H45F-1231 - Mobilization of Trace Elements from Sediments into Groundwater in California's Central Valley

Thursday, 16 December 2021
16:00 - 18:00
Convention Center - Poster Hall, D-F

Abstract

Persistent and more regular droughts in the Central Valley of California put increasing pressure on groundwater for domestic, industrial, and agricultural uses. This increased demand has led to higher scrutiny of groundwater quality. U, As, Fe, Mn are present in drinking water wells and sediments throughout the Central Valley, originating in the Sierra Nevadas. These elements can be mobilized from sediment into groundwater as a result of multiple geochemical mechanisms that have not been fully explored. Our study used sediment samples from the saturated and unsaturated zones to determine bulk trace element concentrations as well as their chemical reactivity to evaluate mobility. Our analyses included 1) bulk chemistry using X-ray fluorescence, 2) sequential extractions to isolate trace elements in the exchangeable, carbonate-bound, Fe-Mn oxide bound, and organic/sulfide bound phases, 3) X-ray diffraction to characterize mineralogy, 4) Fe2+and Fe3+ speciation to inform redox, and 5) grain size distributions of sediments to estimate hydraulic conductivity (K).

Results show that U, which originates in mafic minerals, has been depleted from near-surface sediments of the unsaturated zone (< 1 mg/kg). However, there is an increase in U (> 5 mg/kg) at a depth of ~25 feet, coincident with a 10x increase in Fe3+ concentrations and a 104 decrease in hydraulic conductivity (10-8 m/s). This zone also contains elevated concentrations of Mn and As. Below this depth in both unsaturated and saturated zones, Fe, Mn, As, and U trend together in high concentrations when K is low and in comparatively lower concentrations when K is high. We propose the following conceptual model of U, As, Fe, and Mn cycling: U is oxidatively dissolved in the near-surface sediments and transported downward through the unsaturated zone, where it then sorbs to the abundant Fe and/or Mn oxides in low K sediments, which also sorb As. U- and As-bearing Fe and Mn oxides can then be reductively dissolved during microbial oxidation of organic carbon, releasing Fe, Mn, As, and U to groundwater. (Bi)carbonate produced by microbial oxidation of organic C then forms aqueous U complexes that allow it to

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