

Fingerprinting REE mineralization and hydrothermal remobilization history of the carbonatite-alkaline complexes, Central China: Constraints from in situ elemental and isotopic analyses of phosphate minerals

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ABSTRACT

Carbonatites and related alkaline rocks host most REE resources. Phosphate minerals, e.g., apatite and monazite, commonly occur as the main REE-host in carbonatites and have been used for tracing magmatic and mineralization processes. Many carbonatite intrusions undergo metamorphic and/or metasomatic modification after emplacement; however, the effects of such secondary events are controversial. In this study, the Miaoya and Shaxiongdong carbonatite-alkaline complexes, in the South Qinling Belt of Central China, are selected to unravel their magmatic and hydrothermal remobilization histories. Both the complexes are accompanied by Nb-REE mineralization and contain apatite and monazite-(Ce) as the major REE carriers.

Apatite grains from the two complexes commonly show typical replacement textures related to fluid metasomatism, due to coupled dissolution-reprecipitation. The altered apatite domains, which contain abundant monazite-(Ce) inclusions or are locally surrounded by fine-grained monazite-(Ce), have average REE concentrations lower than primary apatite. These monazite-(Ce) inclusions and fine-grained monazite-(Ce) grains are proposed to have formed by the leaching REE from primary apatite grains during fluid metasomatism. A second type of monazite-(Ce), not spatially associated with apatite, shows porous textures and zoning under BSE imaging. Spot analyses of these monazite-(Ce) grains have variable U-Th-Pb ages of 210–410 Ma and show a peak age of 230 Ma, which is significantly younger than the emplacement age (440–430 Ma) but is roughly synchronous with a regionally metamorphic event related to the collision between the North China Craton and Yangtze Block along the Mianlue suture. However, in situ LA-MC-ICP-MS analyses of those grains show that they have initial Nd values same as those of magmatic apatite and whole rock. We suggest these monazite-(Ce) grains crystallized from the early Silurian carbonatites and have been partially or fully modified during a Triassic metamorphic event, partially resetting U-Pb ages over a wide range. Mass-balance calculations, based on mass proportions and the REE contents of monazite-(Ce) and apatite, demonstrate that the quantity of metasomatized early Silurian monazite-(Ce) is far higher than the proportion of monazite-(Ce) resulting from the metasomatic alteration of the apatite. Therefore, Triassic metamorphic events largely reset the U-Th-Pb isotopic system of the primary monazite-(Ce) and apatite but only had limited or local effects on REE remobilization in the carbonatite-alkaline complexes in the South Qinling Belt. Such scenarios may be widely applicable for other carbonatite and hydrothermal systems.

Keywords: Carbonatite-alkaline complex, phosphate minerals, REE mineralization, in situ isotopic analyses, metasomatic alteration; Experimental Halogens in Honor of James Webster