

Strontium and Cesium desorption from reacted Hanford sediments

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Flow-through column experiments were conducted with Hanford sediment to ascertain mechanisms that control the fate and mobility of contaminant Sr and Cs in the subsurface at Hanford (WA). Sediment was reacted with a high ionic strength, caustic synthetic tank waste leachate (STWL) solution containing 10^{-3} M Sr and Cs. Reactant STWL was flushed through the column until breakthrough, and then flow was stopped, allowing the solution to react for 1 day to 3 months. After reaction, columns were flushed with a simulated background pore water (BPW) solution and effluent Sr, Cs, and dissolved elements were measured for up to 200 pore volumes.

Strontium exhibits greater retention over Cs during contaminant uptake, with Cs showing breakthrough two times faster than Sr. During flush out with BPW, initial Cs release is rapid and reaches a steady state after ~5 pore volumes. Depending on stopped-flow reaction time, 5-15% of total sorbed Cs is eluted after 200 pore volumes. Strontium desorption is retarded until ~25 pore volumes for all reaction times. However, Sr exhibits more rapid desorption than Cs after the initial retardation and up to 55% total Sr (sorbed and native in sediment minerals) is eluted from the column after 200 pore volumes. A three-step sequential extraction of reacted column sediments showed 65% of Sr removed by an extraction targeting exchangeable ions (1.0 M MgCl₂) and 75% of Cs extracted by stronger extractants (acidic ammonium oxalate and aqua regia). Analyses of EXAFS spectra indicate that Sr in reacted sediments is present as native Sr in feldspars, as sorbed Sr, and as Sr associated with a neoformed feldspathoid or zeolite phase.

Current and prior work indicates that the fate of Sr and Cs are controlled by a combination of sorption/desorption and dissolution/precipitation processes operating at different rates, with different reactivities for each contaminant, during both uptake and release. Longer reaction and aging times create recalcitrant neoformed phases that sequester Sr and Cs, which are more resistant to desorption. In a field setting such as Hanford, the rate of fluid migration and neutralization during initial reaction of tank wastes with sediment may strongly influence the subsequent behavior of contaminant migration.

Chemical and textural records during snowball garnet growth

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The growth history of two populations of snowball garnets from the Lukmanier Pass area (central Swiss Alps) was examined through a detailed analysis of chemical zoning, crystallographic orientation and 3D geometry. The first population was collected in the hinge of a chevron-type fold and shows an apparent rotation of 360°. Microstructural and chemical data reveal a modification of the stress field regime during garnet growth occurring after 270° of rotation and for $X_{Mn} = 0.009$. Crenulated inclusion trails indicate that the last 90° of the spiral curvature was formed under a non-rotational regime associated with flexural folding. EBSD maps reveal a crystallographic central domain exhibiting 270° of rotation and distinct smaller crystallographic domains at the end of the spirals. A second population collected on the limb of the folds exhibits rotations that do not exceed 270°. Here, the garnets do not record any evidence for a modification of the stress field regime during garnet growth, and a single crystallographic orientation is observed for the whole spiral.

X-ray compositional maps show strong correlations in the zoning of Mn, Ca, Fe and Mg. These correlations indicate that these cations achieved local equilibrium during garnet growth and justify the use of Mn concentration as a time marker. Compositional information points out that a particular event in the garnet growth history affected all the garnets simultaneously. This event occurs at $X_{Mn} = 0.009$ and is characterized by an unexpected increase in Ca concentration. In contrast, rim chemical data indicate that the growth of the garnets from the limb ceased at $X_{Mn} = 0.009$. Near the rim of these latter garnets, concentration profiles show an abrupt decrease of Ca concentration. The contrasting behavior of Ca at $X_{Mn} = 0.009$ between samples from both sampling localities suggests dissolution of a Ca rich phase in the limb of the fold, and its precipitation in the hinge of the fold. As plagioclase is the main phase that incorporates Ca in these rocks, flexural folding is interpreted as being responsible for pressure dissolution of plagioclase along the limb of the folds and reprecipitation of Ca through garnet crystallization in the hinge of the fold.