Multiple phases of hydrothermal REE remobilization recorded in fluorapatite in the Yinachang Fe-Cu-(REE) deposit, Southwest China

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The ~1700 Ma Yinachang deposit in the Kangdian region, Southwest China, contains economic Fe and Cu, with potentially significant REE. Fluorapatite in this deposit records multiple phases of hydrothermal REE remobilization processes.

In the Yinachang deposit, there are three stages of alteration and mineralization, including pre-ore Na-(Fe) alteration, Fe-(REE) mineralization, and Cu-(REE) mineralization. In the Fe-(REE) mineralization stage, REE-rich fluorapatite, with total REE concentrations ranging from 10,700 to 34,000 ppm, formed together with low-Ti magnetite. In the following Cu-(REE) mineralization stage, large amounts of REE, especially LREE, were leached out of the REE-rich fluorapatite due to the interaction between fluorapatite and Cl-, F-, CO_2-, and Ca-rich, but REE-unsaturated fluids. The leaching of REE was associated with the obvious removal of Si, Na, Th, U, Pb, and Ba, and modification of the oxygen isotopic signature in the fluorapatite.

During a ~840 Ma tectonothermal event, REE-rich fluorapatite underwent the second interaction with oxidized, F-, CO_2-, and possibly Cl-rich, but Na- and Ca-deficient fluids. Due to fluid-fluorapatite interaction, REE were removed from the fluorapatite, but were immediately reincorporated into new phases within the fluorapatite. Thus, the altered fluorapatite contains abundant REE mineral inclusions, including bastnäsite-(Ce), monazite-(Ce), and minor xenotime-(Y). A very small portion of the LREE was transported out of the fluorapatite, and formed bastnäsite-(Ce) and monazite-(Ce) grains in the vicinity of the altered fluorapatite.

This study demonstrates that REE can be mobilized during multiple phases of hydrothermal activities and highlights the significant controls of fluid compositions on REE transportation and deposition behaviors in hydrothermal system.