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Mineralogical fingerprints of crustal silica contamination in the Bayan Obo carbonatite

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Abstract

Carbonatites are carbonate-rich and silica-undersaturated igneous rocks. The presence of various silicates in carbonatites has sparked discussions about the source of silica. In this study, abundant fluorbritholite-(Ce) and humite group minerals are identified in the No. 1 carbonatite dike at the Bayan Obo REE-Nb-Fe deposit. These silicates are relatively rare and poorly understood in carbonatite systems. Mineral textures, in situ EPMA, and LA-ICP-MS analyses have been combined to constrain the mineral genesis in the carbonatite. Fluorbritholite-(Ce), a member of the apatite super-group, occurs as euhedral to subhedral crystals in the dike. They are characterized by remarkably high concentrations of REE_2O_3 (56.0–63.7 wt%), SiO_2 (19.6–21.2 wt%), and F (2.47–3.47 wt%), along with relatively lower P_2O_5 (0.25–3.69 wt%) and CaO (10.3–14.2 wt%) contents compared to common fluorapatite species. Additionally, their high-Y (961–3435 ppm) and low-Sr/Y (0.59–2.70) values suggest a hydrothermal origin from a fluid rich in SiO_2, REE, and F. Humite group minerals, mainly chondrodite and humite, display irregular mineral textures. They also exhibit elevated SiO_2 (32.5–34.7 wt%) and F content (3.59–7.32 wt%) with notably low TiO_2 content (0.02–0.08 wt%), indicating a hydrothermal origin induced by fenitization in the shallow crust. Our results favor a model of crustal silica contamination for the fenitization fluids enriched in F, LREE, and SiO_2. More importantly, the fluid-assisted silica contamination from wall rocks within carbonatites is likely to be a critical trigger of REE deposition in the carbonatite ore-forming systems.

Keywords: Bayan Obo REE deposit, carbonatite dike, crustal contamination, britholite, humite group minerals