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Hydrothermal alteration of magmatic titanite: Implications for REE remobilization and the formation of ion-adsorption HREE deposits, South China

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Abstract

Ion-adsorption rare earth element (REE) deposits in South China are currently the main source of heavy rare earth elements (HREE). The Gucheng deposit in western Guangdong Province is one example of HREE mineralization hosted in weathered coarse-grained biotite granites (CGBG). Titanite is a common accessory mineral in the CGBG and contains significant amounts of total REE (31 621 to 38 431 ppm), especially HREE (18 906 to 22 249 ppm). Titanite with a U-Pb age of 102.6 ± 1.9 Ma in the CGBG crystallized under relatively high temperatures (722–798 °C), high f_{H_2O}, and high f_{O_2} conditions in the late magmatic stage, and has similar Nd isotopic compositions similar to the host CGBG: $^{143}Nd/^{144}Nd$ = 0.512062 to 0.512125 and εNd(t) = –7.4 to –8.6.

Backscattered electron (BSE) imaging and TESCAN integrated mineral analyzer (TIMA) measurements show that titanite in the CGBG has been altered partly to fergusonite-(Y), rutile, calcite, quartz, and fluorite. The hydrothermal fluid responsible for titanite alteration was enriched in CO_3^{2-} and F, and was probably exsolved from the granitic magma. HREE released from the alteration of titanite were mostly scavenged by fergusonite-(Y) and rutile, which have been further replaced by gadolinite-(Y) and synchysite-(Ce). In addition, gadolinite-(Y) in the alteration assemblages exhibits further alteration and is characterized by elevated PO_4^{3-} and SO_4^{2-} contents in the altered parts. These results demonstrate that magmatic titanite in the CGBG underwent complex hydrothermal alteration, with a preferential accumulation of HREE in fergusonite-(Y) and gadolinite-(Y) in the alteration assemblages. Preferential HREE enrichments in magmatic titanite, and its alteration assemblages, are shown to play significant roles in the formation of the Gucheng HREE deposit.

Keywords: Titanite, metasomatic alteration, REE-rich mineral, REE remobilization, ion-adsorption deposit