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Amphiboles of the REE-rich Baerzhe Peralkaline Granite, Northeast China: Recorders of Fluoride-Silicate Melt Immiscibility and Rare Metal Enrichment

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Fluoride-silicate melt immiscibility has been proposed as an important control on LREE and Y enrichment in a peralkaline granite (e.g., the Strange Lake pluton in Canada). It remains uncertain, however, whether this immiscibility is a requirement for ore formation in peralkaline granites globally. We therefore conduct an integrated mineralogical and chemical study of amphibole from the REE-Zr-Nb-Be mineralized Baerzhe peralkaline granite pluton, northeast China, to investigate whether the metal enrichment was facilitated by this immiscibility process.

The Baerzhe pluton comprises, from early to late, a fine-grained hypersolvus granite, a porphyritic hypersolvus granite, and a transsolvus granite that evolved to pegmatite and a comb-textured amphibole unit. Hypersolvus granite enclave(s) can also be found within the transsolvus granite. The amphibole in these granitic units is arfvedsonite, providing evidence of fractional crystallization, magma mingling, fluoride melt immiscibility, fluid exsolution, and degassing. The presence of fluoride melt inclusions in arfvedsonite indicates that fluoride-silicate melt immiscibility took place in all units of the pluton except for the transsolvus granite, where rare metal mineralization occurs, and in pegmatite. The immiscibility was particularly intense in the porphyritic hypersolvus granite, but very weak in other rock units (Figs. 1 and 2). Most fluoride melt inclusions are rich in Ca and are enriched in LREE, MREE, and Y relative to HREE. The estimated volume of fluoride melt in the porphyritic hypersolvus granite was less than 1 wt. %, storing about 2–6 wt.% LREE and up to 8–15 wt. % MREE and Y. The exsolution of fluoride melt, however, does not affect the trends of increasing concentrations of REE and HFSE in the coexisting silicate melt, which were driven by intense fractional crystallization of alkali feldspar, quartz, and arfvedsonite. The absence of fluoride melt inclusions in the transsolvus granite and pegmatite indicates that the early-formed immiscible fluoride melt did not accumulate in the residual silicate melt. Fluoride melts appear to have played a limited role in the concentration of LREE and Y to form the Baerzhe deposit. Instead, fractional crystallization of silicate minerals exerted a dominant control on the enrichment of REE and HFSE by factors of 5 to 20.