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REE-, Sr-, Ca-aluminum-phosphate-sulfate minerals of the alunite supergroup and their role as hosts for radionuclides

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Abstract

Aluminum-phosphate-sulfate (APS) minerals of the alunite supergroup are minor components of uranium-bearing copper ores from the Olympic Dam deposit, South Australia. They typically represent a family of paragenetically late replacement phases after pre-existing REE-bearing phosphates (fluorapatite, monazite, and xenotime). Characterization with respect to textures and composition allows two groups to be distinguished: Ca-Sr-dominant APS minerals that fall within the woodhouseite and svanbergite compositional fields; and a second REE- and phosphate-dominant group closer to florencite in composition. All phases nevertheless display extensive solid solution among end-members in the broader APS clan and show extensive compositional zoning at the grain-scale. Samples representative of the deposit (flotation concentrate and tailings), as well as those that have been chemically altered during the processing cycle (acid leached concentrate), were studied for comparison. NanoSIMS isotope mapping provides evidence that the APS minerals preferentially scavenge and incorporate daughter radionuclides of the ^{238}U decay chain, notably ^{226}Ra and ^{210}Pb, both over geological time within the deposit and during ore processing. These data highlight the role played by minor phases as hosts for geologically mobile deleterious components in ores as well as during mineral processing. Moreover, Sr-Ca-dominant APS minerals exhibit preferential sorption of Pb from fluid sources, in the form of both common Pb and ^{210}Pb, for the first time revealing potential pathways for ^{210}Pb elimination and reduction from ore processing streams.

Keywords: Alunite supergroup, aluminum-phosphate-sulfates, Olympic Dam, ^{238}U decay series radionuclides, mineral processing