidizing conditions. Any sorbed uranium is a potential source of contamination which can be remobilized by changes in ground-water geochemistry. A conceptual reactive transport model will be presented as a way to understand the complex geochemical and hydrogeologic controls on uranium mobility in and around the Tuba City Landfill.