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Elemental Redistribution during Fenitization at the Maoniuping Carbonatite Complex, China

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Carbonatite-related rare earth element (REE) deposits are critical global REE sources, where the pervasive metasomatic process driven by carbonatite-derived fluids (called fenitization) plays a vital role in REE mobilization and enrichment. This study investigates fenitization geochemistry at the Maoniuping complex (Mianning-Dechang metallogenic belt, China) to constrain elemental migration patterns and their implications for REE mobilization.

Two distinct fenite types were identified: Type I (riebeckite fenite), proximal to carbonatite with calcite-riebeckite assemblages, and Type II (aegirine fenite), characterized by aegirine-riebeckite-calcite paragenesis. Whole-rock geochemistry reveals a systematic enrichment gradient from carbonatite to fenite, marked by increasing $Na_2O + K_2O$ (8.2 to 12.5 wt%), MgO (1.3 to 3.8 wt%), and Fe_2O_3 (5.1 to 9.4 wt%), coupled with CaO (15.2 to 8.6 wt%) and HREE (100.18 to 27.64 ppm) depletion. All lithologies exhibit right-skewed REE patterns, with fenite showing a slight HREE enrichment trend, and higher $(Lu/Er)_N$ ratios (0.77 – 2.12). Aegirine and riebeckite from fenite exhibit right-skewed REE patterns consistent with the whole-rock fenite, showing a modest enrichment in HREE. Calcite from carbonatite, fenite, and syenite reveal consistently right-skewed REE patterns and homogeneous in situ C–Sr isotopic compositions ($\delta^{13}C$ = -5.22 to -6.94‰; $^{87}Sr/^{86}Sr$ = 0.70605 to 0.70624), consistent with a common enriched mantle source and minimal CO_2 degassing during fenitization. Comprehensive geochemical investigations suggest that fenitization at Maoniuping resulted from carbonatite-syenite interaction, driving alkali and Fe-Mg metasomatism. LREEs were preferentially mobilized into fenite via fluid-mediated processes, while HREEs remained sequestered in residual carbonatite. These findings highlight the critical role of fluid-rock reactions in differential REE fractionation and provide a framework for targeting HREE-enriched domains in carbonatite systems.