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Formation of the Maoniuping giant REE deposit: Constraints from mineralogy and in situ bastnäsite U-Pb geochronology

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Abstract

The time and processes of hydrothermal mineralization are long-standing problems in geology. This work addresses these questions with reference to the Maoniuping giant rare earth elements (REE) deposit (southwest China), which has rare earth oxides (REO) reserves of 3.17 million tons with an average grade of 2.95 wt%. Bastnäsite is the dominant economic mineral, occurring as four distinct paragenetic types in the Maoniuping syenite–carbonatite complex: (1) primary euhedral bastnäsite (type-A) in syenite, with isolated melt inclusions; (2) macro-crystalline tabular euhedral bastnäsite (type-B) in pegmatitic dikes, with a diverse variety of fluid inclusions; (3) fine-grained, anhedral veinlet-disseminated bastnäsite (type-C) in syenite; and (4) coarse-grained anhedral bastnäsite (type-D) in carbonatite dikes, occurring as veinlets or interstitial to calcite, fluorite, and barite. From the paragenetic and compositional variations, it is inferred that type-A bastnäsite is of primary magmatic origin, whereas the other three types have characteristics of hydrothermal origins. In situ LA-ICP-MS U-Pb geochronology of the four types of bastnäsite results in lower intercept ages of 28.2 ± 0.5 Ma (n = 95, MSWD = 5.10), 27.8 ± 0.4 Ma (n = 43, MSWD = 0.73), 26.8 ± 0.7 Ma (n = 50, MSWD = 0.83), and 25.8 ± 0.7 Ma (n = 55, MSWD = 1.70), respectively, which are consistent with the weighted average $^{206}Pb/^{238}U$ and $^{208}Pb/^{232}Th$ ages by ^{207}Pb-correction method. Compositional variations of clinopyroxene and apatite from the associated syenite, pegmatitic and carbonatitic dikes indicate a genetic relationship of the Maoniuping alkaline complex. The compositions of clinopyroxene range from $Ae_{44–67}Di_{14–18}Hd_{17–41}$ in pegmatitic dikes, $Ae_{43–66}Di_{6–20}Hd_{21–38}$ in carbonatitic dikes to $Ae_{68–90}Di_{0–3}Hd_{10–30}$ in syenite. Apatites in the pegmatitic and carbonatitic dikes have similar compositions with higher F, total REE, and Sr, and lower CaO contents than those in the syenite, which suggests a cogenetic origin for the associated pegmatite and carbonatite. Clinopyroxene and apatite compositions suggest that the pegmatitic melt might differentiate directly from the initial carbonatitic melt rather than the syenitic magma. The bastnäsite U-Pb geochronology and minerals data indicate continuous magmatic-hydrothermal evolution for the REE mineralization in the Maoniuping alkaline complex.

Keywords: U-Pb geochronology, bastnäsite, Maoniuping giant REE deposit, syenite-carbonatite complex, magmatic-hydrothermal evolution