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Contrasting alteration textures and geochemistry of allanite from uranium-fertile and barren granites: Insights into granite-related U and ion-adsorption REE mineralization

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Abstract

Allanite is an important rare earth element (REE)-U-bearing mineral in granites, and it can act as a metal source for the formation of some hydrothermal uranium deposits and ion-adsorption REE deposits. To investigate the potential of allanite as a mineral probe of granite-related uranium mineralization processes and the formation of ion-adsorption REE deposits, we present textures, geochemistry, and in situ U-Pb isotope data for allanite from the fertile Changjiang granite associated with the Changjiang uranium ore field and barren Jiufeng granite in the Zhuguangshan batholith, South China. Alteration of allanite in the Changjiang granite is characterized by the altered domains with lower backscattered electron (BSE) intensities than the unaltered domains and replacement by other secondary minerals such as REE fluorocarbonates, calcite, fluorite, thorite, clay minerals, quartz, chlorite, and epidote. Crystals from the Jiufeng granite were partly replaced by the altered domains appearing darker in BSE images and minor REE fluorocarbonates. The darker domains of the Changjiang and Jiufeng allanite grains have higher $Fe^{3+}/(Fe^{3+}+Fe^{2+})$ ratios and U concentrations than those of the brighter domains, indicating that the alteration of allanite was probably related to more oxidized fluids. This study suggests that the Changjiang granite might have been subjected to the influx of F- and CO_2-bearing fluids.

The brighter domains of the Changjiang and Jiufeng allanite grains have weighted mean ^{207}Pb-corrected $^{206}Pb/^{238}U$ ages of 156.7 ± 4.3 Ma and 161.6 ± 5.3 Ma, respectively, consistent with the corresponding zircon $^{206}Pb/^{238}U$ ages of 156.1 ± 1.4 Ma and 159.8 ± 1.8 Ma. The darker domains of the Changjiang allanite grains yield a weighted mean $^{206}Pb/^{238}U$ age of 141.4 ± 5.6 Ma, which overlaps within error the timing of a uranium mineralization event (~140 Ma) in the Changjiang uranium ore field and the age of a crustal extension event (140–135 Ma) in South China. The BSE images and elemental maps reveal that rare earth elements such as La and Ce have been released from the Changjiang allanites during alteration and were precipitated as REE-fluorocarbonates that are susceptible to chemical weathering, which sets the stage for the formation of an ion-adsorption REE deposit. Our study suggests that the regional crustal extension might have played an important role in the formation of both granite-related uranium and ion-adsorption REE deposits in South China, as it could have triggered alteration or breakdown of REE-U-bearing minerals in source rocks.

Keywords: Allanite, mineral chemistry, geochronology, granite-related U deposits, ion-adsorption REE deposits, South China