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Uranium-bearing opals: Products of U-mobilization, diffusion, and transformation processes

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Abstract

Understanding the retention mechanism of U by amorphous silica (i.e., opal) in the environment is of great importance to nuclear-waste disposal because opals can retain U for millions of years. Uraniferous opals from Spor Mountain and the Thomas Range, Utah, U.S.A., are examined in terms of their mineralogical, chemical, and isotopic compositions. Uranium-rich zones composed of most likely vorlanite, $CaUO_4$, occur in fibrous opal-CT (termed lussatite) along the interface of the phase with microcrystalline quartz. Red- to black-colored precipitates of vorlanite also occur in the interstices between fibers and grains in lussatite and massy opals, respectively. The high abundance of vorlanite in certain growth zones can be explained by the diffusion of Ca and U along boundaries of layers, grains, and fibers and by the release of Ca and U through the transformation of opal-A into opal-CT and from opal-CT into microcrystalline quartz. Similar O-isotope compositions of opal-CT and associated microcrystalline quartz indicate that crystallization processes and deposition of subsequent layers of opal occurred from fluids of similar origin and *T*. Differences in the isotope and chemical composition between uraniferous opals/microcrystalline quartz, the SiO_2 polymorph moganite, and pyrolusite indicate the past occurrence of various alteration processes involving fluids of different composition and *T*. The results of this study indicate that assemblages of opal and microcrystalline quartz can retain U for millions of years as long as confined pore spaces between different generations of opal and quartz or between growth features of opal provide space for the nucleation and adsorption of U-bearing phases and species.

Keywords: Opal, uranium, amorphous silica, vorlanite, SIMS, retention, quartz, transformation