

Texture and trace element geochemistry of apatite in carbonatite related REE deposits: Fingerprinting magmatic-hydrothermal processes

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Apatite is a ubiquitous accessory mineral in carbonatites, which incorporate a variety of trace elements including REEs. Textural and chemical variations of apatite from three carbonatite related REE deposits (Shaxiongdong, Miaoya and Bayan Obo) were investigated with the aim to trace the magmatic/hydrothermal processes.

Detailed cathodoluminescence (CL) and back-scattered-electron (BSE) images of apatite reveal various textures, including (a) euhedral magmatic apatite with grain sizes of 100-300 μm usually showing inerratic zonation with CL yellow-greenish core and purplish rim; (b) euhedral to subhedral metasomatic apatite displaying turbid CL colour with monazite exsolution; (c) anhedral hydrothermal apatite in close association with fluorite, bastnaesite and barite that displays green CL colour or occurring as aggregates with lilac CL colour.

Magmatic apatite displays highest Mn and Sr contents (453 and 19110 ppm in average) and is characterized by steep inclined REE chondrite normalized pattern with average La/Yb_N and La/Sm_N values of 121 and 3.59. Of note, the purplish rim of magmatic apatite shows higher MREE contents (1147-1869 ppm) compared to that of the core (737-1000 ppm). Metasomatic apatite shows highly variable LREE patterns with La/Sm_N ratios varying from 0.13 to 5.80, and the average La/Yb_N and La/Sm_N values (47.5 and 1.88) and Mn and Sr contents (275 and 10065 ppm) are lower compared to that for magmatic apatite. Hydrothermal apatite is characterized by slightly LREE depleted chondrite normalized REE patterns with average La/Yb_N and La/Sm_N ratios of 13.4 and 0.70.

To sum up, the textural and compositional variations of apatite in the three deposits record various magmatic and hydrothermal processes, including 1) mineral fractionation for core-rim zoning in Shaxiongdong magmatic apatite; 2) dissolution-reprecipitation process for monazite exsolution in Miaoya and Bayan Obo metasomatic apatite; 3) co-deposition with fluorite, barite and bastnaesite from hydrothermal fluids for Bayan Obo hydrothermal apatite.