

ACTINIDES IN GEOLOGY, ENERGY, AND THE ENVIRONMENT

Uranium scavenging during mineral replacement reactions†

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ABSTRACT

Interface coupled dissolution-reprecipitation reactions (ICDR) are a common feature of fluid-rock interaction during crustal fluid flow. We tested the hypothesis that ICDR reactions can play a key role in scavenging minor elements by exploring the fate of U during the experimental sulfidation of hematite to chalcopyrite under hydrothermal conditions (220–300 °C). The experiments where U was added, either as solid $\text{UO}_{2+x}(\text{s})$ or as a soluble uranyl complex, differed from the U-free experiments in that pyrite precipitated initially, before the onset of chalcopyrite precipitation. In addition, in $\text{UO}_{2+x}(\text{s})$ -bearing experiments, enhanced hematite dissolution led to increased porosity and precipitation of pyrite+magnetite within the hematite core, whereas in uranyl nitrate-bearing experiments, abundant pyrite formed initially, before being replaced by chalcopyrite. Uranium scavenging was mainly associated with the early reaction stage (pyrite precipitation), resulting in a thin U-rich line marking the original hematite grain surface. This “line” consists of nanocrystals of $\text{UO}_{2+x}(\text{s})$, based on chemical mapping and XANES spectroscopy. This study shows that the presence of minor components can affect the pathway of ICDR reactions. Reactions between U- and Cu-bearing fluids and hematite can explain the Cu-U association prominent in some iron oxide-copper-gold (IOCG) deposits.

Keywords: Uranium, scavenging, IOCG deposits, experiment, sulfidation reaction, interface coupled dissolution-reprecipitation reactions