Fractional crystallization and assimilation processes of the Khangai granitoids, central Mongolia and its role in their petrogenesis

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The Late Permian–Early Triassic Khangai batholith (269–237 Ma) is a large granite pluton emplaced in central Mongolia (Jahn et al., 2008; Yarmolyuk et al., 2016; Dolzodmaa et al., 2020). The granitoids in the Khangai batholith is divided into two stages of magmatism: Stage-I (269–248 Ma granitoids) is characterized by high-K calc-alkaline, I-type Hbl–Bt granodiorite with mafic magmatic enclave (MME) and Bt granite; stage-II (238–237 Ma granitoids) is defined by high-K calc-alkaline to shoshonitic, A2-type pegmatitic granite and granitic dike (Dolzodmaa et al., 2020). We report whole-rock Rb–Sr and Sm–Nd isotopic compositions and chemical compositions of major rock-forming minerals such as hornblende, biotite, plagioclase and K-feldspar as well as combining with geochemical, geochronological data set of the Khangai granitoids (Dolzodmaa et al., 2020) to discuss their source and fractional crystallization–assimilation processes involved in their petrogenesis.
Whole-rock Rb–Sr and Sm–Nd isotopic compositions of Hbl–Bt granodiorite with MMEs show initial $^{87}Sr/^{86}Sr$ ratios between 0.7062 to 0.7109 and $\varepsilon_{Nd}(T)$ values of −1.04 ~ +0.45 with Nd model age of 1.06–0.88 Ga suggests that Hbl–Bt granodiorite with MMEs may have been derived from juvenile to less mature crustal materials involving fractional crystallization, whereas Bt granites show SrI(T) between 0.7116 to 0.7283 and $\varepsilon_{Nd}(T)$ values of −2.24 ~ −0.71 with Nd model age of 1.21–1.04 Ga suggests that Bt granites may have been derived from fractionation product of Hbl–Bt granodiorite magma involving wall-rock assimilation. This hypothesis is also supported by whole-rock geochemistry of the Hbl–Bt granodiorite with MME and Bt granite where their SiO_2 content ranging from 48.98 to 73.35 wt% define a single trend on silica vs. major and trace elements diagrams that likely reflects fractional crystallization processes followed by the fractionation of plagioclase and hornblende (Dolzodmaa et al., 2020). Moreover, REE-patterns of plagioclase from MME and Hbl–Bt granodiorites with low-SiO_2 whole-rock composition (48.98–54.44 wt%) display LREE-enriched, HREE-strong depleted with positive Eu (93.66–20.38) anomalies indicating that plagioclase was an early crystallizing phase supported by the plagioclase occurrence as inclusions in hornblende. And also, plagioclase from Hbl–Bt granodiorite and Bt granite with high-SiO_2 whole-rock composition (67.59–73.35 wt%) have two different REE-patterns. The early crystallized plagioclase shows the same pattern as the plagioclase from MME and Hbl–Bt granodiorites with low-SiO_2 whole-rock composition, whereas the rim of early crystallized plagioclase and later crystallized plagioclase grain display LREE-enriched, HREE-slightly depleted patterns with negative Eu anomalies (0.22–0.57). These plagioclase REE patterns indicate that they crystallized from a magma assimilated by wall-rock (pelitic metamorphic rock). Consequently, REE-pattern and chemical compositions of hornblende from MME and Hbl–Bt granodiorites show LREE-enriched, HREE-slightly depleted pattern with negative Eu anomaly (0.28–0.87) and Mg# decreases with increasing Si that reflects they may have been formed same source involving magmatic differentiation. On the other hand, stage II (238–237 Ma) pegmatitic granite have wide variations of initial $^{87}Sr/^{86}Sr$ ratios from 0.7128 to 0.7576 and $\varepsilon_{Nd}(T)$ values of −1.69 ~ −1.59 with Nd model age of 1.71–1.06 Ga. These data suggest that the pegmatitic granite might be formed from strongly differentiated and assimilated magma derived from the crustal material source. Our results show that fractional crystallization–assimilation processes play an important role in the petrogenesis of the Khangai granitoids which has not previously been recognized.

Keywords: Khangai granitoids, whole-rock Rb–Sr and Sm–Nd isotopic composition, Assimilation fractional crystallization process, mineral chemistry

