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Continuous Be mineralization from two-mica granite to pegmatite: Critical element enrichment processes in a Himalayan leucogranite pluton

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Abstract

Beryllium is a critical metal typically concentrated in highly fractionated granitic rocks such as the leucogranites in the Himalaya. Here, we report beryl mineralization that was continuous from the earlier and less-evolved two-mica granite to the highly evolved albite granite and pegmatite in a typical leucogranite pluton at Pusila in the central of Himalaya. Textural and mineral chemical evidence support a magmatic origin for beryl, and the trends of beryl crystal chemistry indicate magma differentiation. Despite low to moderate fractionation of the biotite granite and two-mica granite in the Pusila leucogranite pluton, the Be contents (~7 μg/g, beryl-free and ~22 μg/g, beryl-bearing, respectively) of these granites are much higher than the average for biotite- and two-mica granites worldwide (~3–4 and 5–10 μg/g, respectively), indicating that the initial magma had a relatively high-Be concentration. The gneisses of Greater Himalayan System, considered the protolith, also show a higher Be abundance (~4–6 μg/g) than the mean value of pelitic rocks worldwide (~2–3 μg/g), which could be the source reservoir of Be. The source contributed the initial Be to the melt, and fractionation resulted in the onset of beryl crystallization from the interstitial residual melt in the two-mica granite. The ubiquity of beryl in two-mica granite to pegmatite stages of the Pusila pluton is explained by a continuous crystallization model, although there was a delay in the onset of beryl crystallization in the two-mica granite. Modeling based on Rayleigh fractionation indicates that Be becomes compatible once saturation is attained because of the beryl crystallization. Our findings indicate that the enrichment of critical elements (e.g., Be) is controlled not only by fractional crystallization but also by the buffering action of a saturating phase (e.g., beryl) on the concentration of the critical element in the melt.

Keywords: Himalayan leucogranite, beryllium, beryl, source, fractionation, delayed crystallization; Lithium, beryllium and boron: Quintessentially crustal